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Managing the Development of Alternative Energy in the Far East Regions

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ABSTRACT

This article addresses the critical challenge of selecting an electricity development strategy amidst power shortages and increasingly stringent global carbon regulation, necessitating effective public governance solutions. The urgency stems from electricity deficits in the Far East and the need to choose a generation development path balancing economic efficiency with environmental imperatives (including risks from carbon taxes like Carbon Border Adjustment Mechanism — European Commission (*CBAM EU*). **The research objective** is to identify optimal approaches for public regulation in developing new generation capacity, ensuring a balance between economic costs, supply reliability, and carbon footprint reduction. **The research aim is** to develop scientifically grounded criteria and mechanisms for public authorities to manage investments in new generation facilities in the Far East. **The methodology** employs comparative scenario analysis (hybrid, traditional, renewable scenarios), utilizing levelised cost of electricity (LCOE) calculations over project lifecycles and assessing environmental-economic consequences, including potential payments under carbon mechanisms. **Results** demonstrate that the hybrid scenario (combining traditional sources, nuclear power, and renewables) offers the best combination of economic efficiency (15% more cost-effective than a purely renewable scenario) and reduced environmental risks compared to traditional coal-based generation. The scenario relying predominantly on renewable energy sources to cover the deficit proved the most capital-intensive. **The findings** and the developed methodology hold practical value for federal and regional authorities in: scientifically substantiating investment decisions and developing regional energy development programs; formulating effective state support mechanisms to attract private investment in new generation capacity modernisation; developing preemptive measures to minimize economic risks associated with cross-border carbon regulation.

Keywords: energy security; carbon regulation; government regulation of power energy (sustainability); energy policy; renewable energy sources; government subsidies; environmental and economic efficiency

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INTRODUCTION

In recent years, renewable energy has become the fastest-growing segment of the global energy market. The leading regions in terms of its development include European countries, the United States, and China. In Russia, electricity generation from renewable energy sources (RES) more than doubled between 2021 and 2025[1].

The rapid expansion of renewable energy is driven by several factors:

- the increasing efficiency of electricity generation technologies based on solar panels and wind turbines[2];
- energy shortages experienced by a number of major consumers. The European Union faces the most acute energy deficit. China is also energy-deficient despite its substantial levels of electricity production and hydrocarbon extraction;
- the growing pursuit of energy independence, a trend particularly characteristic of the EU;
- the rapid development of cross-border carbon regulation systems and the introduction of carbon border taxes, most notably the *Carbon Border Adjustment Mechanism*[3] *(CBAM EU)*.

Under these conditions, the successful development of renewable energy becomes one of the key factors enhancing the competitiveness of a national economy. The ability to generate electricity without relying on hydrocarbons and without significant CO_2 emissions makes it possible, in the long term, to avoid carbon tax payments and to reduce the costs associated with the extraction, transportation, and purchase of hydrocarbon resources. If a country manages to develop renewable energy technologies, implement them in industrial production, and ideally establish export capacity, it gains not only through tax savings and lower production costs, but also by exerting indirect influence on partner countries that purchase such equipment as well as the software products and technologies enabling the integration of renewable energy facilities into a unified power grid.

However, the development of renewable and alternative energy is accompanied by a complex set of economic and technological challenges. Without appropriate energy storage systems or additional backup generating capacities (such as gas-fired or nuclear power plants), full reliance on renewable sources may lead to frequent disruptions in energy supply and threaten the reliability of the national energy system, imposing substantial costs on the economy.

Energy systems based entirely on renewables remain dependent on the variable nature of these sources and face serious technical and economic issues, such as unstable electricity generation (either insufficient or excessively high output) from solar and wind power plants.

1. *Periods of low generation*. Electricity output from solar power plants decreases at night, while wind turbines produce less energy during calm, windless intervals. Seasonality also poses a serious challenge. In winter months, energy demand reaches its peak in some regions, whereas solar activity is minimal. Under such conditions, maintaining energy system stability requires the availability of reserve capacity.

2. *Overloads during periods of overproduction.* When electricity generation exceeds demand (on particularly sunny or windy days), surplus energy is either lost or requires storage systems, which again involves substantial costs.

Moreover, renewable energy is not "green" by default — each project requires careful assessment of potential negative impacts. The manufacturing of equipment, the development of supporting infrastructure, and subsequent disposal all consume energy, resulting in non-zero greenhouse gas emissions (for example, in the case of solar energy technologies).

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[1] Renewable Energy Statistics. Russian Renewable Energy Association (ARVE) URL: https://rreda.ru/industry/statistics/ (date of access: 11.07.2025).

[2] Levelized Cost of Energy. URL: https://www.lazard.com/media/xemfey0k/lazards-lcoeplus-june-2024-_vf.pdf (date of access: 11.07.2025.).

[3] Carbon Border Adjustment Mechanism. EC (official website). URL: https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en (date of access: 11.07.2025).

Although renewable energy sources are generally regarded as environmentally cleaner, the processes of their production and installation may still have adverse effects on ecosystems. In particular, ecosystems that provide biological resources or ensure water quality may be affected. Therefore, managerial decision-making in the field of renewable energy development requires a comprehensive preliminary assessment of interconnected economic, environmental, and technological challenges. It is essential to identify an appropriate balance between different alternative energy sources in order to build a stable regional energy system.

The present study aims to develop management solutions that support the advancement of alternative energy in conditions of energy resource scarcity across several Russian regions, within the broader context of increasing environmental concerns and strengthened carbon regulation.

RESEARCH METHODOLOGY

The methodological framework of the study is based on systemic, integrated, and comparative approaches, as well as methods of economic and mathematical modelling, environmental and economic accounting, forecasting, and scenario analysis.

The research draws on data from international organisations, including the United Nations, the International Energy Agency (IEA), the Intergovernmental Panel on Climate Change (IPCC), the International Renewable Energy Agency (IRENA), the World Bank, and others, as well as national institutions such as the Ministry of Energy and national statistical agencies. In addition, the study incorporates materials from relevant standards and strategic documents related to the development of alternative energy and environmental protection.

The study synthesises the findings of both domestic and international scholars in the field of energy sector development management, as well as the assessment of investment efficiency in renewable energy expansion under the growing scale of carbon regulation and increasing attention to environmental challenges.

Both internationally and in Russia, the future of the electricity sector is closely associated with renewable energy sources[4]. Their development offers several advantages: providing electricity access to remote regions, stimulating economic growth through the adoption of new technologies, reducing the carbon footprint and enhancing the competitiveness of energy-intensive products, and creating new jobs in high-technology industries [1–6].

Nevertheless, despite its strong potential, the development of renewable energy is associated with a number of serious challenges, primarily of a technological and financial nature[5]. The lack of appropriate technologies and operational experience with new equipment, as well as insufficient investment, may become significant barriers limiting the successful deployment of alternative energy sources.

The expansion of renewables requires not only technological capabilities and expertise, but also a substantial resource base. The production of components for solar panels and wind turbines involves the consumption of large quantities of mineral and other raw materials[6]. This contributes to the depletion of natural resources and poses risks to sustainable development, which may be regarded as "long-term costs" for the economy. Moreover,

[4] IRENA Report: Global Energy Transformation. A Roadmap to 2050. URL: https://www.irena.org/publications/2019/Apr/Global-energy-transformation-A-roadmap-to-2050–2019Edition (date of access: 01.07.2025); Renewables Global Status Report. 2023. URL: https://www.ren21.net/wp-content/uploads/2019/05/GSR2023_GlobalOverview_Full_Report_with_endnotes_web.pdf (date of access: 01.07.2025).

[5] World Bank — Scaling Up to Phase Down: Renewable Energy Transition in Emerging Markets. URL: https://www.worldbank.org/en/news/press-release/2023/04/20/scaling-up-to-phase-down-financing-energy-transition-in-developing-countries (date of access: 01.07.2025).

[6] IEA — International Energy Agency. The Role of Critical Minerals in Clean Energy Transitions. 2021. URL: https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions (date of access: 01.07.2025).

the reliance on rare minerals can increase production costs and lead to volatility in raw material markets. This further highlights the importance of life-cycle analysis and the principles of a circular economy. During the manufacturing of renewable energy equipment, the issue of pollution displacement also arises: while environmental costs remain relatively low in regions that utilise renewable energy, areas where raw materials are extracted and components are produced often suffer substantial ecological damage [7].

Methodological Approaches to Assessing the Environmental and Economic Efficiency of Renewable Energy Projects

The complexity and multidimensional nature of issues related to the development of renewable energy sources (RES) requires a careful evaluation of the appropriateness of specific managerial decisions. The justification of investments in renewable energy has been examined in studies conducted by the International Energy Agency, the International Renewable Energy Agency, and other organisations[7]. Contemporary academic research emphasises that projects related to renewable energy should be assessed in terms of their contribution to carbon emission reduction and their ability to enhance resilience to disasters, based on such parameters as:

The volume of avoided carbon emissions — comparing emissions generated by conventional energy sources with those associated with renewable energy technologies [8].

Life-cycle carbon footprint — accounting for all stages, from the development of renewable energy technologies to their operation and eventual disposal [9].

Long-term objectives — determining the extent to which a chosen energy strategy aligns with national and global targets for carbon emission reductions [10].

In evaluating the effectiveness of renewable energy deployment, a key factor is economic feasibility, which includes financial profitability, technological availability, implementation costs, and the long-term implications for both investors and society as a whole. A wide range of methodological tools is applied in this field, including life-cycle assessment (LCA[8]), evaluations of resource renewability, and comprehensive economic analyses of projects that incorporate both financial and social dimensions, among many others [11, 12].

Academician S. N. Bobylev, a member of the Russian Academy of Natural Sciences and the Russian Ecological Academy, emphasises the necessity of considering not only the economic efficiency of renewable energy, but also its environmental impact [13]. IRENA employs various approaches, methods, and models for evaluating the environmental and economic effectiveness of renewable energy development[9], thereby providing a comprehensive understanding of its influence on both the economy and the environment (*Table 1*).

Within the framework of this study, the calculations were based on the method of estimating the levelized cost of electricity (LCOE), taking into account international experience and the specific

[7] Projected Costs of Generating Electricity IEA. 2020. URL: https://www.iea.org/reports/projected-costs-of-generating-electricity-2020 (date of access: 08.07.2025); SIDS Lighthouses Initiative. Progress and way forward. IRENA. 2021 URL: https://islands.irena.org/-/media/Sids/Files/Publications/200121_IRENA_SIDS_Brochure_2021_1P.pdf (date of access: 08.07.2025).

[8] ISO 14040:2006. Environmental Managemen — Life Cycle Assessment — Principles and Framework. URL: https://www.iso.org/standard/37456.html

[9] Renewable Power Generation Costs in 2021. IRENA. URL: https://www.connaissancedesenergies.org/sites/connaissancedesenergies.org/files/pdf-pt-vue/IRENA_Power_Generation_Costs_2021_.pdf (date of access: 08.07.2025); Global Renewables Outlook: Energy Transformation 2050. IRENA. URL: https://www.irena.org/publications/2020/Apr/Global-Renewables-Outlook-2020 (date of access: 08.07.2025); Renewable Energy Benefits: Measuring the Economics. IRENA. URL: https://www.cire.pl/pliki/1/irena_measuringtheeconomics_2016.pdf (date of access: 08.07.2025); Reaching Zero with Renewables Capturing Carbon. IRENA. URL: https://www.irena.org/-/media/Irena/Files/Technical-papers/IRENA_Capturing_Carbon_2021.pdf

Table 1

IRENA Approaches to Assessing the Environmental and Economic Efficiency of Renewable Energy Development

Method	Tools	Description of the approach
Levelized cost of electricity, LCOE	$\mathbf{LCOE} = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$, where E_t – energy produced in year t; r – discount rate; n – project lifetime; M_t – operating and maintenance costs in year t; F_t – fuel costs in year t	LCOE is the key indicator used by IRENA to assess the cost of electricity generation from renewable energy sources. It is calculated as the total sum of all costs (capital, operational, fuel, etc.) divided by the total amount of electricity produced over the entire project lifetime
Energy Returned on Energy Invested, EROI	$\mathbf{EROI} = \frac{E_{\text{obtained}}}{E_{\text{spent}}}$, where E_{obtained} — energy delivered by the system (J or kWh) E_{spent} — energy required for extraction, production, and distribution (J or kWh)	EROI is applied to quantify the energy efficiency of different renewable technologies by converting energy investments into measurable energy benefits
Life Cycle Assessment, LCA	Assessment of environmental impacts at the raw material extraction stage Evaluation of emissions and waste generated during the manufacturing of renewable energy equipment. Analysis of environmental effects during the operation of renewable energy facilities Environmental assessment at end-of-life disposal	LCA represents a systematic approach to evaluating all environmental aspects and potential impacts of renewable energy technologies throughout their entire life cycle
Carbon Footprint Evaluation	$\mathbf{Carbon\ Footprint} = \sum_{i=1}^{n} (Ei\ \ EFi)$, где where Ei – energy produced or consumed from i source ; EFi – carbon emission factor (CO_2 per unit of energy) for source i; n – number of energy sources.	IRENA actively applies carbon footprint evaluation to analyse CO_2 and other greenhouse gas emissions associated with renewable energy production and use, allowing assessment of how renewables reduce the overall carbon footprint of the energy system
Sustainable Development Assessment Models	REMA (Renewable Energy Mapping and Assessment)	Model used to evaluate renewable energy potential in a region, taking into account natural resources and existing infrastructure
	REI (Renewable Energy Index)	An index enabling comparison of countries' progress in renewable energy deployment and their contribution to sustainable development
	RAP (Renewable Energy Policy Assessment)	A model designed to analyse renewable energy policies and their influence on economic and social outcomes
	SEIA (Sustainable Energy Impact Assessment)	Provides an assessment of the impact of sustainable energy development on environmental, social, and economic dimensions of sustainability

Source: Compiled by the authors.

features of regional energy system development in Russia. The following formula was applied:

$$\mathbf{LCOE} = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}},$$

where I_t denotes investment expenditures in year t; M_t– represents operating and maintenance costs in year t; F_t– refers to fuel costs in year t; E_t– is the amount of electricity generated in year t; r — is the discount rate; n — denotes the lifetime of the system.

An advantage of the LCOE indicator is that it makes it possible to account for the unit cost of electricity generation as well as the recovery of capital and operating expenditures associated with the functioning of power generation facilities throughout their entire life cycle — from the design and construction stages to their eventual decommissioning.

Based on the calculations and a systematic analysis of the challenges facing the energy sector in the Russian Far East, a set of recommendations was developed that may be applied to other constituent entities of the Russian Federation.

RESEARCH RESULTS

Given the problem of electricity shortages, particularly in the regions of the Russian Far East, the question arises as to the optimal strategy for the construction of new energy facilities. From both an economic and an environmental perspective, which option is preferable: the development of new power generation capacity (in particular, based on renewable energy sources and nuclear power plants), or the modernisation of existing facilities (including those operating on locally mined coal)?

The study carried out forecasting calculations of the unit costs associated with integrating each additional kilowatt-hour (kWh) of electricity into the energy system of the Far East under three possible scenarios for energy market development:

- a hybrid scenario, involving the combined use of conventional and alternative energy sources (Scenario A);
- a traditional scenario, in which no new nuclear power plants or renewable energy facilities are introduced (Scenario B);
- an alternative scenario based exclusively on renewable energy sources, specifically wind power plants (WPPs) and solar power plants (SPPs) (Scenario C).

To assess *investment expenditures*, the analysis applied specific capital costs for the construction of new generation facilities per 1 MW of installed capacity, including expenses related to grid infrastructure and associated measures. These measures covered, among others, land improvement and reclamation for reservoir construction, the development of social infrastructure, and fuel supply infrastructure. The calculations were based on baseline values of specific capital costs derived from the General Development Scheme[10] (*Fig. 1*). Capital cost recovery was determined using an annuitised payment approach based on the nominal rate of return.

To estimate *operating and maintenance costs*, data from the General Scheme for the placement of electricity generation facilities[11] were also used (*Fig. 2*).

To estimate *fuel costs*, the analysis applied specific fuel consumption rates based on standard values for the existing equipment structure of the Unified Energy System of the East (UES East). For coal-fired generation, the rate was set at 353 g of fuel equivalent per kWh, while for gas-fired generation it amounted to 320 g of fuel equivalent per kWh. The coal price was deter-

[10] the General Scheme for the Placement of Electric Power Facilities until 2042, approved by the Order of the Government of the Russian Federation dated 30.12.2024 No. 4153-r. URL: http://publication.pravo.gov.ru/document/0001202501090002?index=1

[11] Order of the Government of the Russian Federation dated 30.12.2024 No. 4153-r. the General Scheme for the Placement of Electric Power Facilities until 2042 URL: http://publication.pravo.gov.ru/document/0001202501090002?index=1 (date of access: 07.07.2025 r.).

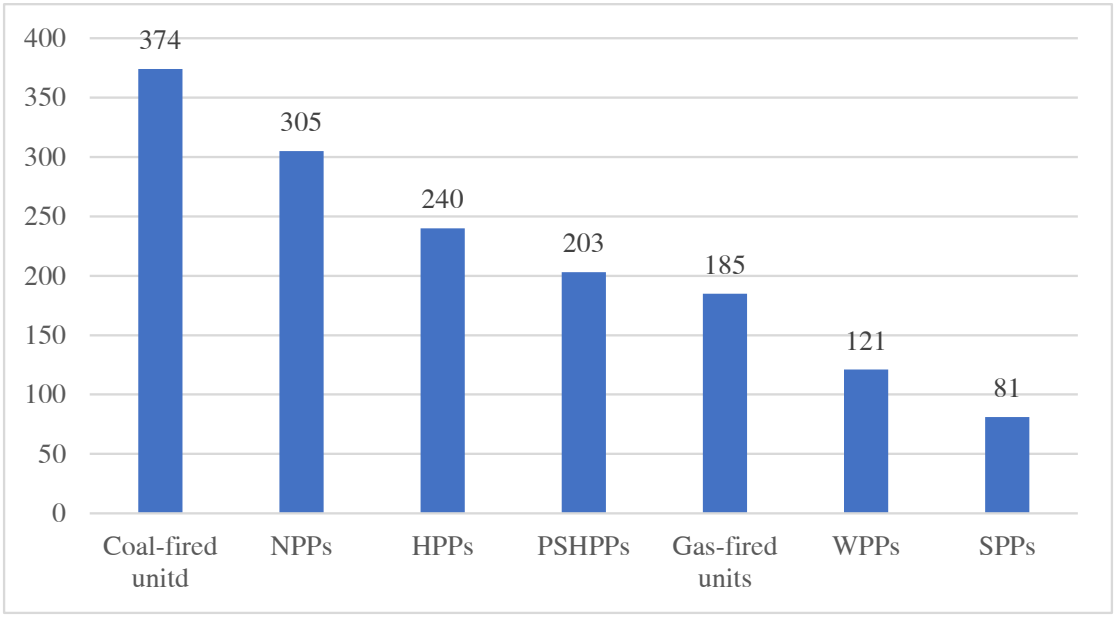

Fig. 1. **Specific Capital Costs of Generating Facilities (in 2023 prices, million Rubles/MW)**

Source: Compiled by the authors based on the General Scheme for the Placement of Electric Power Facilities until 2042, approved by the Order of the Government of the Russian Federation dated 30.12.2024 No. 4153-r URL: http://publication.pravo.gov.ru/document/0001202501090002?index=1 /

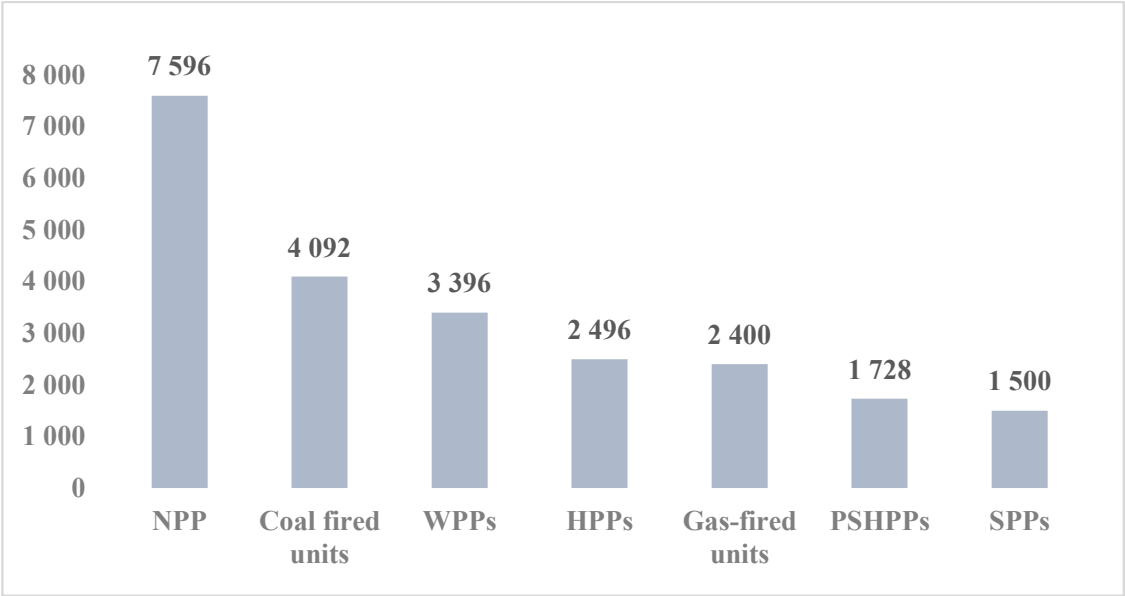

Fig. 2. **Conditionally Fixed Costs of Generating Facilities (in 2023 prices, million rubles/MW/year)**

Source: Compiled by the authors based on the General Scheme for the Placement of Electric Power Facilities until 2042, approved by the Order of the Government of the Russian Federation dated 30.12.2024 No. 4153-r. URL: http://publication.pravo.gov.ru/document/0001202501090002?index=1 /

mined on the basis of the netback price of a coal mine, derived from the average indicator over the past ten years — FOB Vostochny 6000 (USD 64 per tonne)—adjusted for current railway transportation tariffs and the prevailing exchange rate of the US dollar. The gas price was established in accordance with the tariff regulations issued by the Federal Antimonopoly Service (FAS), including tariffs for Gazprom in regional markets and gas distribution organisations, end-user tariffs,

Table 2

Scenario Conditions for Calculating LCOE

Generation Type	Units	Hybrid Scenario (Scenario A)	Traditional Scenario (Scenario B)	Alternative Scenario (Scenario C)
NPP	MW	3 200	0	2 400
HPP	MW	1 864	1 404	1 404
PSHPP	MW	600	0	1 000
TPP	MW	2 176	6 500	2 230
WPP, SPP	MW	2 200	0	10 500
TOTAL	MW	10 040	7 904	17 534

Source: Compiled by the authors.

and the special surcharge applied to transportation services.

The discount rate, corresponding to the long-term yield of Russian federal government bonds, was set at 6.1%, while the baseline required rate of return was 14%. Accordingly, the target rate of return was estimated at 11.5%.

The three LCOE calculation scenarios are presented below (*Table 2*).

According to the electricity balance outlined in the General Development Scheme, additional electricity generation is expected to reach at least 35 billion kWh by 2042, and the outcome of each scenario must satisfy this requirement. In addition, the commissioning of three new flood-control hydropower plants in the Amur Region (with a total installed capacity of 1,404 MW) cannot be excluded from the assessment. It is also important to note the specific operating characteristics of wind and solar power plants, namely daily fluctuations in electricity output depending on climatic conditions. Therefore, the most preferable option is a synergistic combination of wind or solar generation with hydropower plants and pumped-storage hydropower facilities. Such sources can serve as natural storage mechanisms for variable renewable generation, capable of compensating for daily losses in output [14]. Conversely, during low-water periods, renewable generation may offset reductions in electricity production from hydropower and pumped-storage facilities. Accordingly, in order to maintain generation balance, the scenario includes the construction of a pumped-storage power plant with an installed capacity of 1,000 MW.

The calculations showed that *Scenario A (the hybrid scenario)* proved to be the most promising option and demonstrated the strongest economic performance. The levelized cost of electricity under this scenario amounted to 12,689 RUB per kWh, which is 15% lower than in *Scenario B (the traditional scenario)*, where the value reached 14,612 RUB per kWh. The difference in investment costs between *Scenarios A and B* is estimated at 20%, while the projected volume of additional electricity generation remains the same.

Electricity production based on traditional energy sources continues to be the most economically efficient option (11,968 RUB per kWh) both for consumers and for the economy as a whole, provided that the environmental consequences of coal-based generation are disregarded.

Scenario C (alternative scenario) represents a substantial financial burden for the economy, especially in the short term. The cost of each additional kilowatt-hour of electricity reaches 14,612 RUB. Despite the rapid decline in the cost of renewable energy technologies such as solar

Table 3

Results of LCOE Calculation in Three Scenarios

Generation Type	Scenarios								
	A	B	C	A	B	C	A	B	C
	Electricity output in 2042, million kWh			Investment, billion rub.			LCOE, rub./kWh		
NPP	22 426	0	15 558	976	0	732	12 501	0	13 515
HPP	7 169	5 658	5 289	446	337	337	14 526	13 895	14 864
TPP (coal)	2 456	13 140	639	244	935	273	24 336	18 477	92 692
TPP(gas)	8 945	25 930	8 541	282	740	277	8 877	8 249	9 081
RES	4 730	0	11 388	218	0	788	9 474	0	14 210
SPP	526	0	4 555	33	0	325	12 106	0	13 969
PSHPP	1 051	0	1 489	122	0	203	24 137	0	28 397
Total	47 303	44 727	47 539	2 320	2 012	2 935	12 689	11 968	14 612

Source: Compiled by the authors.

panels and wind turbines, the transition to a fully "green" energy system requires significant investment in infrastructure, energy storage solutions, and structural transformation of the energy market (*Table 3*).

At the same time, the results may change if the environmental dimension is taken into account more comprehensively. The inclusion of renewable energy technologies in the energy balance at the very least implies a reduced risk of future carbon tax liabilities.

Moreover, a full assessment of environmental and social impacts should consider the following positive effects associated with reduced

Table 4

Annual CO_2 Emissions in Three Scenarios

Generation type	Unit of measurement	Scenarios		
		A	B	C
NPP	т CO_2/year	252 288	0	189 216
HPP	т CO_2/year	0	0	0
PSHPP	т CO_2/year	0	0	0
TPP	т CO_2/year	11 151 130	33 309 900	11 427 858
WPP, SPP	т CO_2/year	144 540	0	689 850
TOTAL		11 547 958	33 309 900	12 306 924

Source: Compiled by the authors.

pollutant emissions and improved environmental conditions: lower population morbidity rates; enhanced soil quality; reduced damage to forest ecosystems affecting biodiversity; and fewer losses linked to accelerated material degradation caused by acid rain, among others.

In the present study, environmental effects were evaluated in terms of the monetary valuation of CO_2 emissions, which is currently regarded as one of the most widely demanded and internationally recognised approaches for quantifying the benefits of alternative energy development. For each scenario, potential volumes of carbon emissions were analysed (*Table 4*), and the results were converted into monetary equivalents.

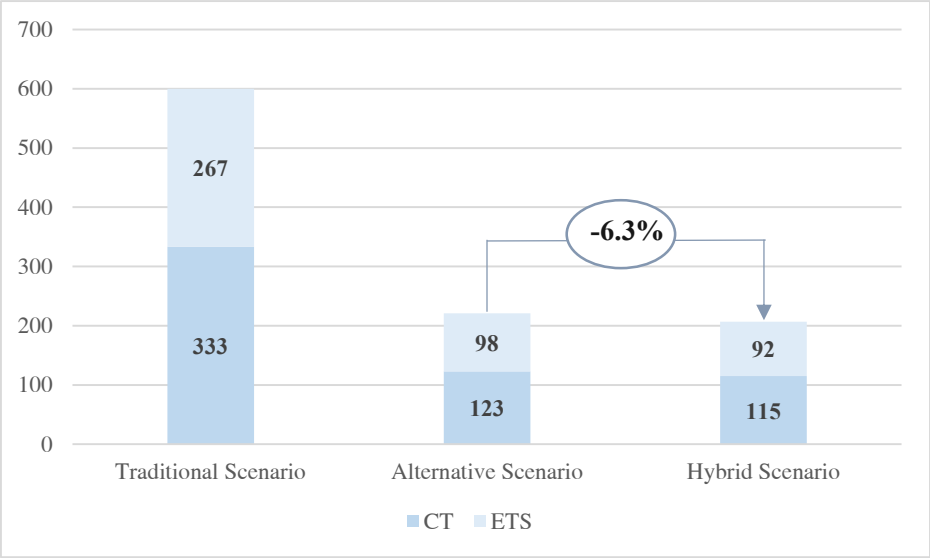

Fig. 3. **Environmental and Economic Assessment of CO2 Emissions Obtained Taking into Account Carbon Tax and Emissions Trading, million US dollars**

Source: Compiled by the authors.

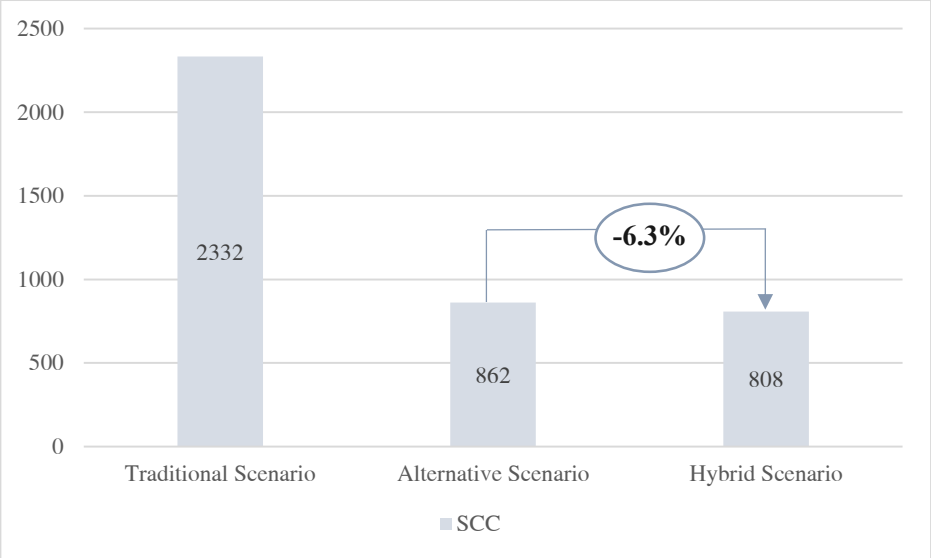

Fig. 4. **Assessing the Long-Term Environmental and Economic Impacts of Climate Change (Social Cost of Carbon), million US dollars**

Source: Compiled by the authors.

The main approaches to assessing CO_2 emissions include the application of a *carbon tax* or an *emissions trading system* (ETS).

The results of the environmental and economic efficiency calculations, performed *using mechanisms such as carbon taxation and emissions quota trading*, are presented in *Fig. 3*. On the one hand, the potential CO_2 emissions tax revenue to the federal budget is estimated; on the other, the additional cost of emissions allowances for the market is evaluated.

An analysis was also conducted of the economic damage associated with the release of one additional tonne of CO_2 into the atmosphere using the Social Cost of Carbon (SCC) approach, which accounts for the impacts of CO_2 emissions on climate change, the economy, public health, agriculture, and ecosystems (*Fig. 4*).

The calculations showed that, all else being equal and with a focus exclusively on incremental emissions, the choice between the *Hybrid (Scenario A)* and the *Alternative (Scenario C)* does not reveal a decisive environmental advantage of one over the other. This suggests that economic factors — particularly the scale of required investment — may play a more significant role in strategic decision-making regarding the direction of regional energy development, without raising concerns about a substantial disproportionate increase in environmental burden according to this indicator. In contrast, the *Traditional Scenario (Scenario B)*, which does not involve the introduction of new technologies, including the use of high-quality coal filtration systems, proves to be the least environmentally favourable option.

In practice, however, due to a shortage of advanced technologies and operational experience, limited investment resources, the absence of accessible local coal reserves, low employment in the coal mining sector, and certain institutional and organisational features of energy sector governance, the expansion of generating capacity is often achieved through facilities operating on conventional hydrocarbon fuels (and in some cases on locally mined low-grade high-sulphur lignite coal) [15–17].

Recommendations for Improving the Investment Management Mechanism in the Electricity Sector Under the Energy Transition

Given the environmental risks associated with coal-fired combined heat and power plants and thermal power stations, as well as the trend of accelerated renewable energy development — which is expected to provide long-term competitive advantages — the authors of this article propose a set of recommendations aimed at improving the organisational and economic mechanism of sectoral governance.

Existing approaches to attracting investment in electricity sector projects exhibit a number of shortcomings. First, the use of a strictly quota-based framework and the absence of direct price competition between different generation technologies weaken economic incentives to optimise capital expenditures. Second, priorities in the allocation of new capacity are often shaped by the objectives of related manufacturing industries rather than by the actual needs of regional power systems. Third, support programmes for hydropower and nuclear generation are implemented outside competitive procurement procedures, limiting the conditions for reducing unit costs. Fourth, the high capital intensity of these technologies complicates their direct price comparability with thermal generation and renewable energy sources within existing market models. Fifth, the current selection system contributes to the preservation of the existing structure of generating assets, thereby constraining the potential reduction of final electricity prices. Collectively, these factors create barriers both to the sector's adaptation to the climate agenda and to the effective deployment of alternative generation technologies.

The situation could be improved through adjustments to the investment attraction mechanism. The following measures are particularly important:

- the regular organisation of competitive tenders (every few years); stable conditions and transparent rules for determining supply and de-

mand would encourage a larger number of applications;

- the gradual development of the domestic engineering industry and power construction organisations;
- the selection of only economically competitive generation projects available on the market;
- determination of the volume of new capacity based on actual system demand rather than on artificially imposed quotas;
- consideration of the availability of flexible capacity required to integrate new renewable facilities, meaning that renewable projects should be implemented primarily in regions with sufficient balancing resources;
- ensuring full competition between renewable energy projects and other generation proposals.

A new competitive project selection mechanism for the energy sector could also help address the shortcomings outlined above. Such a mechanism should combine the advantages of existing investment recovery models with innovations in the form of environmental constraints and the integration of carbon credit trading platforms. Accounting for the environmental dimension is particularly important in view of the possible future introduction of carbon taxes, as it is essential for maintaining the competitiveness of industrial output.

A key role in implementing a comprehensive set of measures to improve governance mechanisms and attract investment in the development of the energy sector should be played by the national Ministry of Energy. This institution is responsible for establishing the regulatory and legal framework for competitive project selection based on efficiency criteria, minimisation of the carbon footprint, as well as long-term planning and monitoring. At the same time, the Ministry of Economic Development should ensure the formation and proper functioning of the carbon credit market, including its infrastructure and regulatory foundations, and contribute to the creation of a favourable investment climate. Energy companies, in turn, are required to develop competitive strategies aligned with the low-carbon economy, supported by appropriate techno-economic justification, and to integrate these strategies into the carbon market through the implementation of emissions monitoring, reporting, and verification (MRV) systems. Such a comprehensive approach would stimulate the "green" modernisation of the sector on the basis of transparent and economically justified criteria and ensure its alignment with global development trends.

CONCLUSION

Ensuring the reliable supply of affordable and environmentally clean electricity is one of the strategic objectives that contributes to the achievement of sustainable development. For Russia, which may face electricity supply challenges in the coming years — particularly in the regions of the Far East — the issue of attracting investment for power system expansion has become especially urgent. The results of the present study demonstrate the feasibility of developing the energy system of the Russian Far East in the short and medium term through a combination of alternative energy sources (including renewable energy deployment and the construction of new nuclear power plants), as well as through traditional, but modernised, coal-based electricity generation. Environmental parameters were incorporated into the analysis, particularly CO_2 emissions, which may significantly affect project economics in the near future due to the potential introduction of carbon taxation mechanisms.

The authors propose a number of recommendations aimed at improving governance and investment attraction in the energy sector, including: monitoring the performance of new energy facilities; coordinated development of the electricity sector and the energy engineering industry; refinement of competitive project selection mechanisms for the power sector; and other supportive measures.

In the coming years, challenges related to electricity sector governance will remain at the

forefront of attention for both Russian and international researchers. The calculation results presented in this study further highlight the importance and strong potential of continued research into the environmental and economic dimensions of energy system development. The introduction of carbon taxes in multiple countries (including the Carbon Border Adjustment Mechanism in the European Union, carbon taxation in China, and others) is expected to substantially reshape the sector. Greenhouse gas emissions, particularly CO_2, are far from being the only negative environmental impact associated with energy system operations. As renewable energy expands, growing importance will be attached to issues such as the relocation of pollution-intensive industries to third countries, the appropriation of large land areas and the transformation of ecosystems, and the resource demands of both the energy infrastructure and energy-related manufacturing. The transformation of the electricity sector configuration and the emergence of a new internal ecosystem shaped by modern technologies and increased attention to environmental preservation will remain central areas of focus for specialists.

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On Ensuring Sustainable Development of Small and Medium-Sized Businesses in Russia

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ABSTRACT

From the standpoint of systems and self-organization theory, this article presents the prerequisites for the qualitative and sustainable development of small and medium-sized enterprises (SMEs) in the Russian Federation. The **relevance of this issue** stems from the spatial and structural imbalance of key SME performance variables and the need to create conditions for achieving the priority directions of technological sovereignty, which will contribute to forming a qualitatively new structure of the national economy. The purpose of the study is to develop and propose methodological principles for achieving an optimal innovative structure of SMEs, while the main **objective** is to minimize losses and management costs in launching a mechanism of self-sustaining SME development. The authors apply the **methodological** framework of systems and self-organization theory, structural and cyclical dynamics, as well as methods of comprehensive and statistical analysis. The research is based on data from regulatory and legal reference systems and official statistics of the Russian Federation. As a **result** of the study, a methodological approach is proposed that enables managerial decision-making based on the principles of harmonious correlation of SME parameters (ownership forms, enterprise size, spatial and territorial characteristics, SME share in GDP, employment rate, etc.) and synergetic analysis. This approach shapes the systemic potential for the qualitative innovative development of SMEs and their transition into the sphere of large business.

***Keywords*:** high-quality development; sustainable development; small and medium-sized enterprises (SMEs); innovative development; harmonious ratio; harmony in management; balanced management; socio-economic system

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INTRODUCTION

Under conditions of economic instability and technological transformation, the pursuit of sustainable economic development is impossible without a balanced relationship between the public and private sectors. At the same time, entrepreneurship — as an integral structural element of the economy — has always attracted significant attention, since it serves as a driving force of socio-economic development within a territory, contributes to the creation of new jobs, helps address unemployment challenges, and enhances labour productivity. In turn, state entrepreneurship shapes the structure of the economic space by implementing national projects, thereby regulating the transparency and the level of entropic dynamics, as well as authorizing the activities of economic actors and determining the vector of their interaction.

It is evident that the state is guided primarily by political and socio-economic interests, addressing a wide range of strategic objectives through authorized bodies and state-owned corporations. Among these, one of the key consolidating challenges is ensuring balanced innovative development of ecological–socio-economic systems (ESES). Its solution should be sought within the frameworks of systems theory and self-organization, drawing on an interdisciplinary and integrated body of knowledge, since the innovative development of humanity constitutes a natural evolutionary phenomenon with an inherent tendency toward acceleration. According to the authors' previous publications, "balanced innovative development of an ESES is understood as the coordinated transformation of its equivalent (homogeneous) subsystems (for example, resource flows, investments, economic actors, institutions, and others), the interconnections among them, and the processes that ensure the systemic potential and the capacity of an ESES to transition to a qualitatively new development trajectory" [1]. At the same time, the main challenge of management lies in understanding this mechanism, analyzing the mutual influence of endogenous fundamentally non-equilibrium processes, and examining the role of the ESES structure in shaping a cyclical trajectory.

RESULTS

One of the most important subsystems of the national economy is small and medium-sized enterprises (SMEs), which are capable of addressing not only a range of economic objectives — such as ensuring the sustainable development of regions, generating tax revenues, and increasing demand for the products of larger enterprises — but also social objectives, including ensuring employment and improvements in living standards, as well as the stimulation of competition and innovation. Moreover, SMEs play a fundamental role in promoting innovative development. SMEs contribute to the saturation of markets with goods and services by mobilizing citizens' financial resources, thereby enhancing the flexibility and adaptability of the national economy. Let us analyze the dynamics of the number of SME entities in Russia over the period from 2016 to 2025 (*Fig. 1*). According to the Unified Register,[1] by 2025 their number reached a record level of 6.6 million, largely due to the establishment in 2024 of more than 1 million legal entities and individual entrepreneurs.

In 2024, average monthly revenues amounted to 1.7 trillion rubles for micro-enterprises, 0.6 trillion rubles for small enterprises, and 0.2 trillion rubles for medium-sized companies. A notable positive development is that average revenue per enterprise increased by 11.2% over the period under review.

Plans for the implementation of the new national project "Efficient and Competitive Economy," scheduled for launch in 2025, envisage a 20% increase in the incomes of SME employees by 2030, as well as an outpacing

[1] Unified Register of Small and Medium-Sized Enterprises URL: https://rmsp.nalog.ru/index.html (date of access: 10.09.2025).

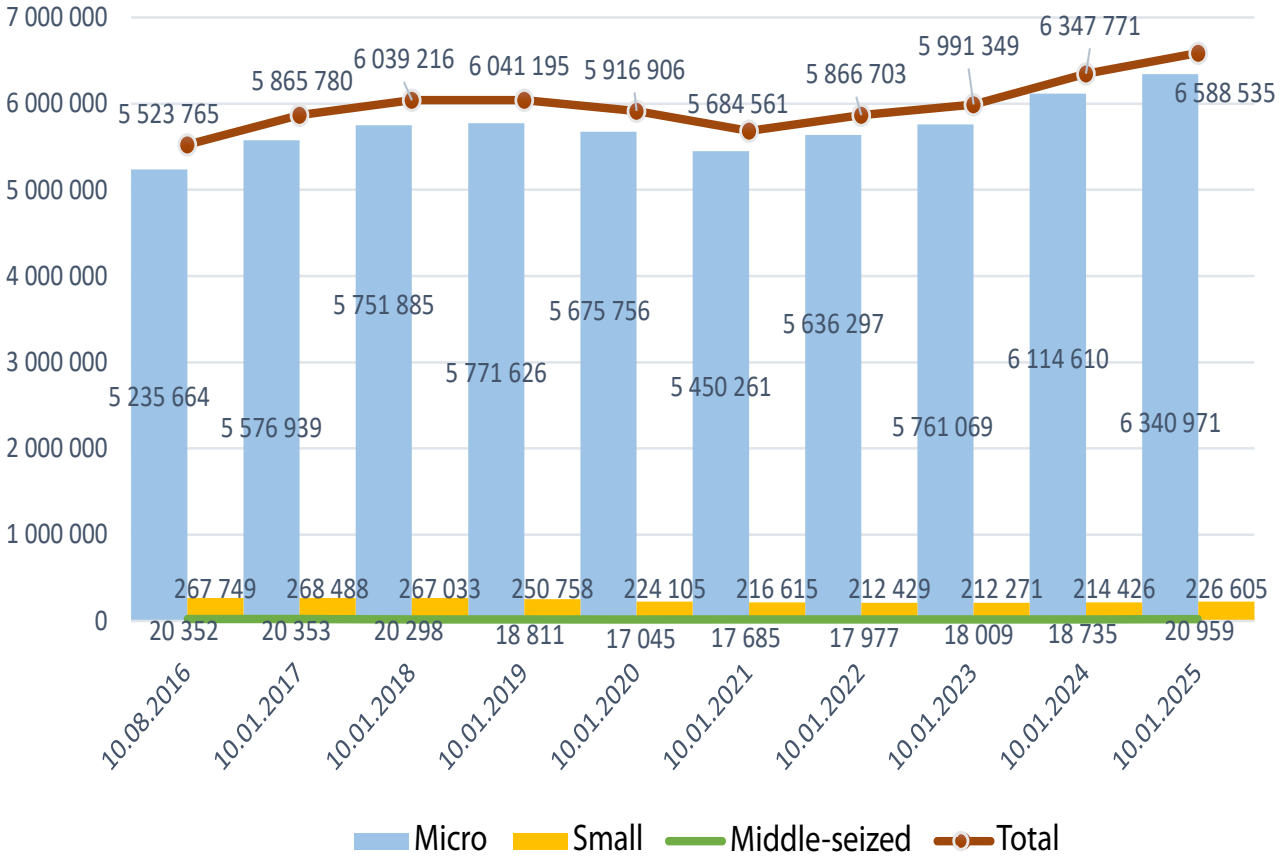

Fig. 1. **Dynamics of the Number of SMEs in Russia, 2016–2025**

Source: Compiled by the authors based on data from the Federal State Statistics Service.

growth of income per worker relative to GDP by a factor of 1.2.[2]

In recent years, the SME sector has not undergone substantial structural changes, with the exception of the expansion of retail trade conducted via postal services or the Internet. An increase has been observed both in the share of SMEs within the country's GDP structure (approximately 20%) and in business turnover, which rose by 14% (to 2,987 billion rubles). Based on the positive dynamics of quantitative indicators, it becomes possible to proceed with the implementation of the goals and objectives articulated by the President of Russia in 2024, namely, to initiate "a transition from quantitative growth to qualitative development of SMEs, the formation of a supply-side economy, and the advancement of technological sovereignty in priority areas.[3]"

Overall, the upward trend in quantitative indicators suggests a certain effectiveness of state support measures for SMEs. These include: expanding business opportunities to utilize non-bank sources of financing; providing company support through specialists of the "My Business" center, granting access to a wide range of services and informational resources, consultations, educational and trade fair events, accelerators, and product promotion tools; reducing transaction costs through the fast payment system; and lowering insurance contributions and the tax burden (the ratio of taxes paid to SME revenues in 2024 amounted to 5.2%).

[2] National project "Efficient and competitive economy" URL: https://www.economy.gov.ru/material/directions/np_effektivnaya_i_konkurentnaya_ekonomika/)

[3] The new role of SMEs in the Russian economy: an expert report.URL: https://xn-80aapampemcchfmo7a3c9ehj.xn—p1ai/new-projects/ (date of access: 10.09.2025).

It should also be noted that the highest concentration of SME entities (approximately 50%) is observed in two federal districts — the Central and Volga districts. The largest share (65.6%) is concentrated in Moscow (910 thousand) and the Moscow region (458 thousand), followed by Saint Petersburg (378 thousand), Krasnodar Krai (309 thousand), and Sverdlovsk Oblast (213 thousand). Within the Volga Federal District, the highest number of SME enterprises is registered in Tatarstan (178 thousand), Bashkortostan (142 thousand), Samara Oblast (135 thousand), and Nizhny Novgorod Oblast (130 thousand). The southwestern regions of Russia account for 116 thousand SME entities.[4]

The analysis of statistical indicators for 2025 in the SME sector points to a certain spatial and structural imbalance[5]:

a) the share of SMEs in the overall structure of the Russian Federation's GDP is 20% (whereas in developed countries this indicator reaches 50–60%);

b) medium-sized enterprises account for only 1% of the total number of legal entities;

c) the largest proportion of SME entities (32%) is located in the Central Federal District;

d) SME turnover represents 34% of the national total;

e) employment in the SME sector amounts to 38% (27.9 million people) of total employment in the country's economy.

It should be taken into account that accumulating structural disproportions typically provoke cyclical crises and financial difficulties, driving any economic system into a state of recession. Timely analysis and managerial adjustments to the sectoral and technological structure of SMEs can restore balance and, consequently, create prerequisites for sustainability [2].

DISCUSSION

The evolution of Nikolai Kondratiev's long economic cycles[6] demonstrates the presence of pronounced structural disproportions — both within the ecological–socio-economic systems (ESES) of individual territories and globally — driven by structural crises [3]. The latter emerge independently of cyclical dynamics, provoking economic crises and influencing their depth, scale, and duration, thereby determining the potential for evolutionary development. A structural crisis inherently accompanies the cyclical economic trajectory, as the two phenomena are closely interconnected and mutually conditioned.

In this context, the entrenched tendency of SMEs to base their economic activity on their own, often self-interested, short-term economic objectives and narrowly local concerns motivates the state, represented by authorized institutions, to undertake stringent coordinating actions aimed at regulating the formation of priority spheres of economic activity and determining directions for their development.

From the perspective of systems theory and self-organization, ensuring the sustainability of SME development, organizational coherence, and favourable qualitative transformations reduces to the challenge of mitigating structural-cyclical fluctuations within the economic system and understanding the nature of their mutual influence. The impact of evolutionary cycle shifts, driven by alternating periods of expansion and contraction, manifests differently at the global level (for example, within Russia's ESES) and at the local level (SMEs operating within a given territory). Smaller-scale systems, such as SMEs, experience more intense fluctuations, generating substantial disturbances that are largely neutralized through the multidimensional nature of development; a recession in one subsystem may be compensated by the achievements of others. Through self-organization, conditions emerge for the realization of synergistic and complementary systemic effects. Therefore, the harmonious and

[4] Official website of the Federal State Statistics Service (Rostat) URL: https://rosstat.gov.ru/ (date of access: 10.09.2025).

[5] Ibid.

[6] Kondratiev cycles (K-cycles or K-waves) refer to periodic long-term fluctuations in the economy, characterized by alternating phases of expansion and contraction of varying duration. They were described in the 1920s by the economist Nikolai Kondratiev.

balanced development of all ESES subsystems ensures sustainability and the potential for the improvement of its individual elements (specific territories) [4–7].

The systemic property of "sustainability" in economics is determined by the cyclical nature of energy (various resource) flows: from a given socio-economic system to its supersystem (the global economy, ecosystem) or to its subsystems (sectors, SMEs, industrial institutions), where the relationship between parts and the whole corresponds to the law of natural harmony (the Fibonacci principle). In this context, restoring the spatial and structural balance of SMEs requires achieving proportional relationships among the variables under consideration (for example, quantitative indicators), as well as a structural-functional balance of SMEs and their components. This implies dividing a given variable (an area of activity or a specific indicator) into parts such that the smaller relates to the larger as the larger relates to the whole quantity [8–10].

The principle of the golden ratio constitutes an objective law of development of ESES, manifesting itself in works of art, biology and genetics, psychology and politics, education and science, engineering and technology, economics and management, among other domains. An optimal relationship between the quantitative and qualitative parameters of SMEs ensures the attainment of essential systemic properties such as reliability, structural stability, economic efficiency, and the potential for qualitative transformations [1, 10, 11].

A sustainable and socially oriented economy may be considered one in which the share of state ownership reaches 60% (for example, as in Sweden), whereas a liberal-oriented economy corresponds to a level of approximately 40% state ownership (for example, Japan [35%] or the United Kingdom [40%]). In the Russian Federation, this indicator remains at the level of 10–15%, which is unsatisfactory from the standpoint of both socially and liberal-oriented economic models [1, 10, 11].

As the study demonstrates, the achieved parameters of the resulting variables of SME system development in Russia do not meet the criteria of harmony and sustainability, specifically the ratio of 62% to 38%. In particular, the share of SMEs in the overall GDP structure of the Russian Federation should tend toward 38%; the proportion of small and medium-sized enterprises within the total number of SMEs should correspond to 38%; and the number of employees in the SME sector should amount to 62% of total employment in the economy.

If relationships among SME elements and processes are dominated by proportions consistent with harmonic balance, the system will develop in a stable and balanced manner with minimal management costs. Although the described structure is idealized, it serves as an important benchmark for conducting systematic and objective analysis of economic systems and for elaborating effective governance strategies. The sustainability and balanced trajectory of SME development also contribute to managerial efficiency among entrepreneurial actors, optimal predictability of the economic space, the formation of innovative potential, and qualitative transformations [10, 12, 13].

The practical value of such balance-achievement methods represents the quintessence of complex optimization-based governance technologies, ensuring the reasoned and objective character of evolutionary trends. A number of Russian SMEs applying contemporary advances in the theory and methodology of innovation management successfully employ harmonic proportions in improving their structural-functional forms, as well as in developing marketing and competitive strategic actions [14].

METHODOLOGY

To model the harmonic space of SMEs, let us represent the market as an unbalanced structure comprising a complex of interconnected economic entities, in which medium-sized enterprises account for only 1% of the total number of legal entities producing a good (G):

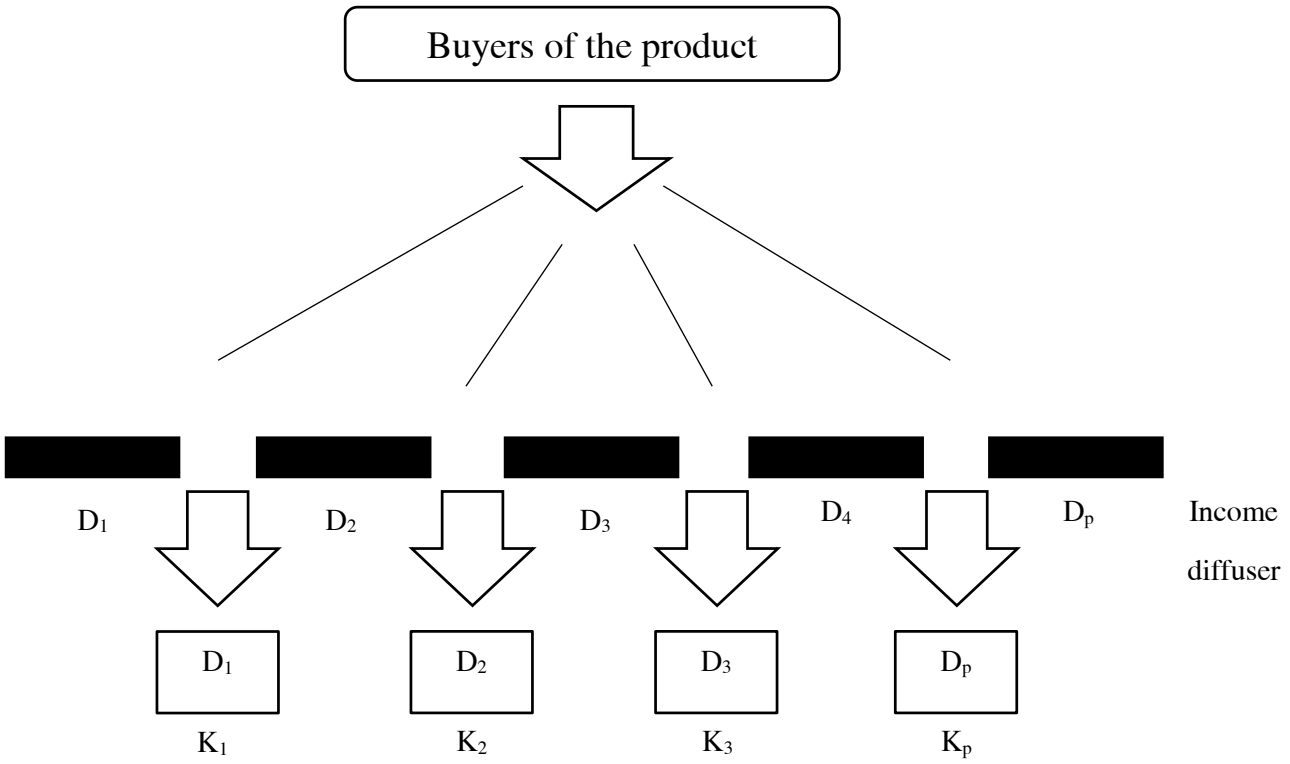

Fig. 2. **Key Components of the SME Market Model**

Source: Compiled by the authors based on [1, 9, 10, 11].

• the aggregate of producers (P) supplying the good (G);

• the set of consumers purchasing the good (G);

• the revenues (R) of producers.

The total monetary flow $K = \sum(K_1 + K_2 + K_3 + ...+ +K_p)$ from consumers to producers stimulates the production of the good over a certain period of time.

At the same time, each *i*-th seller receives the *i*-th share of the financial flow K_i, depending on the difference between its own revenues $R_{i)}$ and those of competitors. As a consequence of self-organization, after some time the system acquires a temporary competitive–compromise structure with a certain degree of stability.

For example, the aggregate revenues of small enterprises $R = \sum (R_1, R_2, ... R_p)$ operating in a given market may conventionally be represented in the form of an "income membrane" that performs a barrier function in determining the scale of SME actors. Such an income barrier should correspond to the material and financial flows within a particular sphere of economic activity of small enterprises and to the flow (K) within the given market segment, ultimately determining the spatial and structural trajectory. Therefore, the initial monetary flow (K), passing through a certain barrier, is divided into (P) parts and becomes partially ordered, exhibiting a tendency toward stability (*Fig. 2*) [1, 9, 10, 11].

The structural-technological and spatial balance of a competitive SME market should be based on proportional relationships consistent with the harmonic ratio. For this purpose, within the existing set of revenue values of SME entities, two key values are distinguished: the minimum revenue $R_{min} = \sum min (R_1, R_2, ...R_p)$ and the maximum revenue $R_{max} = \sum max (R_1, R_2, ...R_p)$. The entire revenue range $[0, R_{max}]$ is divided

into two parts: the variable component R_{var} = $= (R_{max} — R_{min})$ and the constant component R_{const} = $= (R_{min} — 0)$. The latter is determined by the stable revenue component of the good.

A proportion is constructed in accordance with the principle of harmonic distribution:

$$(R_{const}+R_{var})/R_{const} = R_{const}/R_{var.},$$

where $R_{min}/R_{max} = 0{,}62$.

Such a structural distribution in a real SME market would represent the best possible configuration [1, 9, 10, 11].

For example, the average revenue of an entrepreneur may be compared with the industry-weighted average. In this case, the statistical analysis of sales data for various goods produced by SME organizations can be expressed as:

$$(R_{avr} — R_{min}) / (R_{max} — R_{min}) = 0{,}62.$$

The average revenue per entrepreneur should correspond to its variable component (R_{var}) in the following proportion:

$$R_{min}/R_{max} = (R_{avg} — R_{min}) / (R_{max} — R_{min}) = 0{,}62,$$

which constitutes a necessary condition for a sustainable and balanced structure of the SME market.

A substantial deviation of these variables from the optimal value of 0.62 would indicate instability, leading to an increase in entropy and, consequently, excessive expenditures of all types of resources. Minor deviations, in turn, may be corrected through appropriate regulatory and managerial interventions.

If self-organization of the SME market proves impossible, and the system fails to achieve stability or satisfy the conditions of balance, its subsequent behavior becomes unpredictable and weakly controllable. Preventing such situations requires an understanding of the inherent properties, regularities, and governing parameters of SMEs [14, 15].

FINDINGS AND RECOMMENDATIONS

As practice demonstrates, at present the achievement of sustainability for an economic entity is often pursued through a single and rather rudimentary method — namely, the expansion of financial resources. However, when asset volumes become excessively large, difficulties arise in maintaining them, while the entropic component and associated costs continuously increase. Existing management practices cease to remain effective, creating a demand for organizational and managerial innovations. Such innovations should be grounded in the principles of optimizing governance systems and balancing the structure of ESES in accordance with the golden ratio. In order to ensure a sustainable and qualitatively new development trajectory for SMEs, it is advisable not only to impose order on assets, but also to cultivate cultural, scientific, and intellectual potentials that reduce system entropy and contribute to increased managerial effectiveness [1, 14, 16].

The foundation of the modernization process is innovative potential, understood as the inherent capacity of an entity to generate and adopt innovations, realized under the availability of resources and appropriate conditions.

With regard to SMEs, it should be noted that morally and physically obsolete production assets, as well as unqualified and unmotivated labour resources, regardless of their structure, cannot contribute to the manifestation of innovative potential within an organization or to the establishment of harmonic proportions [2, 17].

In light of the above, SME innovation development policy should adopt a multi-dimensional perspective, proceeding from an understanding of entrepreneurship as a subsystem of the national ESES, rather than focusing on isolated solutions to particular problems of the structural and technological development of SME entities. These entities are constantly engaged in dynamic interaction, generating local and systemic transformations that should ultimately lead to balance, sustainability, and qualitative change in response to the demands of innovation-driven progress and contemporary challenges [2, 14].

Achieving the strategic objective of transitioning from the quantitative growth of SMEs to the

qualitative development of the economy is possible through the following measures:

- periodic monitoring of the dynamics of the key parameters of the SME system and assessing their compliance with the harmonic approach (structure). For systemic characteristics, phenomena, and processes, the point of equilibrium is represented by the proportional ratio of 62:38. This approach should be applied in the allocation of SME resources, the selection of areas and instruments of managerial intervention, the maintenance of structural stability, and the formation of innovative potential. This process should be carried out using technologies of economic and mathematical modeling, digital solutions, and artificial intelligence tools [18, 19];
- the implementation of a multi-dimensional management framework, in which the direction and intensity of managerial influence aimed at ensuring effectiveness are based on an understanding of the inherent properties of SMEs at each specific moment and on consideration of their spatial and temporal position;
- the cultivation of innovative actions by SME entities and their structural-functional interaction across all hierarchical levels, which will undoubtedly contribute to organizational integrity and to the creation of the potential for transition into the sphere of large-scale business.

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G.A. Timoshenko — development of calculation schemes and analysis of theoretical provisions on the research topic.

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Transformation of Approaches to Determining the Complexity of Fire Response Actions

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ABSTRACT

In most countries of the world, financial metrics are used predominantly to assess the complexity of firefighting and rescue operations. Nowadays, experts are trying to develop a new evaluation system. **The objective** of this research is to explore one of such approaches. **The findings** may prove valuable to managers at all levels, experts in business development and public administration, as well as scientific researchers.

Keywords: fire; fire safety; management; tactics; resources; fire departments

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INTRODUCTION

Theoretical considerations lead to the conclusion that the complexity of a fire is determined by the material losses incurred as a result of the ignition and its subsequent suppression. This approach was developed consistently over the course of nearly a century and was applied initially in the USSR and, after 1992, in the Russian Federation. In the 1990s, following the shift in economic policy from a centrally planned to a market-based model, repeated attempts were made in Russia to transfer certain state functions in the field of fire safety to public and private organisations. For example, fire supervision systems were established within insurance structures and similar institutional arrangements were introduced. At present, however, there remains an objective necessity for state regulation in this area.

By the late 2010s, a rather paradoxical situation had emerged in Russia: for many property owners, it became more convenient not to report the true extent of material losses caused by fires and, in some cases, even to indicate zero damage. This has resulted in the ineffectiveness of the existing system for assessing the tactical complexity of fires and, consequently, in the inability to ensure full-scale management of fire suppression activities.

The maintenance of fire protection services imposes a considerable burden on the state budget. In Russia, the fire safety system operates under continuously increasing requirements for effectiveness and under tightening conditions related to resource provision. To justify the necessary level of such resources, two methods are typically employed. The first involves comparing the fire situation under a hypothetical scenario of a complete absence of fire protection in the country with the actual state of affairs in this sphere[1]. The second relies on assessing the dynamics of key indicators — such as the number of fires, the number of casualties, the magnitude of damage, and others — relative to a baseline level.

The first method provides the most objective results; however, it is rather difficult to apply in practice. The second is considerably simpler, yet it may lead to what can be termed a "stability trap," whereby prolonged successful performance contributes to the formation of a steady trend of improving reported fire-related indicators and, consequently, creates formal grounds for reducing resource allocation. If the number of fires declines, it is then assumed that expenditures on fire safety should likewise be reduced.

The fire safety system comprises two major directions: the implementation of preventive measures and the suppression of fires by operational response units (the latter hereafter denoted as S_2[2]). The present study examines approaches to evaluating S_2 in order to identify prospective development trends and to substantiate the scale of the required resource provision.

DEVELOPMENT OF A SYSTEM FOR ASSESSING FIRE SCALE AND COMPLEXITY DURING SUPPRESSION OPERATIONS

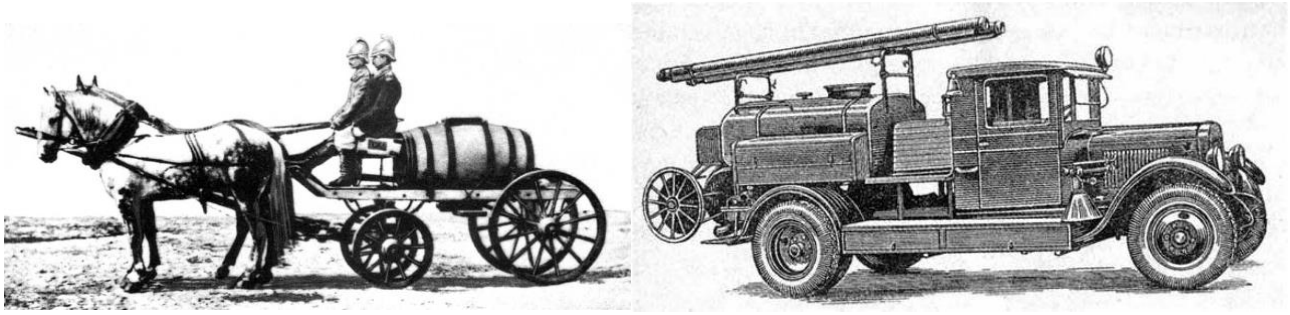
The development of combustion can occur extremely rapidly, as reflected in the proverb "all Moscow was burnt down by a farthing dip[3]." While it is easy to extinguish the flame of a "farthing dip", as the size of the burning area increases, the amount of resources required to combat a fire grows exponentially. For example, in the eighteenth century, the capacity of fire units was generally sufficient only to eliminate an ignition within a single household. As the fire continued to spread, it typically expanded across the city, and its suppression required the collective efforts of the entire community.

The earliest evidence of organised firefighting teams dates back to the emergence of large cities in the fourth century BCE in Ancient China

[1] Brushlinsky N. N. System Analysis of the Activities of the State Fire Service. Textbook. Moscow: MIPB of the Ministry of Internal Affairs of Russia; 1998. 255 p.

[2] A similar approach is applied in the United States, the European Union, and a number of other countries: fire protection is commonly divided into Passive Fire Protection (PFP) and Active Fire Protection (AFP) and is regulated accordingly by the standards NFPA 3 and NFPA 10.

[3] According to legend, in 1737 the Trinity Fire in Moscow began from a candle (a farthing dip) placed before an icon in the house of the merchant A. Miloslavsky on Znamenka Street



a *b*

Fig. 1. **Fire Transport: a) Horse-drawn Fire Truck, XIX Century; b) Fire Tanker Truck PMZ-2 Model 1935**

Source: Bezborod'ko M., Aleshkov M. [1].

and the Roman Empire[4]. For a long period, nearly all S_2 operations were carried out using manual labour, while fire personnel and equipment were transported by horse-drawn convoys (*Fig. 1a*). The invention of the steam engine in the eighteenth century had a positive impact on S_2 activities; however, overall, the situation remained largely unchanged.

Since the beginning of the twentieth century, horse-drawn convoys in the fire services of Russia and other countries were gradually replaced by motor vehicles. In 1935, the Miussky Plant began the serial production of PMZ-2 fire tanker trucks (*Fig. 1b*), which can be regarded as the starting point of a qualitative re-equipment of the domestic fire service [1]. This modernization enabled firefighting units to operate more independently, without the need to involve military formations, local populations, or other auxiliary forces. However, the downside was a substantial increase in budgetary expenditures required to maintain the fire protection system. From approximately this period onward, both in Russia and abroad, an active search began for opportunities to reduce the costs of the fire safety system and to enhance the economic efficiency of its operations, for which it was decided to rely on financial indicators.

In 1950, the term "large fire[5]" was officially introduced in the USSR. The principal criterion for its definition was the magnitude of damage, which made it possible to identify promising directions for the development of firefighting services based on experience gained from the most tactically complex incidents. Up until the 2010s, this method was actively refined, and a relationship was established between the scale and tactical complexity of fires and the amount of damage they caused. A similar approach is used in the United States, European countries, and other states with well-developed insurance systems [2].

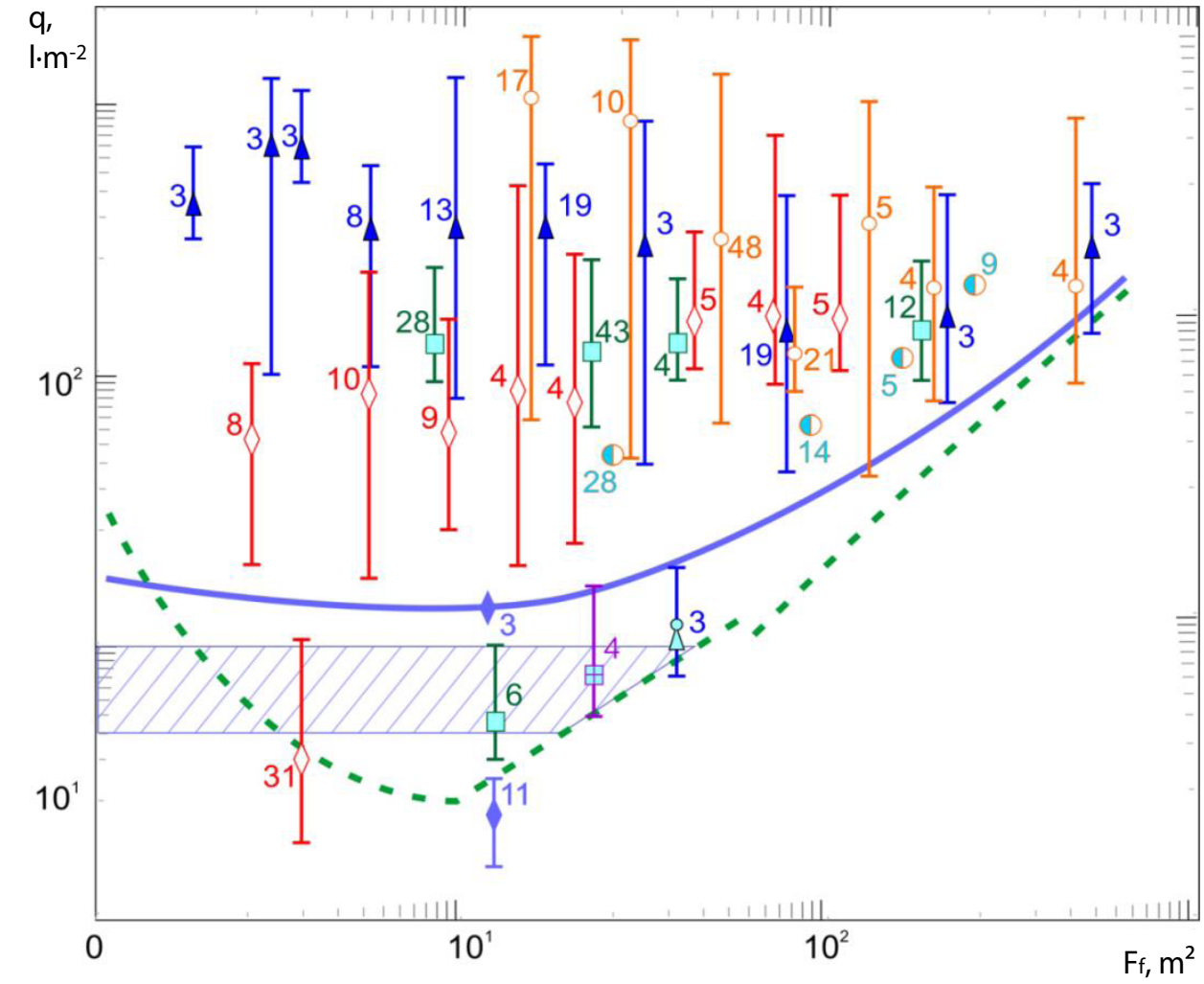
However, in 2017, the officially reported damage from a fire at the "Sindika" shopping centre in Moscow — an incident that required nearly two days of suppression efforts by all fire brigades of Moscow and the Moscow region — was declared by the property owner to be zero rubles. This was far from the first, nor the last, such case. At present, property owners are legally entitled to assess their own losses. While this may offer certain advantages for them, for the fire service it undermines the foundations of a system of fire-scale assessment that had been built over decades. In 2020, this methodology was officially abolished[6].

[4] Abramov V.A., Glukhovenko Yu.M., Smetanin V.F. History of Fire Protection. A Short Course: Textbook. Part 1. Abramov V.A., ed. Moscow: Academy of the State Fire Service of EMERCOM of Russia; 2005. 285 p.

[5] Instruction on the Investigation of Fires. Moscow: Fire Protection Directorate of the Ministry of Internal Affairs of the USSR; 1950. 13 p.

[6] Letter of the Ministry of the Russian Federation for Civil Defence, Emergencies and Disaster Relief (EMERCOM of Russia) dated 23 December 2020 No. M–ID-28. URL: https://normativ.kontur.ru/document?moduleId=8&documentId=380058

Currently, specialists in the fire safety system are seeking alternative indicators and methods for determining fire complexity. The following section considers several approaches to evaluating S_2 activities.



— data from Suchkov A.A., Kolbasin P.A.
— data from Solzberg, Vodraka Maatman
— data from Yavorsky G.A.
Real fires:
— Lobes data
— data from Kiev
— data from Vietnam for 1975–1980 and 1981–1983
— data on Poland
The given figures indicate the number of fires.

Fig. 2. **The Actual Unit Water Consumption for Extinguishing Fires in Residential Buildings at F_f< 50 m², l·m⁻²**

Source: Rodionov E.G. [6].

Notes: where Fp denotes the fire area (m²), and lg(q) indicates that the parameter q is expressed on a logarithmic scale. The dashed line in Figure 2 represents a piecewise linear approximation of this relationship [#].

INDICATOR FOR ASSESSING THE VOLUME OF WORK PERFORMED DURING FIRE SUPPRESSION

At present, as in the past, virtually all fires are extinguished using water [3]. When planning the construction of residential areas and industrial facilities, the capability to ensure the required water flow rate for firefighting purposes (Q_{tr}) is always taken into account.

The earliest attempts to develop quantitative methods for determining Q date back to the 1970s [4]. However, due to the difficulty of providing a rigorous analytical description of the suppression process, this problem was addressed through the synthesis of extensive data from real and experimental fires (*Figure 2*). I.M. Abduragimov and a number of other researchers derived a relationship for the minimum values of specific water consumption (q, L·m^{-2}) required to extinguish solid combustible materials in residential buildings with an area not exceeding 50 m² (1):

$$\lg(q) = 1{,}1 \cdot \lg(F_S) - 0{,}302, \qquad (1)$$

where F_s — denotes the fire area (m²); lg(q) indicates that the parameter q is expressed on a logarithmic scale.

The dashed line in *Figure 2* represents a piecewise linear approximation of this relationship [5] $q = f(F_S)$.

The solid line corresponds to $q = 36F_S^{-0{,}157} + 0{,}5F_S$.

By the mid-1980s, in the USSR and in most countries worldwide, methods and mathematical relationships based on population size were used to determine Q values for urban areas [6]. For comparison, the numerical values of Q were converted into the International System of Units (SI7)[1] and are presented as analytical relationships in the diagram (*Figure 3*).

Let us examine it in greater detail.

- Line 1 reflects the calculations of the American civil engineer and hydraulics specialist J.R. Freeman (1869–1930) (Model 1):

$$Q = 3{,}79N + 189{,}42,$$

[7] The United States currently uses the British Imperial system of measurement for physical quantities.

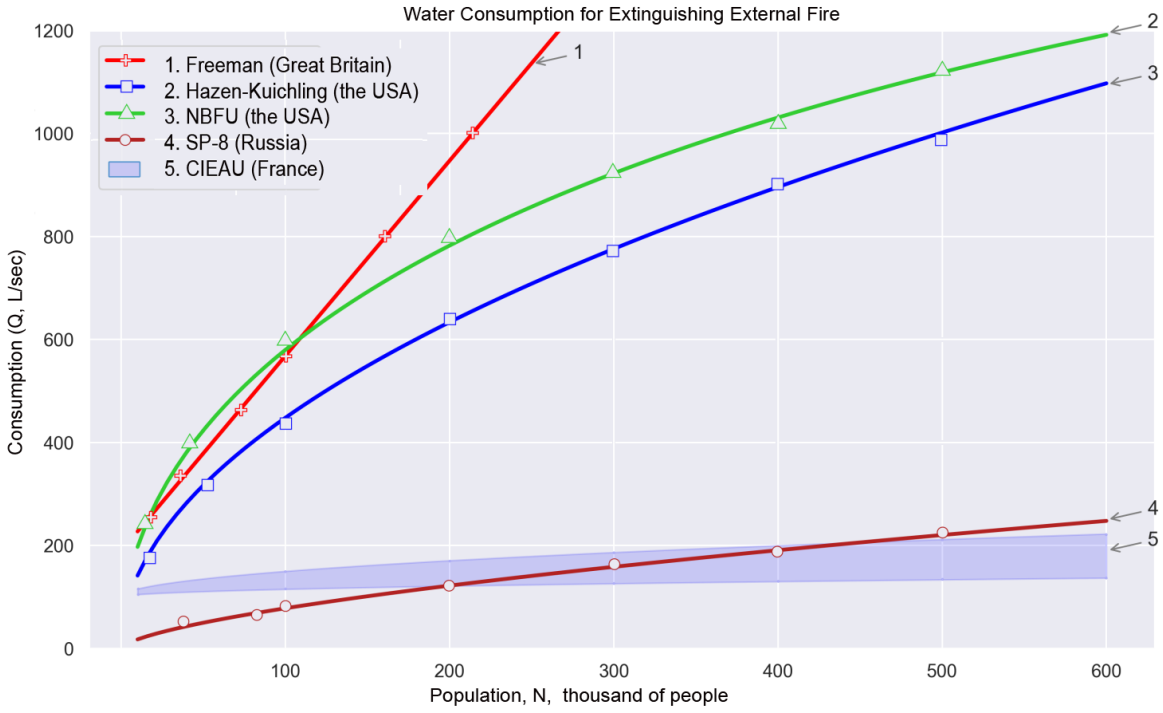


Fig. 3. **Water Consumption (*Q*, L/sec) for Extinguishing External Fire Depending on the City Population**

Source: Compiled by the author.

where N — denotes the city population (persons);

• Curve 2 corresponds to the model proposed by the British hydraulic engineer E. Kuichling (1848–1914) (Model 2):

$$Q = 44,8\sqrt{N};$$

• Curve 3 represents the model of the National Board of Fire Underwriters (NBFU) of the United States (Model 3):

$$Q = 64,35\sqrt{N} - 0,64N;$$

• Curve 4 is constructed in accordance with SP-8 (Russia) (Model 4) [8]:

$$Q = 4,02N^{0,64};$$

• Curve 5 follows the French methodology (Model 5):

$$Q = 100 + c\sqrt{N},$$

where c is an importance coefficient of the object (c = 1,5 … 5).

The substantially higher values of Q in Models 1, 2, and 3 compared with the others can be explained by fundamentally different tactical approaches to S_2 across countries. In the United States, the United Kingdom, and a number of other states, suppression is predominantly carried out using high-capacity water nozzles operated from outside the building. By contrast, the Russian approach requires nozzle operators to select positions in close proximity to the fire seat [7].

Let us assume that there exists a statistical relationship between the indicator of the volume and complexity of work performed during S_2 and the amount of water consumed in the process (ΣQ). In this case, for the purposes of S_2, the value of Q may be adopted as a baseline evaluative indicator on the basis of which the operations of fire and rescue units within the firefighting garrison may be planned. Consequently, as the complexity and volume of work performed at a fire increase, the value of Q should grow proportionally.

On the other hand, a poorly trained unit will likely expend more water when extinguishing a similar fire than a more experienced one. Formally, this may give the impression that the former unit has performed a more complex task. A similar situation is discussed by Karl Marx: "If the value of a commodity is determined by the quantity of labour expended in its production, it might appear that the value of a commodity increases the lazier or less skilled the worker is, since more time is required to produce it" [8, p. 36]. Marx further demonstrates that the appropriate solution lies in the use of average indicators: "Each individual commodity counts here only as an average specimen of its kind" [8].

Approaches to defining the indicator "Volume of operational work performed during fire suppression" have been developed over the years by specialists in fire-technical scientific and educational institutions. Among them, V.M. Gavriley examined labour costs during fire response operations[9] [9]; V.M. Panarin applied differential calculus to model firefighting unit activity [10]; A.V. Terebnev proposed micro-element planning of fire and rescue unit actions [11]; N.N. Brushlinsky analysed workload indicators of operational firefighting units [12], among others. Building on the contributions of these researchers, the author of the present article proposes an approach based on the quantitative assessment of labour input and produced output, where the output is represented by the indicator ΣQ. It is assumed that the workload level of fire and rescue units correlates with the value of Q.

The selection of ΣQ is determined by the following considerations:

• approximately 99% of fires in the Russian Federation are extinguished using water or aqueous solutions [3];

[8] SP 8.13130.2020 — Code of Practice "Fire Protection Systems. External Fire Water Supply. Fire Safety Requirements." URL: https://acs-nnov.ru/assets/files/sp_8.13130.2020_sistemy_protivopozharnoj_zashhity._naruzhnoe_protivopozharnoe_vodosnabzhenie._trebovaniya…_tekst.pdf

[9] Conduct Research and Develop Recommendations for Determining the Required Staffing Levels of Fire Protection and Improving Fire Prevention Activities at Nuclear Power Plants. Research Report / All-Union Research Institute for Fire Protection of the Ministry of Internal Affairs of the USSR (VNIIPO MVD USSR). Moscow; 1986. 188 p.

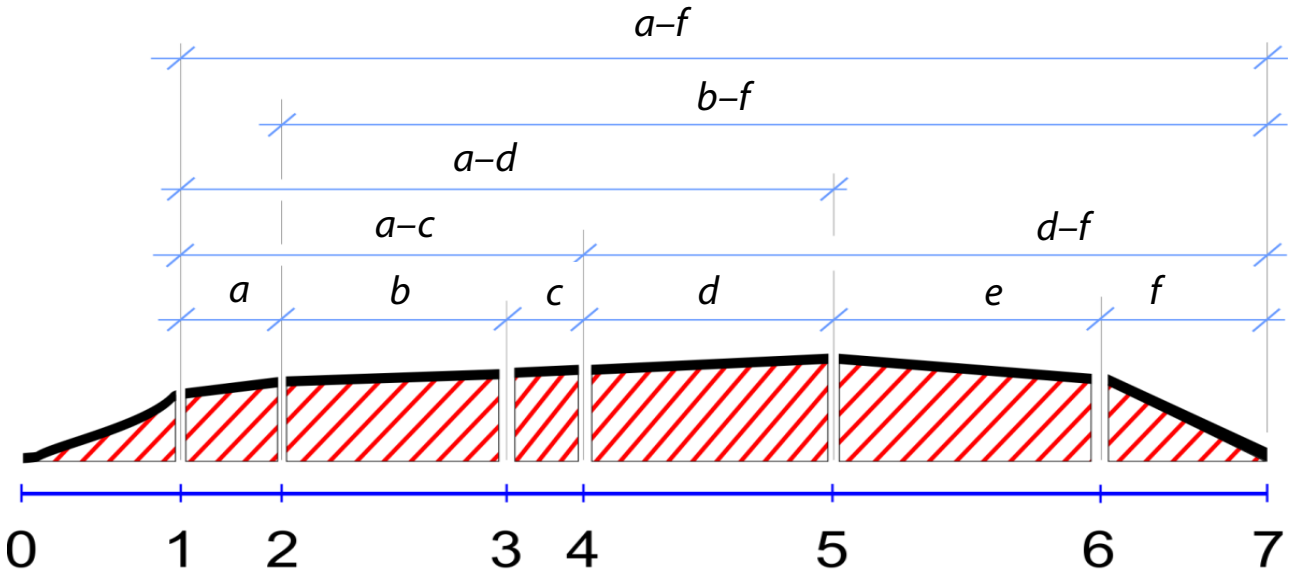


Fig. 4. **Fire Development Intervals**

Source: Compiled by the author.

Notes: 1) 0 — occurrence; 1 — detection; 2 — message; 3 — arrival; 4 — supply of the 1st trunk for extinguishing; 5 — localization; 6 — liquidation; 7 —elimination of consequences.
2) Intervals: a —message; b — follow; c — supply of the 1st barrel; d — localization; e —elimination of open combustion; f — elimination of consequences; a–c —free burning; d–f — fire extinguishing; a–d — concentration; b–f — time of employment on fire; a–f — call service.

• the "FBD-Fires[10]" database contains factors that allow ΣQ to be determined with a high degree of reliability, including parameters describing time intervals — $\tau_{a\text{-}d}$, $\tau_{d\text{-}f}$ (*Figure 4*), the number and types of water delivery devices used, the number of fire engines, and the duration of smoke-diving service deployment;

• reference data are available regarding the performance capacity of water delivery devices (q_{stv}, L/s) employed by fire and rescue units[11] [13].

Let us consider the empirical relationship (2):

$$Q = f\left(3,7N_{\text{stvB}} + 7,4N_{\text{stvA}} + 21N_{\text{LF}} + 5,64N_{\text{GPS}}\right), \quad (2)$$

where N denotes the number of nozzles of the respective types (RS-50, RS-70, monitor nozzles) and foam generators (respectively), expressed in units; f presents various functions[12] applied depending on the specific task.

This approach makes it possible, *first*, to determine ΣQ for routine (day-to-day) S_2 operations in response to ordinary fires occurring within the territory of the fire and rescue garrison; and *second*, to assess the required reserve of forces and resources available for the rapid operational scaling-up of Q when suppressing large-scale fires.

SIMULTANEOUS FIRES

A distinctive feature of fires is the possibility of their simultaneous occurrence in different locations within the territory of a single city. In such cases, one of the most challenging tasks for fire and rescue units becomes the organisation of S_2 activities and the rational allocation of the fire and rescue group resources, while the degree of operational complexity increases as the scale of the incident grows.

Simultaneous fires are defined as those whose time intervals ($\tau_{a\text{–}f}$) overlap. Prior to the early 1970s,

[10] Federal database for storing data on fires registered in the territory of the Russian Federation. Maintained by the Ministry of the Russian Federation for Civil Defence, Emergencies and Disaster Relief (EMERCOM of Russia).

[11] Melnik A. A., Martinovich N. V., Kalyuzhina Zh.S., Malyutin O.S. Handbook for a Fire Station Watch Commander. Krasnoyarsk: Siberian Fire and Rescue Academy of the State Fire Service of EMERCOM of Russia; 2019. 176 p.

[12] Vlasov, K. S. Applied Methods for Studying the Operational Activities of Fire and Rescue Units: Problems and Solutions: A Study Guide. Moscow: VNIIPO, 2023. 406 p.

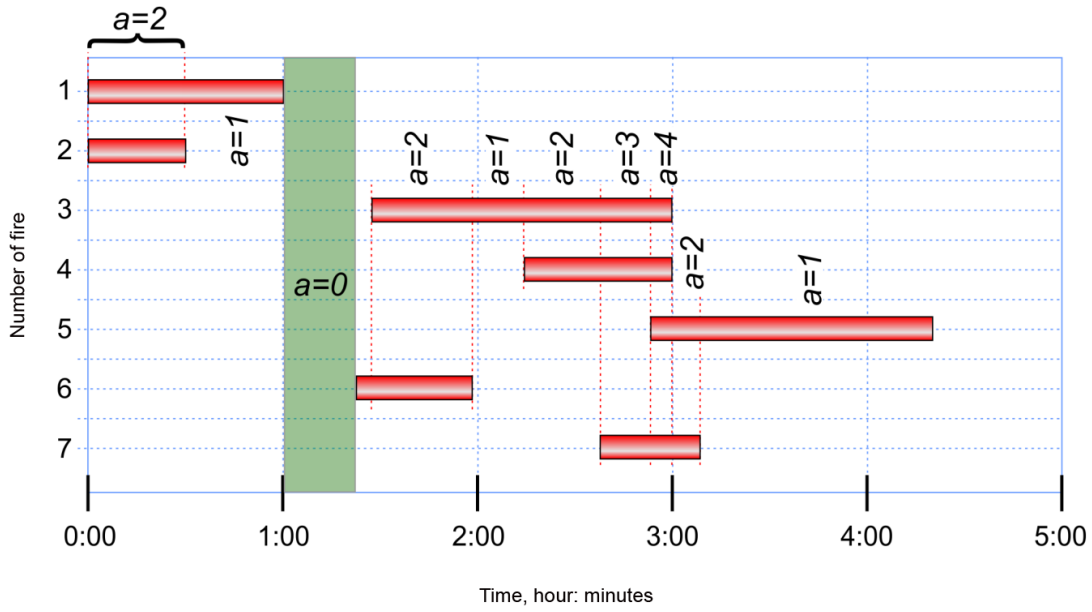


Fig. 5. **Gantt Chart**

Source: Compiled by the author.

Note: according to the approach of N.A. Tarasov-Agalakov, all fires indicated on the diagram are considered simultaneous; simultaneous fires from the point of view of N.N. Brushlinsky are those with the intervals "a>0".

in Russia all fires occurring within the same settlement during three consecutive hours were considered simultaneous, regardless of their scale or duration. This approach was substantiated by the scholar and organiser of advanced professional training for fire protection personnel, N.A. Tarasov-Agalakov [14]. One of his arguments was the necessity of restoring fire and rescue units to operational readiness (refilling water supplies, replacing used equipment, and so forth), a process requiring approximately three hours. Tarasov-Agalakov assumed, for example, that all cases shown in the diagram (*Fig. 5*) should be regarded as simultaneous, even taking into account the interval indicated by the green band, which represents a fire-free period.

ANALYSIS OF EMPLOYMENT TIME

By the 1970s, another modernisation of firefighting equipment and technology had been carried out, which made it possible to significantly reduce the time required to restore the operational readiness of fire and rescue units. Consequently, the specialist in mathematical modelling of complex systems and applied statistics, N.N. Brushlinsky, examined the activities of fire and rescue units through the lens of probability theory and queuing theory, interpreting them as a class of Markov ergodic stochastic processes in continuous time [15]. Within this framework, only those fires that truly overlapped in time were considered simultaneous — for instance, cases No. 1 and 2 within the interval "a = 2" (see *Fig. 5*). Accordingly, the diagram allows the identification of four segments during which two fires were occurring simultaneously in the city, as well as one segment each with three and four concurrent fires.

In the legislation of many countries, the possibility of simultaneous fires is taken into account. In particular, in the United Kingdom, the staffing and resources of fire services are determined based on the assumption of two simultaneous fires in one city. In the United States, a similar calculation is applied to cities with populations exceeding 200,000 [6].

For the practical identification of simultaneous fires, a minimum interval of one minute was adopted. This choice was based on the following considerations: first, the same interval is used in the "FBD-Fires[13]" database; second, empirical tests have

[13] Order of the Ministry of the Russian Federation for Civil Defence, Emergencies and Disaster Relief No. 714 of 21 November 2008 "On Approval of the Procedure for Recording

Fire	Vector of minutes									
	1	2	3	4	5	6	7	...	7889759	7889760
1	1	1	1	1	0	0	0	...	0	0
2	0	0	1	1	1	1	0	...	0	0
...	...	...	...	...	...	...	...	...	...	...
N	0	0	0	1	1	1	1	...	0	0
Σ	1	1	2	3	2	2	1	...	0	0

Fig. 6. **Gantt Chart for Determining the Employment Rate of Fire Departments**

Source: Compiled by the author.

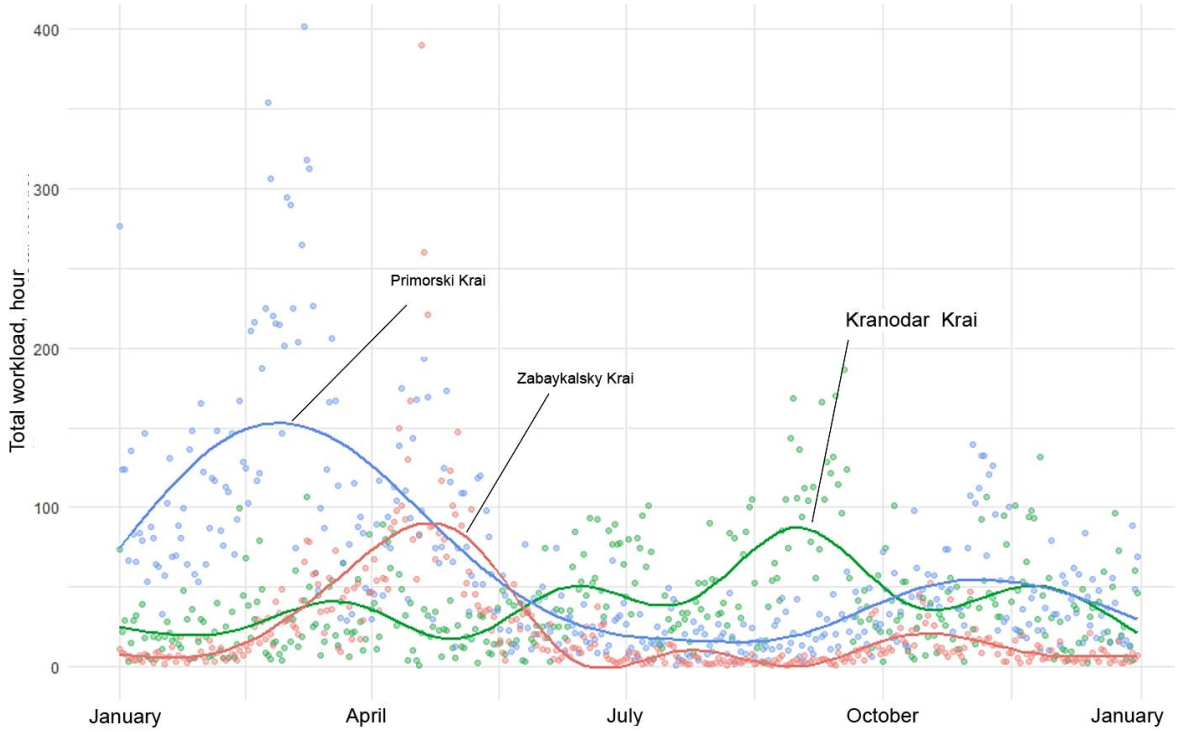


Fig. 7. **Indicators of the Total Daily Employment of Fire and Rescue Units in the Zabaykalsky, Krasnodar and Primorsky Krai (for the year of 2020)**

Source: Compiled by the author.

demonstrated the suitability of this measurement unit for describing the actions of fire and rescue units [16].

Using this method, we construct a row vector

$$x_t = (a_1, .., a_i, ..., a_n),$$

where $a_1 = 0$ corresponds to the beginning of the interval on 01.01.2010 at 00:00, and $a_n = 7{,}889{,}760$ corresponds to its end on 31.12.2024 at 23:59:59. The vector x_t constitutes a discrete stochastic time series with a fixed step of one minute.

Next, for each a_i, it is necessary to determine the number of fires occurring during the i — th minute ($a_i = 0$ if no fires are observed in the i — th minute).

The calculations included only cases satisfying the following conditions (C_3):

- fire and rescue units responded to the call and carried out S_2 operations; for example, if a fire was extinguished before their arrival, the case is not considered a fire event for the units, since no suppression actions were required;
- firefighting devices for delivering extinguishing agents were necessarily used during S_2 (figura-

Fires and Their Consequences." URL: https://mchs.gov.ru/uploads/document/2024–01–22/36a3b2a6333c2aaeaa759acb23a040ea.pdf

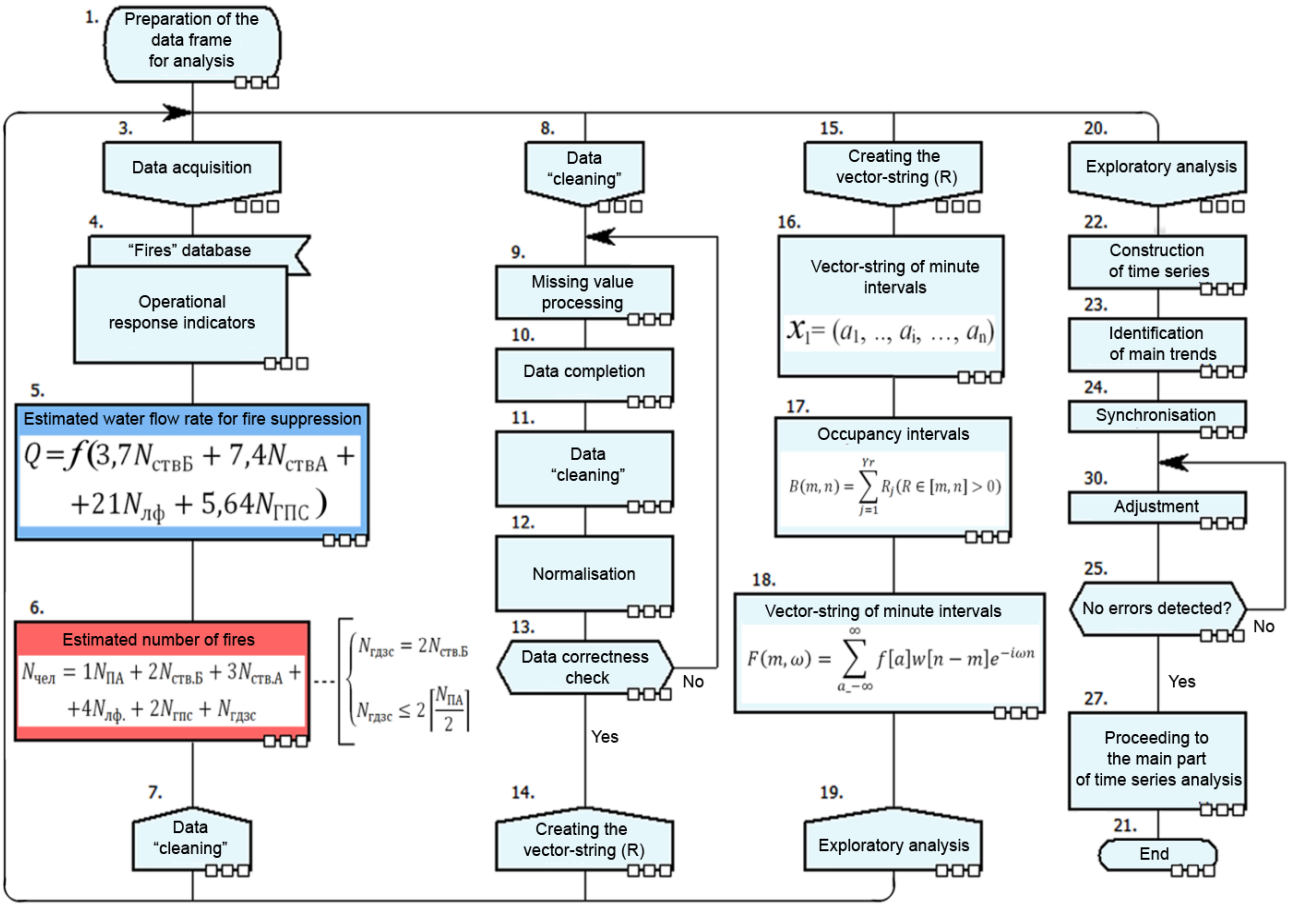


Fig. 8. **The General View of the Data Preparation Algorithm for Time Series Analysis Using Python Tools**

Source: Compiled by the author.

tively speaking, if combustion is eliminated with a single cup of water, it is not classified as a fire);

- the data fields in the fire incident report were completed correctly[14].

ANALYSIS OF OCCUPANCY TIME

By analogy with the calculation of *Q*, it is possible to construct a Gantt chart for x_t and determine aggregate occupancy indicators (Σ) for each minute (*Fig. 6*).

An analysis of the time-occupancy measures of fire and rescue units during fire incidents revealed the presence of certain regularities. This is illustrated by the example of an annual additive workload model for fire and rescue units, both for Russia as a whole and for individual regions in 2020 (*Figure 7*). Similar distributions of these indicators were observed in other years as well (from 2010 to 2024).

Let us consider this situation using the city of Chita in Zabaykalsky Krai as an example. Between 2010 and 2024, a total of 33942 fires occurred in the city that satisfied the conditions of C_3. Applying the method proposed by N.N. Brushlinsky (see *Fig. 5*), we determine the number of simultaneous fires in Chita. Practical calculations and data processing were carried out using the Pandas, NumPy, and Scikit-Learn modules of the Python programming language according to the following procedure (*Fig. 8*).

Over the 15-year period under consideration, more than two thousand simultaneous fires occurred in the city; and on two occasions — in 2014 and 2019 —there were 14 fires whose time intervals partially overlapped. The overlaps were calculated using formula (3):

[14] Ibid. Annex 1.

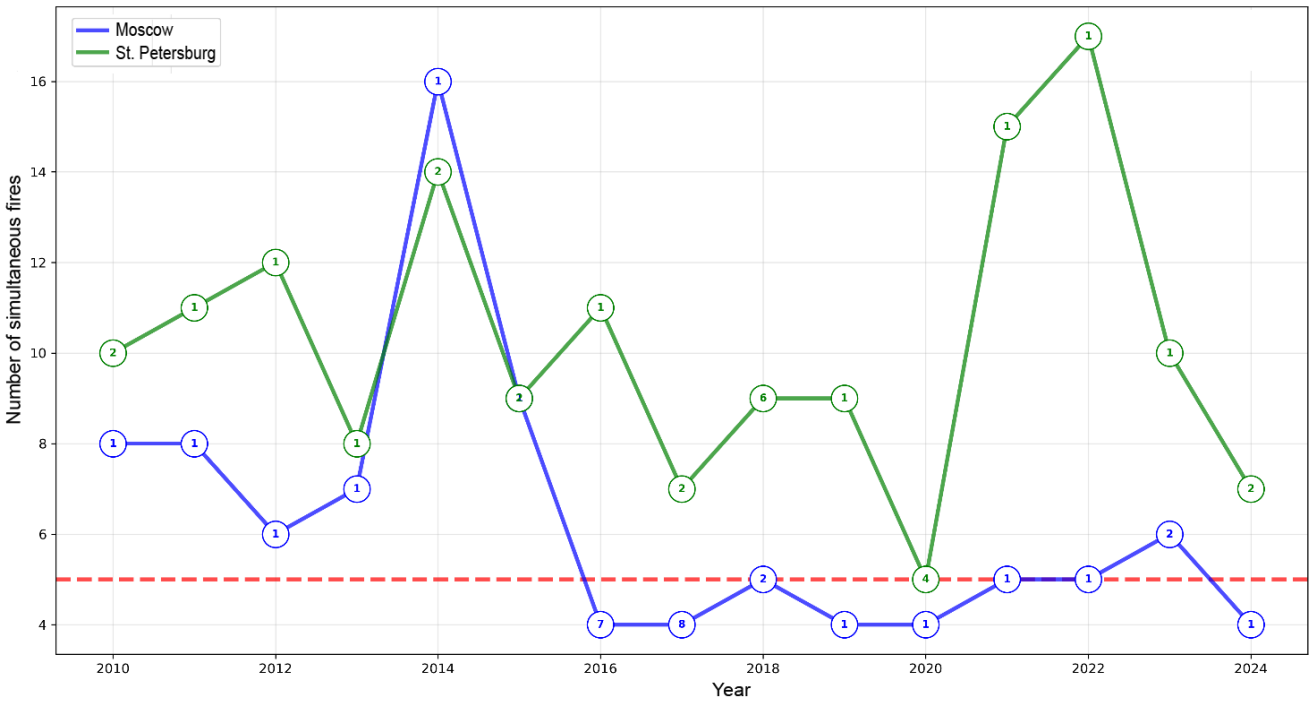


Fig. 9. **Dynamics of the Maximum Amount of Simultaneous Fires in Moscow and St. Petersburg in 2010–2024.**

Source: Compiled by the author.

Note: In the circles on the lines is the maximum number for simultaneous fires per year. The dotted line is the standard value.

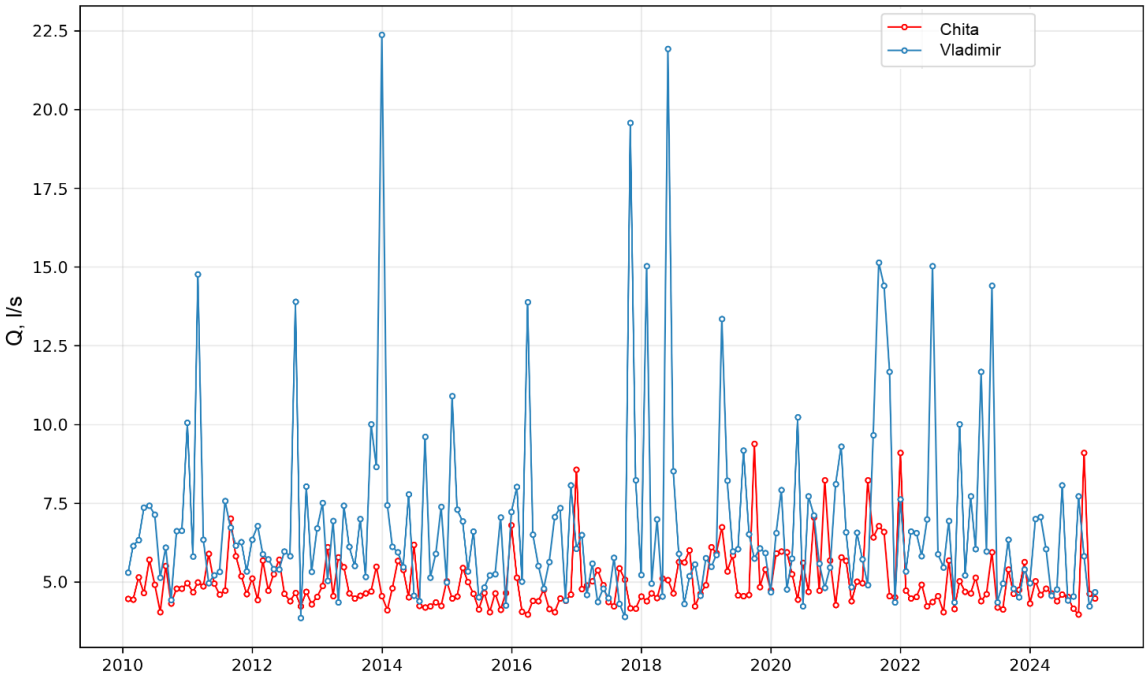


Fig. 10. **Dynamics of Average Water Consumption During Fires in the Cities of Vladimir and Chita by months for the Years of 2010–2024**

Source: Compiled by the author.

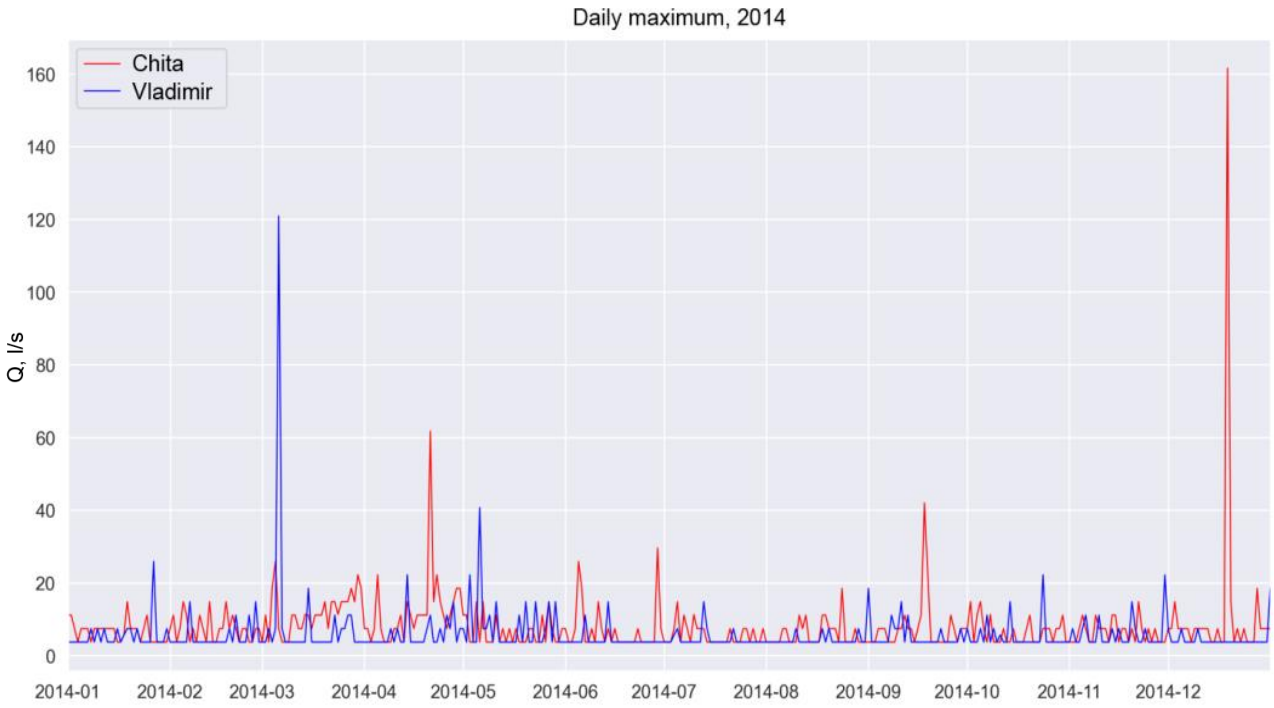


Fig. 11. **Dynamics of Maximum Indicators of Daily Water Consumption During Fires in the Cities of Vladimir and Chita in 2014**

Source: Compiled by the author.

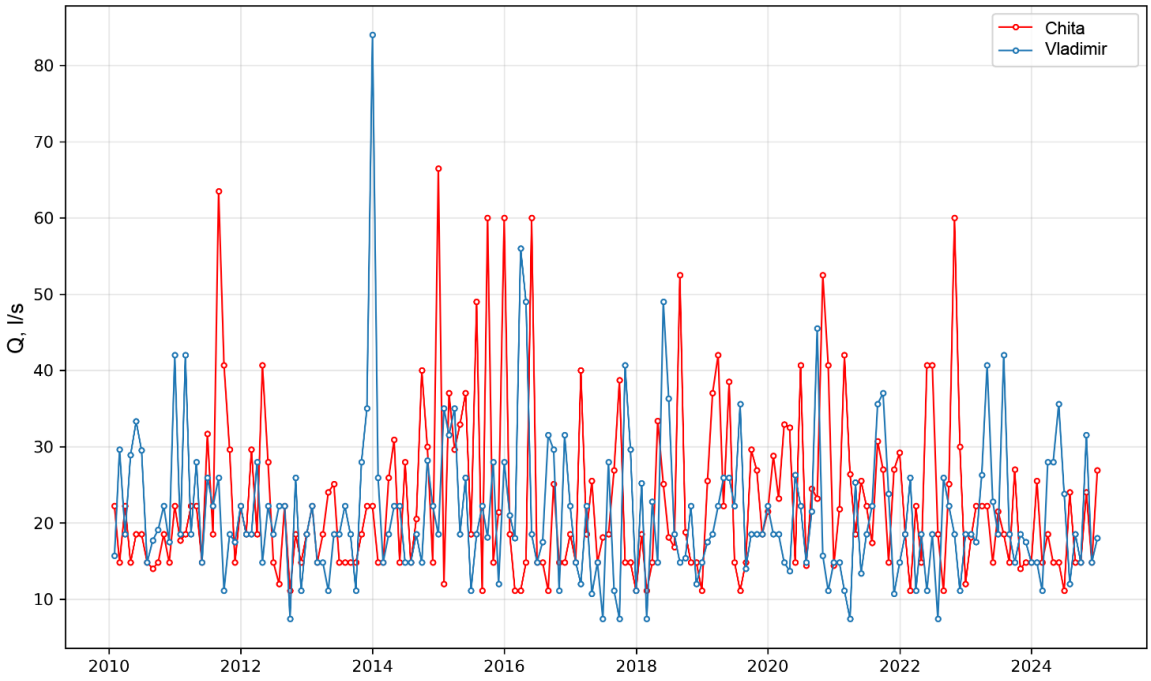


Fig. 12. **Dynamics of Maximum Water Consumption Indicators by Month for Fires in the Cities of Vladimir and Chita in 2010-2024**

Source: Compiled by the author.

$$B(m,n)=\sum_{j=1}^{Yr}R_j\left(R\in[m,n]>0\right), \quad (3)$$

where m and n denote the boundaries of the unit row vector; Yr represents the duration of the interval from 2010 to 2024 measured in minutes; and R_j is a random variable indicating the occurrence of a fire event, provided that R belongs to the interval ($[m, n] > 0$).

In Russia, the number of simultaneous fires constitutes one of the factors used to determine the regulatory value of Q_{tr}, which is required to ensure external fire suppression in urban settlements[15]. For example, in cities with populations exceeding one million, it is calculated on the basis of five simultaneous fires. However, in practice, a different situation is observed (*Figure 9*). For instance, in 2014, a case involving 16 simultaneous fires was recorded in Moscow, whereas in 2016 and 2017 (and on several other occasions) the indicator was below the prescribed standard.

A similar pattern is found in other cities as well.

Let us compare the actual dynamics of the Q indicator from 2010 to 2024 for the cities of Vladimir and Chita. During this period, the population of each city averaged approximately 350,000 residents, while the calculated number of simultaneous fires was three[16]. In Vladimir, a total of 7,964 fires satisfying the C_3 conditions occurred over the 14-year period under consideration, which is significantly fewer than in Chita (33,942).

The average value Q_{avr} is typically applied in long-term planning of fire safety system parameters. As the analysis demonstrates, Q_{avr} is strongly influenced by factors associated with the large number of ordinary fires, the share of which reaches up to 99%.

The distributions of the Q_{avr} indicator (*Fig. 10*) for Vladimir and Chita differ markedly, despite the nearly identical population size of the two cities. This observation, for the period from 2010 to 2024, refutes the existing hypothesis of a correlation between population size and the factors characterising the state of the fire safety system [15] (see *Fig. 3*).

In addition to simultaneous fires, real-life conditions may also involve phenomena referred to as large-scale fires. Their suppression requires the deployment of fire and rescue group resources at the maximum level. The diagram (*Fig. 11*) shows sharp spikes in Q for Chita and Vladimir. Coincidentally, both events occurred in 2014: in Vladimir, a major fire broke out on 3 May at the warehouse of the Globus hypermarket, while in Chita, a large fire occurred on 18 December at the "Vysokogorye" sports and recreation complex.

In both cases, the time series contain so-called "gaps," that is, days when no fires were recorded in the city or only minor ignitions occurred that did not satisfy the $У_3$ conditions.

FORECASTING WATER CONSUMPTION FOR FIRE SUPPRESSION

In forecasting-related tasks, evaluation of results is usually based on measures of central tendency (mean, median, etc.). The primary purpose of such methods, originally developed to address commercial objectives, is to increase profitability indicators. In the case of fires, however, this approach is not entirely appropriate, since a fire is a destructive event whose occurrence is highly undesirable. The application of such tools in the field of fire safety would require certain adjustments, because the main objective of fire and rescue units is to reduce damage and other economic losses.

As is well known, historical information gradually loses its influence on predicted outcomes over time. Therefore, in order to construct a reliable forecast for the next two to three years, it is advisable to consider data from approximately the last five to six years. Information obtained from earlier periods is needed to assess the overall dynamics of the process as a whole [17]. With regard to the activities of fire and rescue groups, planning can be understood as a practical activity aimed at de-

[15] Set of Rules SP 8.13130.2020 "Fire Protection Systems. External Firefighting Water Supply. Fire Safety Requirements "URL: https://acs-nnov.ru/assets/files/sp_8.13130.2020_sistemy_protivopozharnoj_zashhity._naruzhnoe_protivopozharnoe_vodosnabzhenie._trebovaniya..._tekst.pdf

[16] Ibid.

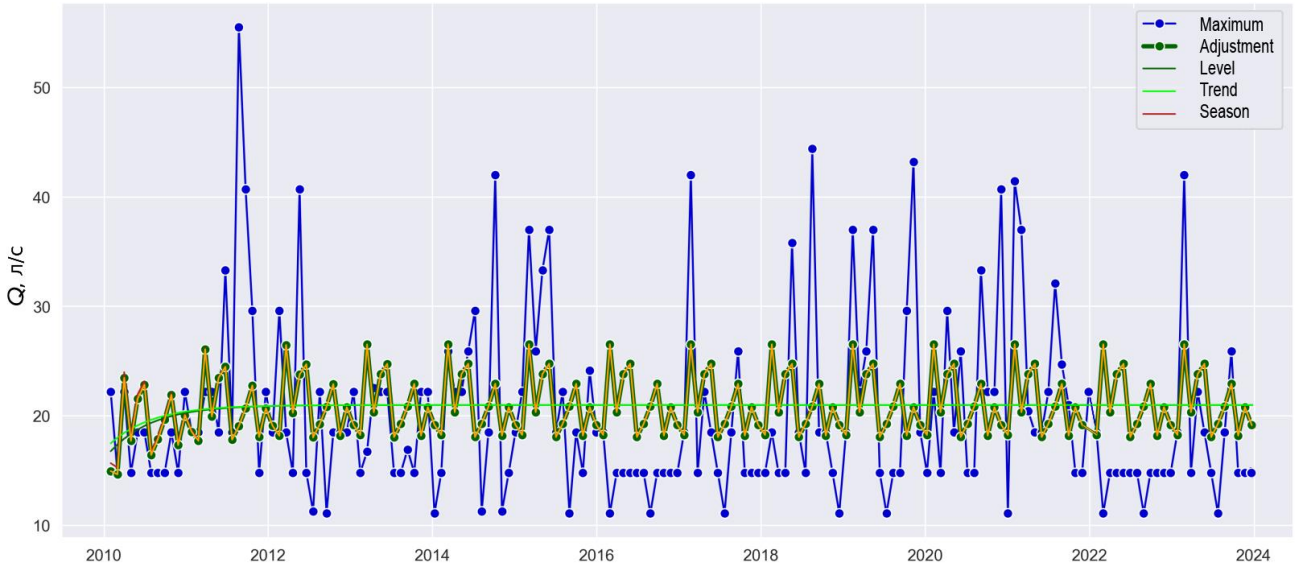


Fig. 13. **Calculated Indicators of Water Consumption for Fire Fighting in Chita**

Source: Compiled by the author.

veloping a strategy for the development of the fire garrison[17] [13].

Above (see the section "Indicator for Evaluating the Completed Volume of Fireground Work"), it was proposed to adopt the indicator Q_{tr} for planning the activities of fire and rescue groups with respect to task S_2, since it objectively reflects the use of the main material resource — water — and, in general, the volume of work performed by fire and rescue units during a fire.

A sufficiently comprehensive set of information on fires in the Russian Federation is contained in the Federal Fire Database "Fires." Although this database does not record the value of Q, it can be approximately determined using formula (2), based on the number of devices employed at a fire to deliver extinguishing agents.

The diagrams of maximum values Q_{max} for Vladimir and Chita (*Fig. 12*) may be regarded as representations of random time series $Q(t)$. In that case, in order to assess their current changes and forecast future transformations, the additive model equation (4) can be applied:

$$Q(t) = s_t + b_t + S_t + \varepsilon, \quad (4)$$

where s_t denotes the level of the time series, b_t is the overall trend component, S_t represents the seasonal component, and ε is Gaussian noise.

After preliminary data processing according to the algorithm (see *Fig. 8*), an exponential smoothing procedure is applied. As a result of the calculations, the values of Q were determined using Chita as an example (*Fig. 13*).

Aggregate indicators for Chita and several other Russian cities with populations ranging from 300,000 to 400,000 residents are presented in the *Table*.

Positive values of b_t (4) over the 2018–2021 interval indicate the need for a consistent increase in Q in Vladimir, Arkhangelsk, and Kurgan, whereas in the remaining cities there are prerequisites for a reduction of this indicator.

Using calculations based on the methodology applied in the USSR [6], in the 1980s a standard value of Q_{norm} = 70 L/s was established for all cities with populations ranging from 300,000 to 400,000 residents. This value is still reflected in current regulatory documents[18] and, as can be

[17] Baille S., Philippe R., Braudel. F. Le Monde actuel histoire et civilisation.. Livre scolaire: histoire / géographie. Belin: 1963.

[18] Set of Rules SP 8.13130.2020. Fire Protection Systems. External Fire Water Supply. Fire Safety Requirements. URL: https://acs-nnov.ru/assets/files/sp_8.13130.2020_sistemy_protivopozharnoj_zashhity._naruzhnoe_protivopozharnoe_vodosnabzhenie._trebovaniya..._tekst.pdf

Table

Recommended Calculated Water Consumption Rates for Fire Extinguishing (Q, l×s^{-1}) for Some Cities of the Russian Federation with a Population of 300–400 Thousand People

Month	City					
	Chita	Vladimir	Arkhangelsk*	Belgorod	Kaluga	Kurgan
January	18.3	19.4	34.7	8.8	14.1	18.7
February	26.5	12.0	32.8	7.3	13.4	22.2
March	20.3	22.2	32.5	9.2	16.0	23.9
April	23.8	21.2	28.4	11.6	16.7	33.7
May	24.8	22.0	40.0	13.5	13.3	24.0
June	18.1	18.8	41.0	11.0	13.2	25.0
July	19.3	18.5	37.3	8.2	14.7	20.1
August	20.9	17.6	36.9	9.8	12.3	20.8
September	18.2	20.7	24.6	9.7	12.0	17.3
October	20.8	25.1	30.2	10.1	13.3	18.4
November	19.2	15.9	35.1	11.9	11.8	18.8
December	18.3	19.4	34.7	8.8	14.4	18.7
Population in 2024.	333.2	341.6	296.7	321.8	329.7	302.4
Trend, b_t	$-2.57 \cdot 10^{-6}$	$1.50 \cdot 10^{-4}$	$4.32 \cdot 10^{-4}$	$-2.52 \cdot 10^{-4}$	$-1.3 \cdot 10^{-3}$	$3.4 \cdot 10^{-5}$
Q_{max}, l/s	161.6	120.9	142.0	117.7	87.6	147.0

Source: Compiled by the author.

Note: * — The population of Arkhangelsk decreased to less than 300 thousand people after 2022.

seen, substantially exceeds actual observed indicators. For its time, such a standard value of Q_{norm} was justified from a practical perspective. However, under contemporary conditions, discrepancies between real and prescribed values of Q and Q_{norm} can be readily identified for each city using information technologies. In the future, a transition is likely toward a new differentiated system of standardising Q_{tr}, based on the data presented in the *Table*, which may lead to a significant reduction in expenditures on fire water supply in urban settlements.

At the same time, it is important to keep in mind the real threat of large-scale fires, during which the actual value of Q may exceed Q_{norm} by several times. For Vladimir and Chita, once every 10–12 years a fire may occur requiring $Q \approx 160$ L/s in Chita (as in 2014) and $Q \approx 120$ L/s in Vladimir. Therefore, it is necessary to ensure the technical capability for the rapid scaling-up of Q to its maximum values.

Similar calculations were also carried out to determine the actual routine demand of the fire and rescue garrison for firefighting equipment and staffing levels. For clarity, these data can be presented as a range of indicators sorted in ascending order (*Fig. 14*).

The height of the bars in the diagram corresponds to the calculated number of firefighting personnel required to ensure the delivery of the estimated Q value across the 85 regions of the Russian Federation. The highest staffing demand is observed in Altai Krai. In the Khanty-Mansi Autonomous Okrug, there are grounds for

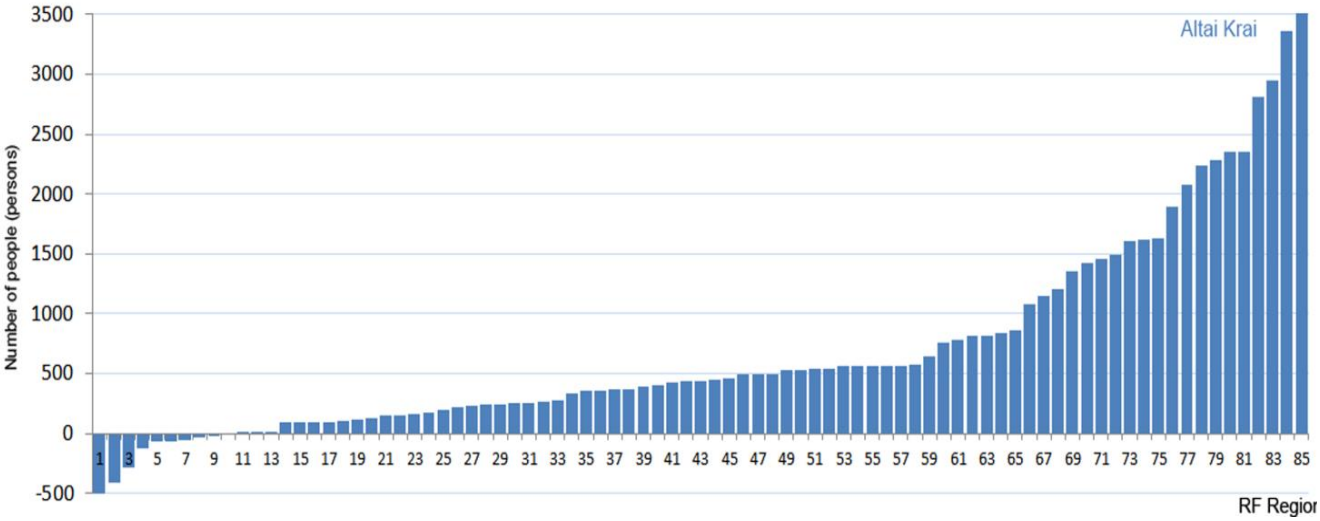


Fig. 14. **Ranges of Changes in the Minimum Number of Fire Departments**

Source: Compiled by the author.

Note: a– The minimum is in the Khanty-Mansiysk Autonomous Okrug, the maximum is in the Altai Territory; b – Federal subjects of the Russian Federation in numerical order:

1. Khanty-Mansi Autonomous Okrug – Yugra
2. Moscow
3. Republic of Tatarstan (Tatarstan)
4. Yaroslavl Oblast
5. Republic of Crimea
6. Lipetsk Oblast
7. Krasnoyarsk Krai
8. Penza Oblast
9. Republic of Ingushetia
10. Ivanovo Oblast
11. Republic of Khakassia
12. Tver Oblast
13. Vladimir Oblast
14. Republic of North Ossetia-Alania
15. Novosibirsk Oblast
16. Kostroma Oblast
17. Altai Republic
18. Khabarovsk Krai
19. Sakhalin Oblast
20. Kaliningrad Oblast
21. Republic of Karelia
22. Nizhny Novgorod Oblast
23. Kamchatka Krai
24. Ulyanovsk Oblast
25. Belgorod Oblast
26. Rostov Oblast
27. Republic of Mordovia
28. Smolensk Oblast
29. Arkhangelsk Region
30. Republic of Buryatia
31. Kursk Region
32. Chuvash Republic - Chuvashia
33. Orenburg Region
34. Vologda Region
35. Republic of Kalmykia
36. Samara Region
37. Kemerovo Region - Kuzbass
38. Primorsky Krai
39. Republic of Tyva
40. Saint Petersburg
41. Jewish Autonomous Region
42. Republic of Adygea (Adygea)
43. Chukotka Autonomous Okrug
44. Irkutsk Region
45. Komi Republic
46. Pskov Region
47. Amur Region
48. Tomsk Region
49. Chechen Republic
50. Kurgan Region
51. Nenets Autonomous Okrug
52. Republic of Sakha (Yakutia)
53. Sverdlovsk Region
54. Bryansk Region
55. Novgorod Region
56. Republic of Dagestan
57. Chelyabinsk Region
58. Voronezh Region
59. Krasnodar Region
60. Oryol Region
61. Karachay-Cherkess Republic
62. Saratov Region
63. Kaluga Region
64. Transbaikal Territory
65. Leningrad Region
66. Omsk Region
67. Stavropol Territory
68. Kirov Region
69. Udmurt Republic
70. Tambov Region
71. Republic of Bashkortostan
72. Murmansk Region
73. Astrakhan Region
74. Sevastopol
75. Mari El Republic
76. Volgograd Region
77. Yamalo-Nenets Autonomous Okrug
78. Magadan Region
79. Perm Region
80. Tyumen Region
81. Kabardino-Balkarian Republic
82. Tula Oblast
83. Moscow Oblast
84. Ryazan Oblast
85. Altai Krai

c – New subjects of the Russian Federation are not considered in the study due to the lack of objective statistical data.

reducing personnel numbers by approximately 500 individuals. However, this applies only to the core operational units performing S_2 tasks. The staffing levels of managerial personnel and units responsible for fire prevention, logistical support, and other functions are determined using a separate methodology.

CONCLUSION

At present, virtually all fires are extinguished using water. Based on the conducted study, the following conclusions can be drawn:

The system for assessing the fire safety framework and, in particular, the activity of operational firefighting units in fire suppression (S_2), which has traditionally been based on the magnitude of associated material losses, has lost its relevance under contemporary conditions. In the proposed model, the baseline indicator is the *water flow rate used for fire suppression* (Q, L/s).

The historically established approach to standardising the required firefighting water demand (Q_{tr}) in cities — based on population size and factors broadly characterising fire hazard in urban development or industrial facilities — is not always justified in present-day circumstances. As demonstrated in the article, the fire situation in Vladimir and Chita, despite their nearly identical population size, differs substantially.

The findings indicate that, given the current level of scientific and technological development, there is a practical possibility to determine the current value of Q_{tr} for each city more accurately and for different time periods.

The calculated values of Q_{tr} are several times lower than those prescribed by existing standards, which, in our view, opens opportunities for modernising the current fire water supply system through technical and organisational redistribution of water provision resources.

The maximum Q_{tr}, most frequently arising during simultaneous and large-scale fires and exceeding the prescribed standard by multiple times, should be treated as a reference level to which Q must be locally and temporarily increased when necessary. During ordinary conditions, it should be maintained at the calculated operational level.

Thus, a new system for organising the activity of operational firefighting units in fire suppression, based on the calculation of water consumption indicators, makes it possible to substantiate the required staffing levels of fire and rescue units and ensure an adequate level of resource provision. The implementation of this system is consistent with broader societal trends aimed at enhancing environmental sustainability and promoting a more responsible use of water resources.

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Strategic Planning of Small Cities Development: Modernization Based on Growth Drivers and Innovative and Technological Priorities

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ABSTRACT

The article examines the issues of strategic planning for the development of small cities and proposals for their modernisation based on the new elements in the strategic planning process, incl. the assessment of growth drivers and the analysis of innovation and technological priorities. **The relevance** of this topic is that today the theory of strategic planning process strongly needs development and available information on this issue is not sufficient. **The purpose** of this study is to develop a modernised mechanism to form and implement the development planning strategy of small cities. **The objectives** of the study are to assess the author's approaches to implementing the process of strategising the development of small cities and justify the inclusion of new elements in the methodological framework for developing the strategy. The study assesses the potential for using a master plan for spatial development, outlining its objectives, tasks, and construction methodology. Based on the given analysis, a methodological framework was compiled for the main stages of implementing the development strategy for small cities, and the main strategic directions for the development of small cities have been proposed, supported by the assessment of its species profile and the level of innovation and technological development. **The research methodology** included the use of grouping, comparative analysis, and generalization methods. The empirical foundation was based on data from the State Statistics Service, the provisions of the Spatial Development Strategy of Russia for the period up to 2030 with a forecast up to 2036, and Federal Law No. 172-FZ of June 28, 2014, "On Strategic Planning in the Russian Federation". The practical significance of the study implies **the findings** that can be used by municipal, regional, and federal authorities to develop programs and strategies for the development of small cities, as well as to monitor their implementation.

Keywords: strategic planning; strategies; small towns; spatial development; innovation and technology priorities; growth drivers; master plan; indices of innovation and technology development

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INTRODUCTION

At present, the issue of the strategic development of small towns is associated with the insufficient effectiveness of existing approaches to their long-term planning. Among the scholarly works addressing this topic, particular attention should be given to studies by S.I. Risin, E.A. Shatalova, O. Yu. Kosenko, and N.N. Kiseleva [1, 2]. However, these authors focus primarily on large urban centres, leaving small towns largely outside the scope of their research interests. At the same time, at the legislative level a number of regulatory and legal documents on strategic planning are provided for both large and small municipalities, including municipal programmes and medium- and long-term socio-economic development forecasts, among others[1] [1]. The mechanism for formulating a development strategy for a small town should be grounded in the analysis of additional elements, which the authors of this article identify as an assessment of its sectoral profile, the level of innovation and technological specialisation, and the factors influencing its development.

RESEARCH METHODOLOGY

To examine issues of strategic planning for the development of small towns, the study employed methods of classification (grouping), comparative analysis, and generalisation, drawing on modernisation principles based on growth drivers and innovation-technological priorities.

RESULTS

Theoretical Review of Scholarly Literature on the Research Topic

The authors support the position of scholars from Pyatigorsk State University, Kh. Basnukaeva and T. Kasaeva, who argue that defining development trajectories when preparing strategic planning documents for small towns requires consideration of their specific characteristics [3] (*Fig. 1*).

K. Basnukaev and T. Kasaeva identify the key methodological aspects of the stages of strategic planning for the development of small towns, including the following:

1. Strategic analysis and synthesis for subsequent application in the collective formulation of

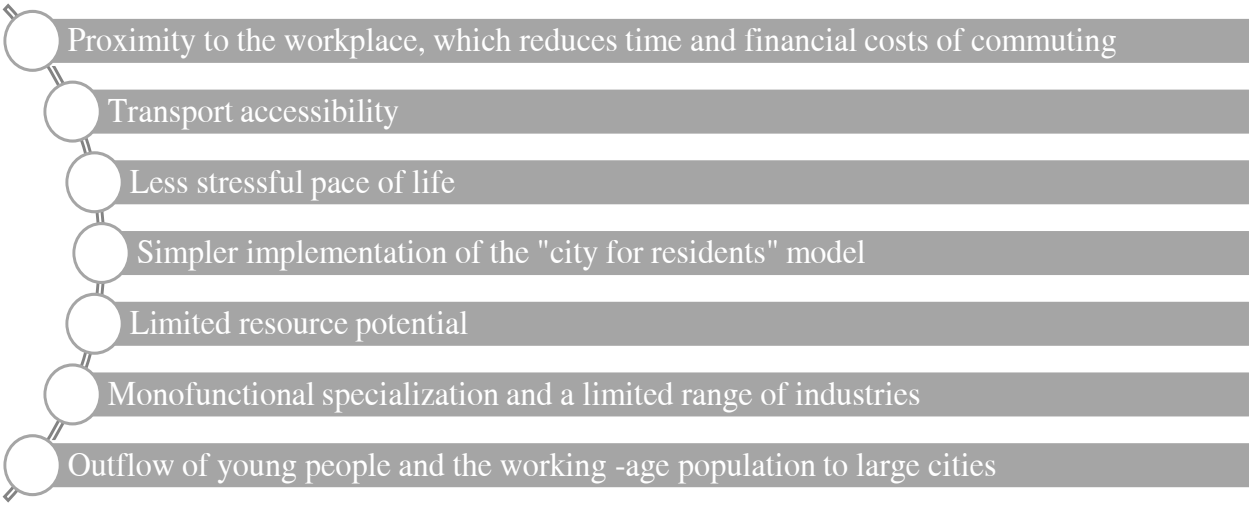

Fig. 1. **Features of the Trajectory in the Development of Strategic Planning Documents for Small Cities**

Source: [3].

[1] Spatial Development Strategy of the Russian Federation until 2030 with a Forecast to 2036. URL: https://www.economy.gov.ru/material/directions/regionalnoe_razvitie/strategicheskoe_planirovanie_prostranstvennogo_razvitiya/strategiya_prostranstvennogo_razvitiya_rossii_do_2030_goda_c_prognozom_do_2036_goda/

specific target benchmarks for the city's strategic development.

2. The articulation of a "triad" of interrelated formulations at the goal-setting stage: the vision of a desirable future, the mission of the territory within the external environment, and the overarching strategic objective.

3. The elaboration of the "goal tree" through programmatic detailing.

Drawing on source [4], it should be noted that there exists a specific group of small towns in Russia that may be regarded as positive examples in terms of strategy development and implementation. These include Lermontov (North Caucasus Federal District), Gdov (North-Western Federal District), Volkhov (North-Western Federal District), Myshkin (Central Federal District), and Pokrov (Central Federal District). The strategies were designed in 2007–2008 for a period of 10–15 years and now require updating, as the chain "strategy–programme–project" is often not clearly traceable.

Scholars from the Vologda Research Center of the Russian Academy of Sciences have identified a set of key directions for the development strategies of small towns, taking into account their individual trajectories. These authors argue that, in order to ensure sustainable territorial development, the unique potential of such towns should be realised through strategic planning, whose starting conditions (a view with which we concur) are constituted by a range of inherent socio-economic challenges and competitive advantages [5].

According to M.S. Gunko, Yu.A. Eremenko, and E. Yu. Batunova, particular importance is attached to the paradigm of determining the optimal strategic level for the long term in the context of the sustained depopulation of small towns in Russia [6]. G.J. Hospers rightly observes that the demonstration of limited resources does not allow the growth trajectory of a region and its economic development to be fully supported [7].

Ya. Yu. Eferin and E.S. Kutsenko note that an important aspect to be considered in selecting urban development strategies is intermunicipal cooperation. Based on the resources available within a region, integration with neighbouring territories is pursued, and either an individual or a combined type of development is selected [8].

Attention should also be given to the assumption put forward by M.F. Chernysh, V.V. Markin, and others [9] that strategic planning should be grounded in the processes presented in *Fig. 2*.

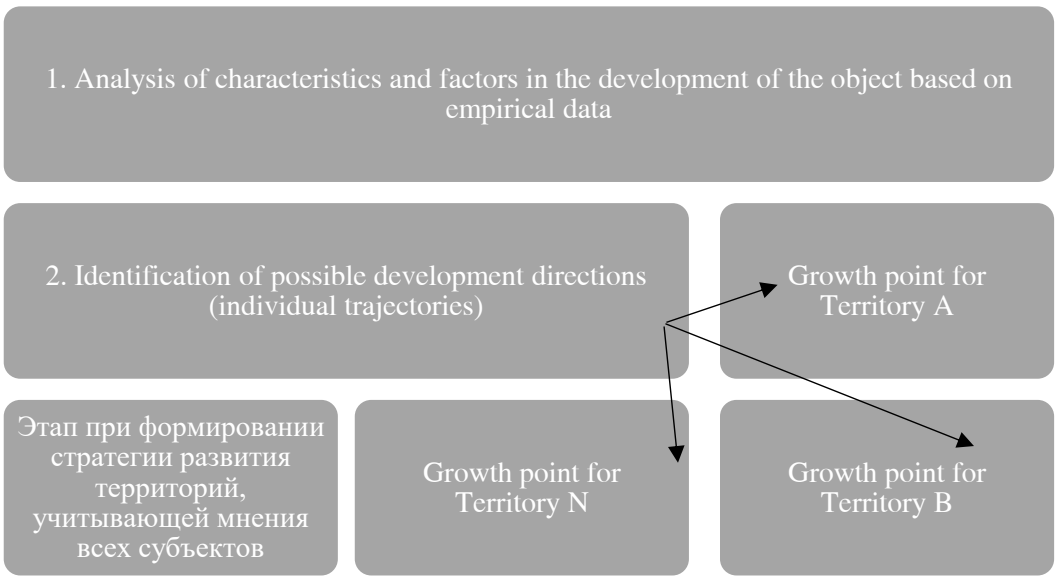

Fig. 2. **Basic Processes of Strategic Planning**

Source: Based on [9].

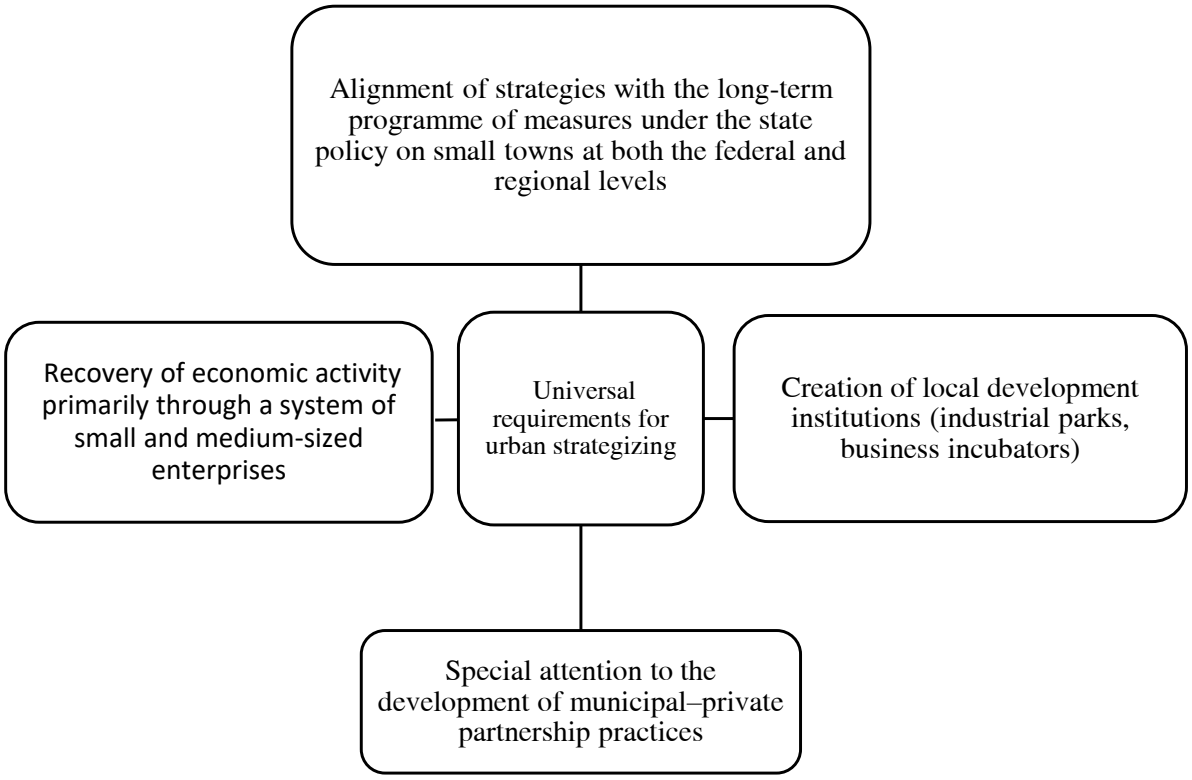

Fig. 3. **Universal Requirements for Urban Planning**

Source: Based on [10].

Particular scholarly interest is attracted by the approach proposed by researchers of the Centre for Federal Relations and Regional Development — E. Bukhvald, O. Valentik, A. Kolchugina, and A. Odintsova — which holds that the specificity of the socio-economic and other challenges faced by small towns indicates the expediency of implementing a particular type (a distinct model) of strategic planning [10]. Relying on a number of provisions of the Federal Law "On Strategic Planning in the Russian Federation[2]" [1], it should be noted that these challenges themselves constitute the necessary preconditions for the effective functioning of the proposed model. As an institutional innovation within the current stage of municipal reform — the implementation of which requires addressing economic and legal issues — strategic planning for small towns should be established by federal law as a mandatory component [10].

At the same time, methodological support becomes an important factor. Resolution No. 870 of 20 August 2015[3] [2] states that strategic planning should be implemented on the basis of the results of "assigning cities and regions of the Russian Federation to specific types." E. Bukhvald and co-authors emphasize that small towns represent distinctive objects of social and economic strategizing: conditions should be created to enhance the importance of small-scale forms of economic activity and to strengthen the growth of their logistical capacities. Within the territory of the Russian Federation, small towns perform an important role in economic development — many of

[2] Federal Law of 28 June 2014 No. 172-FZ "On Strategic Planning in the Russian Federation URL: https://www.consultant.ru/document/cons_doc_LAW_164841/

[3] Government Resolution of 20 August 2015 No. 870 "On the Content, Composition, Procedure for Drafting and Approval of the Spatial Development Strategy of the Russian Federation and on Monitoring and Control of its Implementation" URL: https://base.garant.ru/71170676/

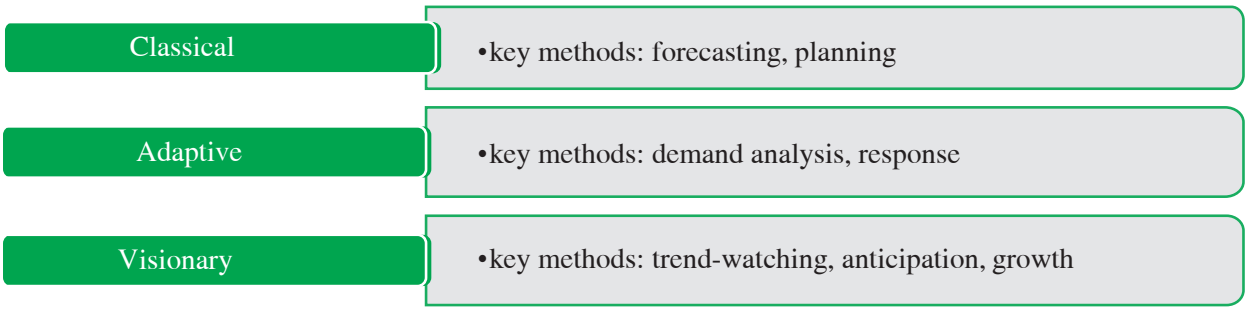

Fig. 4. **Options for Possible Strategies with Key Methods Based on the Formation of a Leading Development Driver**

Source: Based on [11].

Fig. 5. **Research Approaches to Describing Possible Strategies for Revitalizing Small Towns**

Source: Based on [12].

them function as centres concentrating historical assets. The following aspect highlighted by these authors is also noteworthy: the incorporation of small-town issues into the strategizing of spatial development should indirectly correspond to elements of the requirements applied to the strategies of the small towns themselves (*Fig. 3*).

It is also important to note that there exists a number of specific features of strategic planning within the framework of the Spatial Development Strategy[4], namely: the diagnosis of the main urban development challenges; the preparation of cartographic materials; and the identification of the city's spatial development as one of the key priorities.

A comprehensive study by L. V. Dmitrieva [11] presents a methodological approach that makes it possible to determine a medium-term development model for small towns. The work proposes alternative strategic options based on the identification of a key development driver (*Fig. 4*).

[4] Spatial Development Strategy of the Russian Federation until 2030, with a forecast until 2036 URL: https://www.economy.gov.ru/material/directions/regionalnoe_razvitie/strategicheskoe_planirovanie_prostranstvennogo_razvitiya/strategiya_prostranstvennogo_razvitiya_rossii_do_2030_goda_c_prognozom_do_2036_goda/

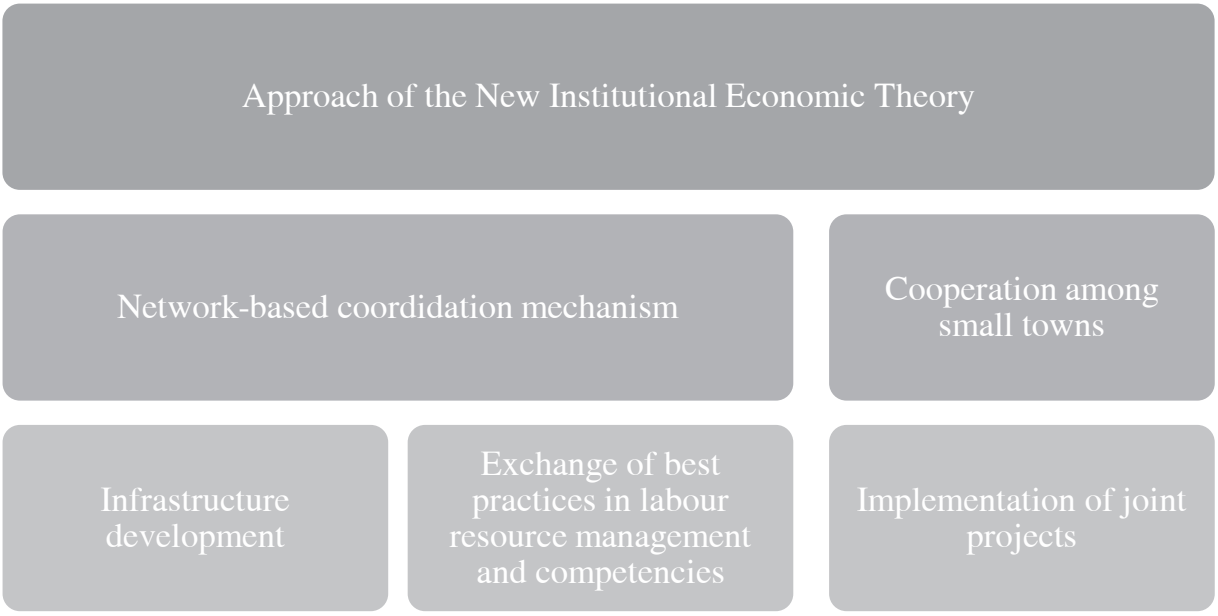

Fig. 6. **The Authors' [13] Approach to Using a Network-Based Coordination Mechanism**

Source: Based on [13].

Similar views on the necessity of identifying possible development strategies for small towns are held by Russian scholars A.V. Popov and M.A. Gnatyuk [12], as well as by the British researcher R. Hudson — their proposals are visualised in *Fig. 5*.

Continuing the review of scholarly works on the research topic, it should be noted that attention must be paid to issues of the effectiveness of strategic planning for the development of small towns. Thus, M.S. Oborin, A.M. Pakhalov, and M. Yu. Sheresheva propose enhancing its effectiveness through the application of the capabilities of a network coordination mechanism [13] *(Fig. 6)*.

The use of the proposed mechanism is possible provided that an instrument exists for achieving specific goals and accomplishing concrete tasks within the framework of small-town development planning — these are listed in *Fig. 7* and reflect the viewpoint of M.S. Oborin and A.M. Pakhalov.

In examining issues of strategic planning, it is also important to highlight such a type of strategic document as the master plan, which defines the principal vectors of

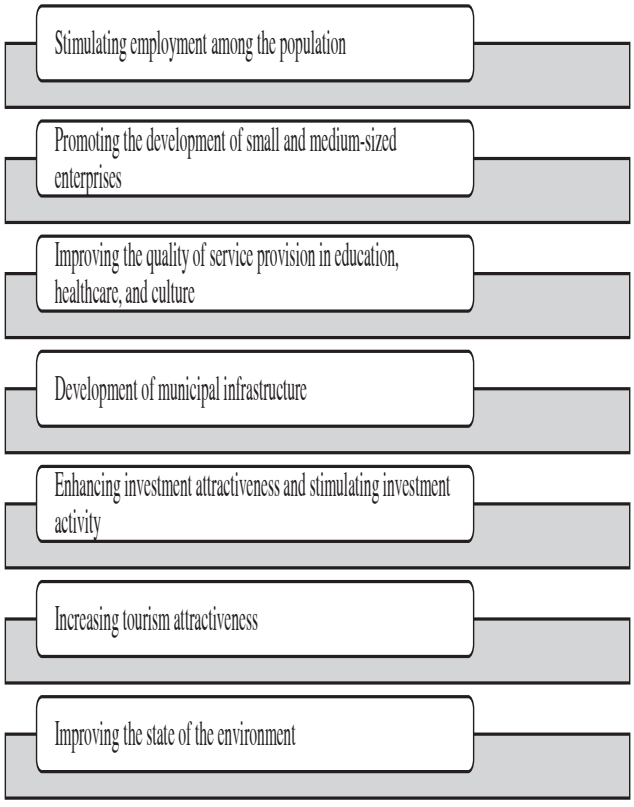

Fig. 7. **Achieving Goals (Tasks) in the Aspect of Strategic Planning for the Development of a Small City Through a Network-based Coordination Mechanism**

Source: Based on [13].

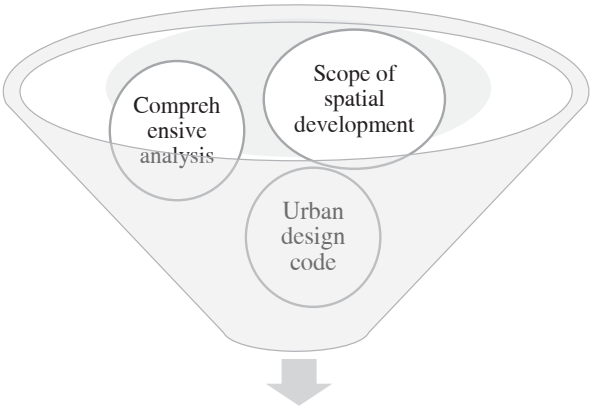

Fig. 8. **Components of a Spatial Development Master Plan**

Source: Compiled by the authors.

a city's social, economic, and spatial development (*Fig. 8*).

Participants in discussions at SPIEF-2023 reached a consensus that the development of territorial master plans may contribute to attracting investment. Experts emphasise the particular promise of this direction for the further development of small towns.

Researcher A.V. Davydova considers the master plan to serve as a development guideline for a small town and illustrated this position using the example of Olekminsk (Far Eastern Federal District) [14]. Indeed, at present, the development of master plans represents a key trend in strategic planning *(Fig. 9*).

G.M. Mustafin, in the course of the round table "Key Instruments for Managing Territorial Development: Master Plans or General Plans," identified the following advantages of the master plan [15] (*Fig. 10*).

It should be emphasised that there exists a Presidential instruction of the Russian Federation concerning the inclusion of the master plan in the system of territorial strategic planning[5].

The methodology for developing a master plan is presented in *Fig. 11*.

[5] List of Instructions Following the Meeting on the Development of Far Eastern Cities.URL: http://www.kremlin.ru/acts/assignments/orders/72690

Modernisation of the Process of Developing a Small-Town Development Strategy with Consideration of Elements for Assessing Growth Drivers and Innovation-Technological Priorities

The formulation of a small-town development strategy is a rather complex process requiring both a clear definition of objectives and the instruments necessary to achieve them, as well as the competent structuring of strategic scenarios comprising a set of key measures.

The implementation of the strategy should be linked to the achievement of such priorities as:

- the creation of comfortable socio-economic conditions for residents of the small town;
- enhancing its recognisability through the implementation of projects aimed at improving the image of the urban territory, the attractiveness of its way of life, and clearly articulated values;
- creating conditions for the development of enterprises capable of producing competitive products, including innovative ones.

Summarising the views of scholars regarding the features of constructing development strategies for small towns, it should be noted that at present the principal mechanism of this process requires modernisation. Regional and state authorities face the tasks of increasing the level of urban development, equipping production with innovative technological solutions, and selecting strategic benchmarks. Ignoring these issues may lead to many small towns disappearing from the economic landscape of regions and the state.

The implementation of the strategy should contribute to addressing a significant issue related to ensuring sustainable spatial development of territories and the state, increasing population concentration, and reducing interregional disparities. The development of small towns will make it possible to improve the quality of life of the population and reduce the impact of negative phenomena associated with declining economic growth.

In our view, the methodological framework for the process of forming a small-town development

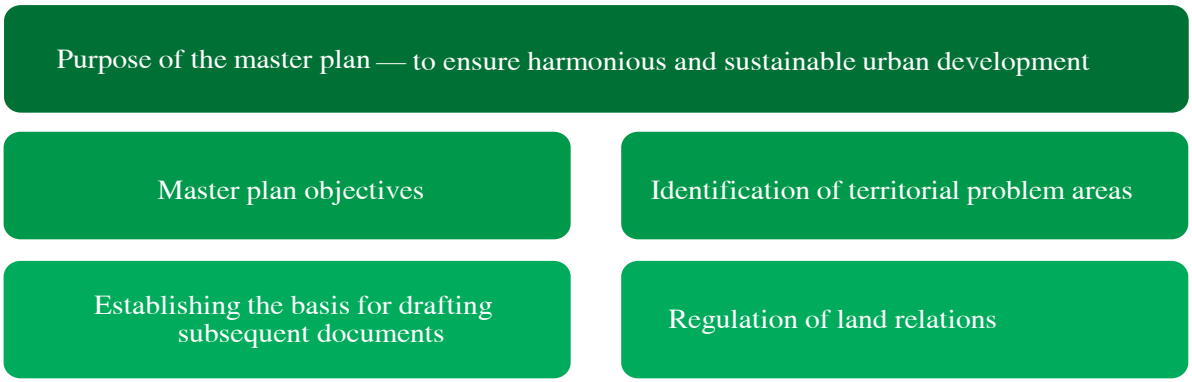

Fig. 9. **Defining the Purpose and Objective of the Master Plan**

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

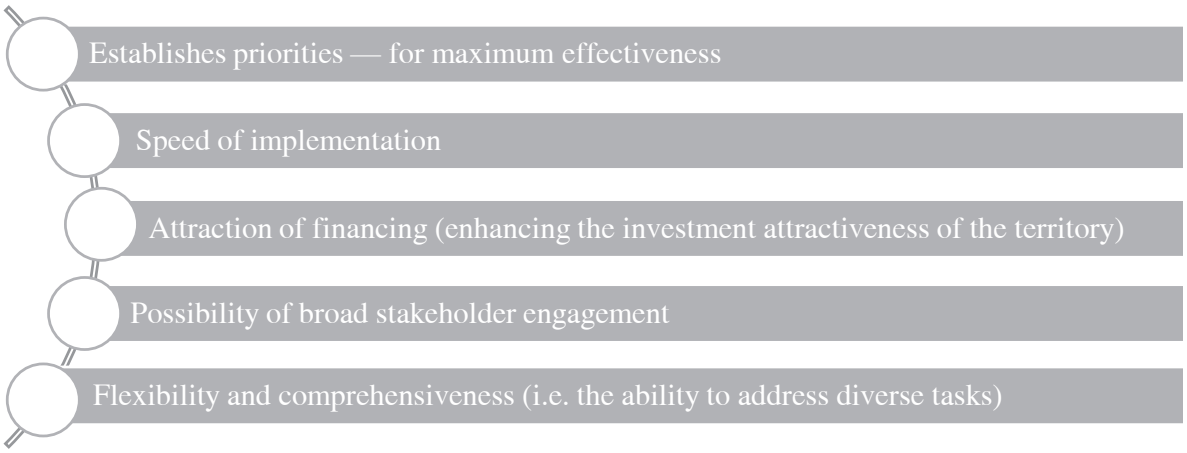

Fig. 10. **Advantages of Master Plan Development**

Source: Compiled based on [15].

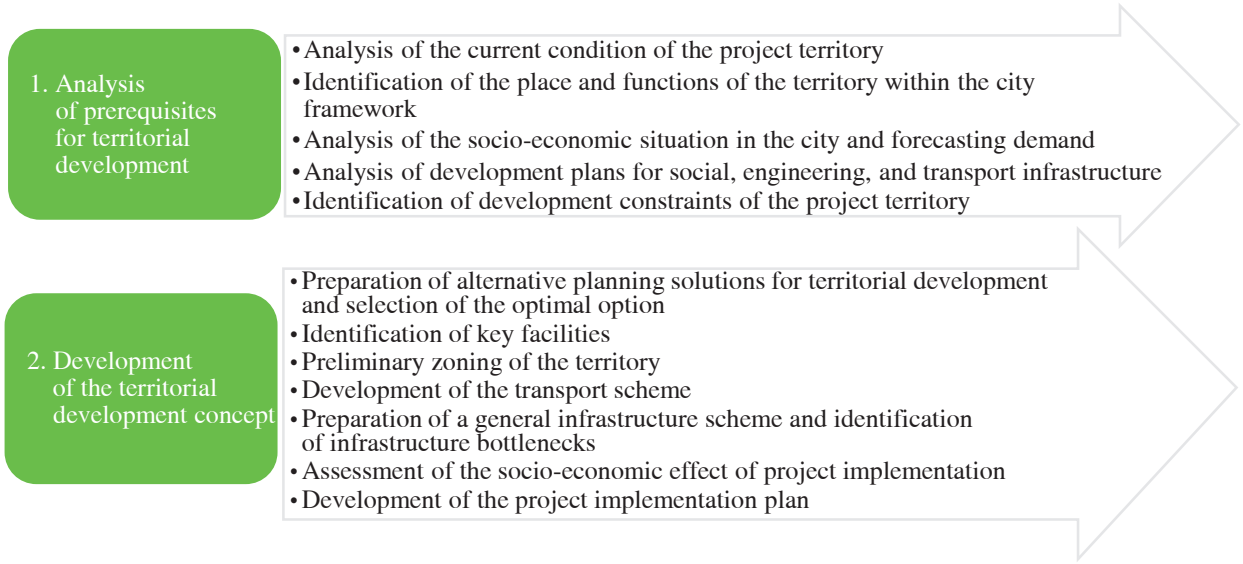

Fig. 11. **The Methodology of Master Plan Development**

Source: Compiled based on [15–17].

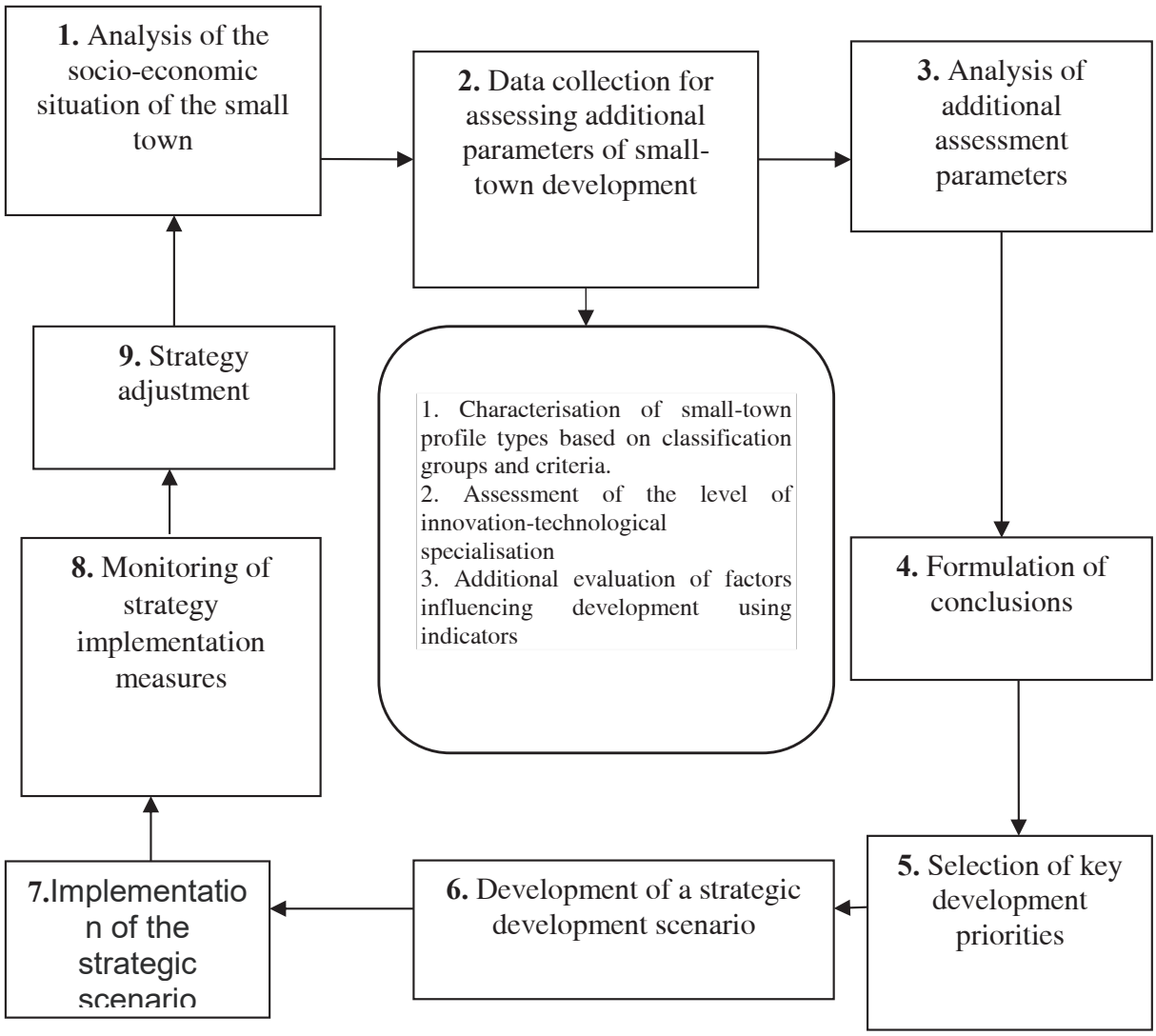

Fig. 12. **Methodological Outline of the Main Stages of the Process of Forming and Implementing a Small City Development Strategy**

Source: Compiled by the authors.

strategy should include, in addition to its core elements, the following supplementary components:

1. Characterisation of types of small-town profiles (as supporting nodes) based on classification groups and criteria.

2. Determination of the type and level of the city's innovation-technological specialisation and the use of these indicators in establishing its development priorities.

3. Additional analysis of factors influencing small-town development (social, sectoral, infrastructural, economic, environmental, and digital) through appropriate indicators.

Based on the assessment of the above elements, it becomes possible to determine key benchmarks and develop a strategic scenario for the development of a small town.

The methodological framework of the main stages of the process of forming and implementing a small-town development strategy consists of nine principal stages (*Fig. 12*).

A more detailed characterisation of the elements incorporated into this framework should be provided. The principal task in formulating the strategy is the identification of the profile type of a small town. Previous research has shown that,

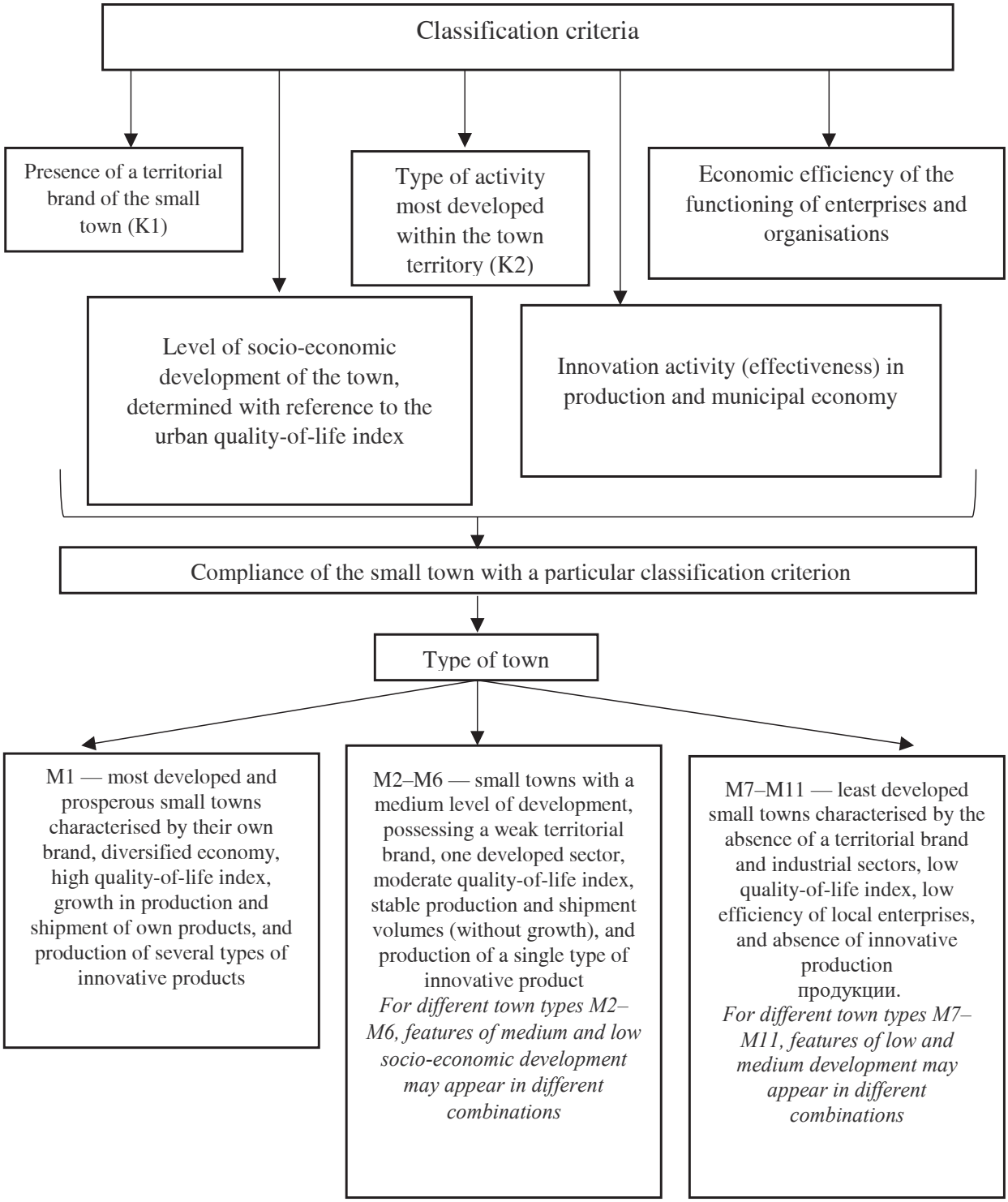

Fig. 13. **Typology of Small Towns According to a Set of Classification Criteria**

Source: Compiled by the authors.

from the perspective of the main classification criteria, three groups and eleven types of small towns in Russia can currently be distinguished (*Fig. 13*).

On the basis of this classification of cities (their attribution to specific types), it becomes possible to provide a more comprehensive description of their development challenges and to

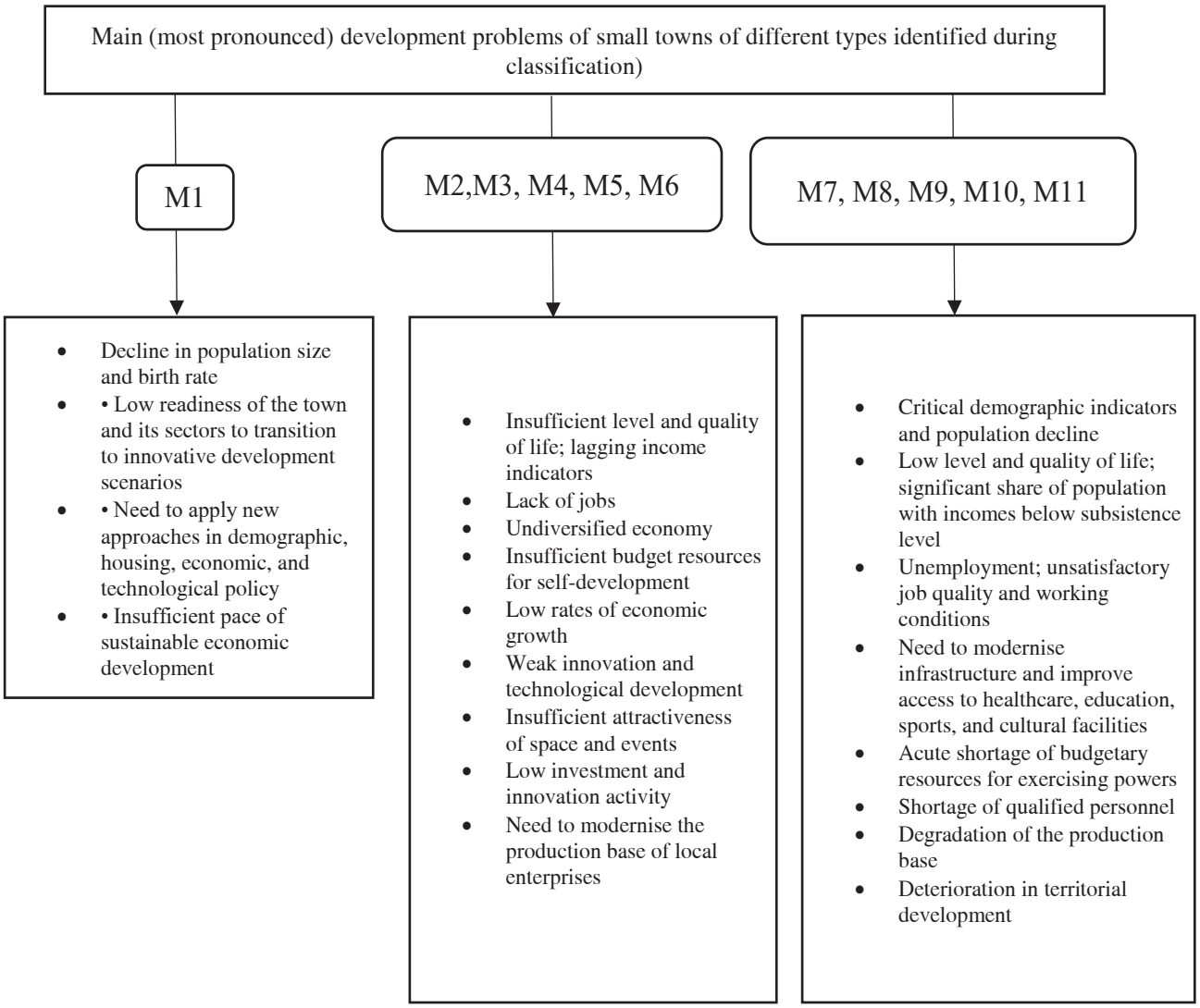

Fig. 14. **ПList of Problems in the Development of a Small City, Identified During the Process of Classifying a Small City as a Certain Type**

Source: Compiled by the authors.

determine with maximum precision the strategic measures that need to be implemented (*Fig. 14*).

The assessment of the level of innovation-technological specialisation and the establishment of development priorities for a small town in accordance with its type and innovation-technological level also constitute an important task of strategizing.

Earlier studies conducted by the authors provide a substantiated rationale for prioritising the selection of specific instruments for assessing the level of innovation-technological specialisation of a small town and its specific features [18]. Innovation-technological development represents one of the principal priorities for small-town development, as it enables the identification of opportunities for economic growth and prospects for the adoption of technologies aimed at producing highly competitive goods. The development of production activities within the territory of a small town contributes to reducing population outflow and improving quality of life.

From this perspective, the formulation of a development strategy should employ in-

struments that allow the level of innovation-technological development of a small town to be determined and its development priorities to be selected.

The authors established that the most prioritised instrument for determining the development vector of small towns is the matrix of sectoral innovation-technological specialisation. This matrix may be used by regional and state authorities in the strategizing process both to determine the level of innovation-technological development and to assess the balance of the formation of these domains.

As noted above, in order to identify the development priority of a small town, it is advisable to calculate the following two indices:

1. Innovation Specialisation Index (Iis), characterising innovation potential. The principal indicator for calculating Iis is the number of organisations in the town engaged in research and development activities (I1). Iis may be evaluated by comparing it with the corresponding indicator of a city that is a regional leader (and has the maximum Iis value).

2. Technological Specialisation Index (Its), used to determine technological potential. The main indicator for its calculation is average revenue (I2) measured in million roubles. Its may likewise be evaluated through comparison with the maximum value of the corresponding index observed in the regional leader.

The choice of the principal indicators is determined by the shortage of necessary statistical information and the difficulties associated with obtaining it. A resource that may be used to select the values of these indices is the statistical database of Russian cities — the SPARK system available on the Interfax platform[6].

The distribution of small towns by level of innovation-technological development (innovation-technological specialisation) is as follows:

- ultra-low level — Iis (Its) ⩽ 0.19;
- low — Iis (Its) = 0.20–0.39;
- medium — Iis (Its) = 0.40–0.59;
- high — Iis (Its) = 0.60–0.79.

Based on the calculation of the indices and the construction of the matrix of innovation-technological specialisation levels, the development priority of a small town is determined:

- implementation of innovation-technological development measures, introduction of new technologies, improvement of innovative production (strategic direction C1);
- further enhancement of implemented innovation-technological development measures, introduction of new technologies, improvement of innovative production (strategic direction C2);
- preservation of competitive advantages in terms of innovation-technological specialisation and level (strategic direction C3).

The identification of factors influencing small-town development using assessment indicators constitutes another important element of strategy formation. These factors include social, sectoral, infrastructural, economic, environmental, and digital dimensions. The implementation of this element makes it possible to construct a matrix for selecting priority development measures for a small town (*Table 1)*.

In earlier studies, the authors conducted a sample-based analysis of small towns across seven federal districts of the Russian Federation, determined their types in accordance with classification criteria, and assessed indices of innovation and technological development. Based on this analysis, the principal strategic directions for development were proposed (*Table 2*).

Представленные данные свидетельствуют о том, что с точки зрения

The presented data indicate that, in terms of the innovation level of production, Shatura and Kingisepp are the leaders, while in technological terms the leading position is held by Tynda.

Fig. 15 illustrates the relationship between the indices of innovation and technological

[6] URL: https://group.interfax.ru/products/systems/spark/?ysclid=mgizhe6gfc596362651

Table 1

Matrix for Selecting Priority Activities for the Development of a Small City

Factors/Parameters for measures to increase the attractiveness of a small town	Small town development measures						
	Social sphere	Industry sphere	Infrastructure sphere	Economic sphere	Ecological Sphere	Digital Sphere	Small town development priorities
Problems of a small town from the perspective of social factors	A1	B+	C+	D+	E+	F+	A
Problems of a small town from the perspective of sectoral (industrial) factors	A+	B1	C+	D+	E+	F+	B
Problems of a small town from the perspective of infrastructural factors	A+	B+	C1	D+	E+	F+	C
Problems of a small town from the perspective of economic factors	A+	B+	C+	D1	E+	F+	D
Problems of a small town from the perspective of ecological factors	A+	B+	C+	D+	E1	F+	E
Problems of a small town from the perspective of digital factors	A+	B+	C+	D+	E+	F1	F

Source: Compiled by the authors.

Notes: A — increasing the level of development of the social sphere of a small town;

B — increasing the level of industrial development of a small town;

C — increasing the level of development of a small town's infrastructure;

D — increasing the level of economic development in a small city;

E — increasing the level of ecological development of a small town;

F — improving the digital development of a small town;

A+ — satisfactory development of the social sphere in a small town, and maintaining positive trends in this area;

B+ —satisfactory development of the industry in a small city, and maintaining positive development trends in this area;

C+ — satisfactory development of the infrastructure sector in a small city, and maintaining positive trends in this sector;

D+ — satisfactory development of the economic sphere in a small city, and maintaining positive positions in this sphere;

E+ — satisfactory development of the environmental sphere in a small city, and maintaining positive trends in this area;

F+ — satisfactory development of the digital sphere in a small city, and maintaining positive positions in the development of this sphere.

Table 2

The Main Strategic Directions for the Development of Small-Scale

Name of Federal district/small town	Type (species profile of small town)	Iis	Its	Main strategic directions for the development of a small town based on an assessment of the species profile and the level of innovative and technological development (priority C1–C3)
Central Federal District — Shatura	Type M3	1	0.25	C1–C3: The development strategy should focus on forming or enhancing the territorial brand (e.g., "Shatura — eco-friendly furniture in every home in Russia"), further diversification of economic activities, improvement of the urban environment quality index, increased economic efficiency of enterprises and organisations, and the introduction of new technologies into enterprise operations.
North-Western Federal District — Kingisepp	Type M3	1	0.85	C3: The strategy should aim at maintaining the high level of development achieved, strengthening competitive positions, and enhancing the territorial brand (e.g., "Kingisepp — fortress town on the Luga River").
Southern Federal District — Bakhchisarai	Type M5	0.57	0.11	C1–C2: The strategy should focus on improving the territorial brand (e.g., "Bakhchisarai — historical heritage of Crimea"), further diversification of activities, improvement of the urban environment quality index, growth in economic efficiency of enterprises, and the development of innovation activity and technological implementation.
North Caucasus Federal District — Mozdok	Type M7	0.32	0.06	C1: The strategy should focus on developing the territorial brand (e.g., "Mozdok — gateway to the Caucasus"), implementing measures to develop dominant industries, improving the urban environment quality index, and introducing innovative production of goods, works, and services.
Ural Federal District — Alapayevsk	Type M7	0.21	0.1	C1: The strategy should focus on strengthening the territorial brand (e.g., "Alapayevsk — the oldest town of the Urals"), developing key industries, improving the urban environment quality index, and implementing innovative production measures.
Siberian Federal District — Tayshet	Type M8	0.21	0.05	C1: The strategy should focus on strengthening the territorial brand (e.g., "Tayshet — a town with harsh conditions but with a long history"), implementation of strategic measures for developing production activities within the city; improving the urban environment quality index; introducing innovative types of production of goods, works, and services, as well as new technologies in the activities of enterprises operating in the city.
Far Eastern Federal District — Tynda	Type M7	0.21	1	C1–C3: The strategy should focus on forming the territorial brand (e.g., "Tynda — capital of BAM"), implementing measures to develop dominant industries, improving the urban environment quality index, and introducing innovative production.
Volga Federal District — Gorodets	Type M1	0.71	0.3	C1–C3: The strategy should aim at maintaining the high level of development achieved, increasing recognisability of the territorial brand, strengthening competitive positions, and introducing new technologies into enterprise activities.

Source: Compiled by the authors.

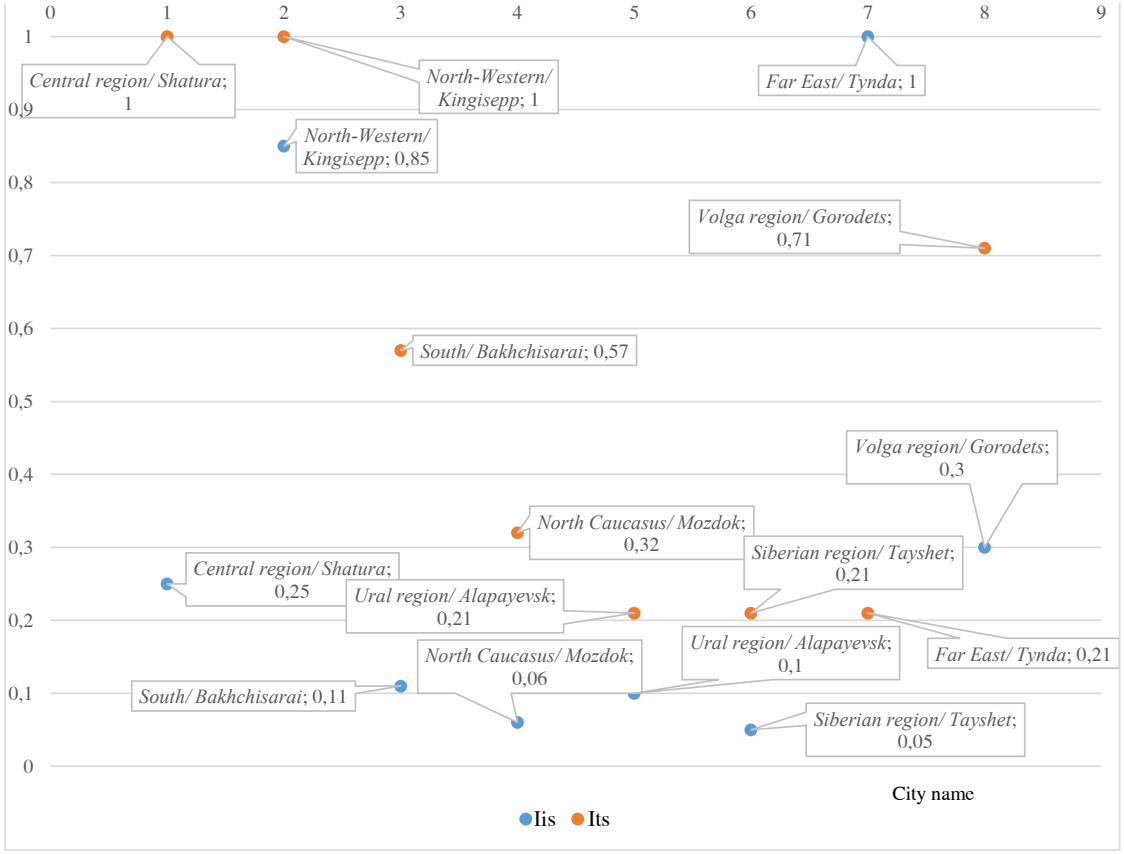

Fig. 15. **Graphical interpretation of the indices of innovative and technological development of small cities (sample of seven districts of the Russian Federation)**

Source: Compiled by the authors.

development of small towns. It is evident that a relatively high level of technological potential is characteristic of the small town of profile type M3 — Kingisepp — as well as Gorodets (M1). However, despite its high Its value, Tynda demonstrates a very low level of innovation development and urban environment quality index, which represents a significant problem requiring the adoption of appropriate measures by regional and state authorities. At the same time, although Shatura displays a high Iis value, it is characterised by a low level of technological development and an insufficiently developed territorial brand, which necessitates corresponding managerial actions to address these shortcomings.

The highest indicators in terms of innovation-technological development are observed in the town of profile type M3 — Kingisepp. In formulating its development strategy, it is necessary to maintain these competitive advantages while further developing the town's brand.

A more detailed analysis by the authors on this issue is presented in [18].

Summarising the above, it should be noted that the formulation and implementation of a strategy in accordance with the mechanism proposed by the authors will allow the basic priorities of a small town to be identified more precisely and will enable the application of a differentiated approach. This approach implies the clear structuring of all components influencing the level of urban development and their utilisation in the strategizing process.

CONCLUSION

Under contemporary conditions of small-town functioning, the need to modernise the system of strategic planning for their development con-

tinues to increase. The specific characteristics of such towns — cultural, historical, technological, and others — require the consideration, analysis, and evaluation of additional elements within the strategizing process. This approach makes it possible to identify development challenges and bottlenecks, formulate key priorities, and implement them according to a clearly defined algorithm. It will contribute to enhancing the image of small towns, increasing population concentration, slowing processes of decline, overcoming depressive conditions of urban territories, stimulating technological and investment activity, and improving the level of municipal governance.

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P. S. Seleznev — development of the article's concept, formulation of the problem, formulation of the research goal, interpretation of the obtained results, and proposals for the formation of a methodological outline for the main stages of the process of forming and implementing a small city's development strategy.

S. A. Vuymenkov — theoretical review of the authors' research approaches on strategic planning for the development of small cities; determination of the typology of small cities based on classification criteria.

V. V. Zubov — graphical interpretation of indices of innovative and technological development, and critical analysis of the literature.

I. O. Korenkov — determination of the main strategic directions of technological development in a small city, and a critical analysis of the literature.

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Analysis of Measures Administered to Ensure Technological Safety in the Russian Industry

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ABSTRACT

The objective of this study is to analyse the current implemented measures to support technological security in Russian industry. This is due to the necessity to measure the set strategic objectives with the key interim results of their implementation to assess effectiveness and, if necessary, adjust the "roadmap" for stimulating a technological breakthrough in domestic production. The methodological framework of the study relied on a combination of general scientific and specialized **methods** of scientific cognition of economic phenomena and processes. The article analyses the state policy in the context of achieving technological sovereignty of the Russian industrial complex, considering its sector-specific features of operation. It also examines the dynamics of industrial production amid increasing sanctions pressure, and evaluates the import dependency within the sectors of industries, including trends of both reduction and growth in import dependence. Supported by statistical data and current regulatory-legal documents, the given study concludes that reducing import dependency and building domestic production capacity is a long-term, multi-stage process that requires coordinated efforts from both the state and the business community. **The research findings** hold practical value for management personnel at various levels, representatives of the scientific community, and specialists in industrial complex development.

Keywords: Russian industry; technological security; import substitution; technological sovereignty; technological breakthrough

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INTRODUCTION

At present, one of the key components of national security for any state striving for sustainable development, economic independence, and the protection of sovereign interests is technological security.

Its essence lies in a country's ability to maintain control over critically important production processes, infrastructure, and scientific and technological potential, as well as to ensure independence in strategically significant industrial sectors [1, p. 154].

Against the backdrop of a shifting global trajectory, in which globalization is increasingly complemented by new trends such as digitalization, logistics reconfiguration, Industry 4.0 and 5.0, and intensified international technological competition, the vulnerability of the Russian national economy to external influences is growing. The high degree of dependence of domestic industry on foreign technologies, equipment, and components, and consequently the limited capacity of the country to enter international markets for advanced technologies, may destabilize individual sectors of the economy as well as the nation as a whole. In this context, ensuring technological sovereignty has become a priority task of state policy [2].

In recent years, this issue has attracted the attention of numerous Russian and international scholars who have examined technological security from various perspectives, including: the general conceptual foundations of technological progress [3–5]; approaches to the formation of technological sovereignty [6–8] and its provision through the development of industrial innovation based on digitalization [2, 9]; the conceptual framework for methodologies assessing the level of technological sovereignty in order to achieve a technological breakthrough in the national economy [10]; contemporary pathways of import-advancing development as a factor strengthening technological sovereignty [11, 12] and its enhancement through the localization of industrial capacities [13]; and the development of indicators of scientific and technological security [14, 15].

Contemporary scholarly research converges on an important conclusion: in a complex and hostile geopolitical environment, a carefully designed and effectively implemented industrial policy plays a decisive role in ensuring technological security. State support measures for key sectors of the economy, aimed at reducing dependence on external supplies and establishing domestic technological value chains, include stimulating scientific research, promoting the adoption of national innovations, creating conditions for the growth of high-technology businesses, and developing the infrastructure necessary for the localization of production.

The authors of the present study aim to analyze both the current support measures for technological security in Russian industry being implemented at present and the main intermediate results achieved through the execution of strategic initiatives. This objective is driven the need to monitor progress and assess individual stages of the implementation of organizational and technical measures aimed at modernizing industrial production technologies and ensuring a flexible response to deviations from the intended trajectory toward achieving technological sovereignty.

MATERIALS AND METHODS

The study utilized various statistical materials and data obtained from official governmental online resources, including information provided by the Federal State Statistics Service (Rosstat) and the Ministry of Economic Development of the Russian Federation. Particular attention was also given to the regulatory and legal framework defining strategies for industrial and technological development, as well as measures aimed at ensuring socio-economic sustainability in the Russian Federation.

The methodological foundation of the research consisted of general scientific methods, including analysis, synthesis, generalization, induction and deduction, and abstraction, as well as specialized methods of data analysis and processing. These included statistical methods involving the collection and examination of relevant data and time-series

indicators; methods of comparison and aggregation; sociological methods; logical and comparative analysis; expert assessment techniques; graphical methods, and others. Through the application of these methods, an objective picture of the development of Russian industry, production dynamics, and changes in import dependence was obtained. Furthermore, conclusions were drawn regarding trends in the formation of technological sovereignty and the prospective tasks associated with its strengthening.

Special attention was devoted to identifying opportunities for advancing the technological security of Russian industry under current economic conditions.

SECTORAL SPECIFICS OF INDUSTRIAL ENTERPRISE OPERATIONS UNDER CONTEMPORARY ECONOMIC CONDITIONS

The development of science, technology, and innovative potential as key factors of sustainable socio-economic growth and the provision of technological security in national industry constitutes an important component of the modern strategic national agenda.

In operational, tactical, and strategic planning of measures aimed at enhancing technological sovereignty, it is necessary to take into account the principal sectoral characteristics of industrial companies under current economic conditions:

- Industrial enterprises belong to both the primary sector (extractive industries) and the secondary sector (manufacturing industries) of the economy and are characterized by the high resource intensity of their output.
- The industrial sector faces internal contradictions that pose threats to its development. On the one hand, economic globalization has made enterprises dependent on external environmental factors (suppliers, consumers, competitors, transnational production conglomerates, technological evolution, technology transfer, state and public institutions, and others). On the other hand, unprecedented sanctions hostility toward Russia limits the country's ability to maintain established technological linkages with Western companies, necessitating logistics restructuring and the expansion of domestic developments in the field of innovative technologies.
- The activities of industrial enterprises are in many cases regulated and supervised by the state, and numerous types of output are subject to certification requirements.
- Most manufacturing enterprises are highly specialized, which increases their dependence on counterparties and prevents them, when necessary, from rapidly shifting to the production of alternative goods.
- The creation of innovative products is a complex process characterized by a diversity of production technologies, product nomenclature, and organizational conditions, highlighting the role of the production component in the sustainable functioning of industrial enterprises.
- Human resources, as well as information support systems for production (especially concerning the latest technological data and information on market dynamics), are significantly more important for industrial firms than for organizations in other sectors of the economy.
- The relocation of an industrial enterprise is difficult due to the challenges associated with its physical movement.
- Contemporary interaction between the R&D sector and manufacturing represents a lengthy cycle — from a technological idea to mass production —which underscores the need for priority measures aimed at increasing the effectiveness of both research organizations and the associated production and technological base.

MAJOR TRENDS AND PRIORITIES IN THE TECHNOLOGICAL DEVELOPMENT OF INDUSTRIAL PRODUCTION

Both traditional and current objectives of industrial policy require not so much an expansion of production volumes as accelerated advancement in cross-cutting and critical technologies.

In recent years, the Government of Russia has supported scientific developments in the field of laser and photonic technologies, including the launch of projects for the production of photonic integrated circuits. To date, the state has identified such research areas as unmanned aerial systems, medicine, artificial intelligence, space technologies, and others as critically significant.

The sectoral characteristics of industrial production, when monitored, make it possible to identify external and internal factors that negatively affect technological security and to develop adequate measures to prevent or minimize adverse consequences. This, in turn, implies the development of compensatory mechanisms within the broader system aimed at strengthening technological sovereignty.

In this context, public authorities have prepared regulatory and legal acts defining the long-term priorities of state policy. A central document in this regard is the Decree of the President of the Russian Federation No. 309 of 7 May 2024, "On the National Development Goals of the Russian Federation for the period up to 2030 and for the longer-term perspective up to 2036[1]" (hereinafter referred to as the Decree). The Decree substantiates the necessity of achieving technological leadership, regarded as a condition for strengthening Russia's international standing and ensuring internal resilience.

In accordance with the provisions of the Decree, particular attention is given to a number of concrete target benchmarks for 2030, reflecting both quantitative and qualitative indicators. The most significant among them include:

- ensuring technological sovereignty in critically important sectors, which involves the development of domestic economic actors and a reduction of import dependence in the high-technology domain;
- creation of new markets and technological niches through the mastery of advanced trajectories of scientific and technological progress;

[1] Decree of the President of the Russian Federation No. 309, 7 May 2024, "On the National Development Goals of the Russian Federation for the period up to 2030 and for the longer-term outlook of up to 2036. URL: https://www.garant.ru/products/ipo/prime/doc/408892634/

Table

The dynamics of Industrial Production in the Period of 2022–2024

Name of the indicator	Rate of growth (+), decrease (–) by year to the previous years, in %		
	2022	2023	2024
Industrial production, total	+0.7	+4.3	+4.6
Mining and quarrying	–1.5	–1.0	–0.9
Manufacturing industries, including:	+0.3	+8.7	+8.5
•Food industry	+1.6	+5.2	+4.1
•Light industry	+4.5	+11.4	+3.6
•Wood processing industry	–2.0	+1.3	+4.9
•Manufacture of coke and petroleum products	–0.6	+2.5	–2.1
•Chemical industry	–0.3	+4.9	+4.8
•Metallurgical industry	+2.7	+8.7	+7.7
•Machinery and equipment manufacturing	–5.9	+25.0	+19.5
•Other manufacturing activities	0	+7.0	+4.2

Source: Compiled by the authors based on data from the Ministry of Economic Development URL: https://www.economy.gov.ru/material/file/8aa341310b8d9fb9d1c97ae486d87979/o_dinamike_promyshlennogo_proizvodstva_itogi_2024_goda.pdf

• an increase in the industrial production index and gross value added in manufacturing by no less than 40%, reflecting the commitment to modernize the production sector and increase its contribution to the economy;

• Russia's entry into the top ten leading countries worldwide in terms of R&D volume, which implies expanding research capacity and enhancing its efficiency and applied relevance;

• an increase in domestic expenditures on R&D to at least 2% of GDP, with an emphasis on raising the share of private investment to stimulate business innovation activity and its engagement in technological development processes.

One of the most important indicators of the effectiveness of implementing the objectives set out in the Decree is the dynamics of industrial production growth rates disaggregated by sector (see *Table*).

According to the data presented in the *Table*, the industrial production index in 2024 increased by 4.6%, exceeding the growth rates recorded in both 2023 and 2022. This expansion was driven primarily by manufacturing industries, whose output rose by 8.5% despite the relatively high baseline achieved in 2023. A particularly positive contribution came from the machinery and equipment manufacturing sector, which ensured production growth of 19.5% and maintained the strong momentum established in 2023, following the decline in business activity observed in 2022. In that year, output in this segment fell by 5.9%. Overall, the figures reported in the *Table* indicate favourable trends in 2024 relative to the period of economic uncertainty and slowdown triggered by geopolitical developments in 2022.

Against the backdrop of profound external economic changes caused by sanctions pressure, the withdrawal of foreign companies from the Russian market, and the simultaneous strengthening of state import-substitution policies, the Russian economy has demonstrated a stable trend toward reducing industrial dependence on imported materials, equipment, and components, particularly during 2022–2023. This has been driven by a forced reorientation toward domestic resources and the active implementation of targeted state projects supporting national production. These include preferential financing programs administered by the Industrial Development Fund, aimed at technological modernization and the launch of serial production of domestic substitutes, as well as support from the Ministry of Industry and Trade of the Russian Federation, including within the framework of the cluster investment platform that consolidates enterprise activity in key sectors. In addition, sectoral support measures have been introduced, including subsidies, tax incentives, and preferences for producers focused on strategically important goods [12, 16].

CHALLENGES IN THE IMPLEMENTATION OF CONTEMPORARY IMPORT-SUBSTITUTION POLICY IN INDUSTRY

In autumn 2024, the Institute of Economic Forecasting of the Russian Academy of Sciences conducted a survey of representatives of Russian enterprises. The results made it possible to assess the dynamics of import-substitution processes in industry since the introduction of sanctions restrictions in 2022 [17]. The findings indicate a gradual improvement in the situation; however, the scale of progress achieved remains far from the desired level.

According to the survey results, 53% of respondents reported the absence of domestic suppliers capable of fully replacing imported technological solutions that have become unavailable due to sanctions (*Fig. 1*). Previously, this problem was reported by 62% of respondents, which suggests a positive trend. Nevertheless, the figures indicate a persistent shortage of critically important production resources in the domestic market.

A pressing issue for half of those surveyed remains the increase in production costs and, consequently, the rise in producer prices. This is largely driven by growing domestic demand in the context of the withdrawal of imported goods

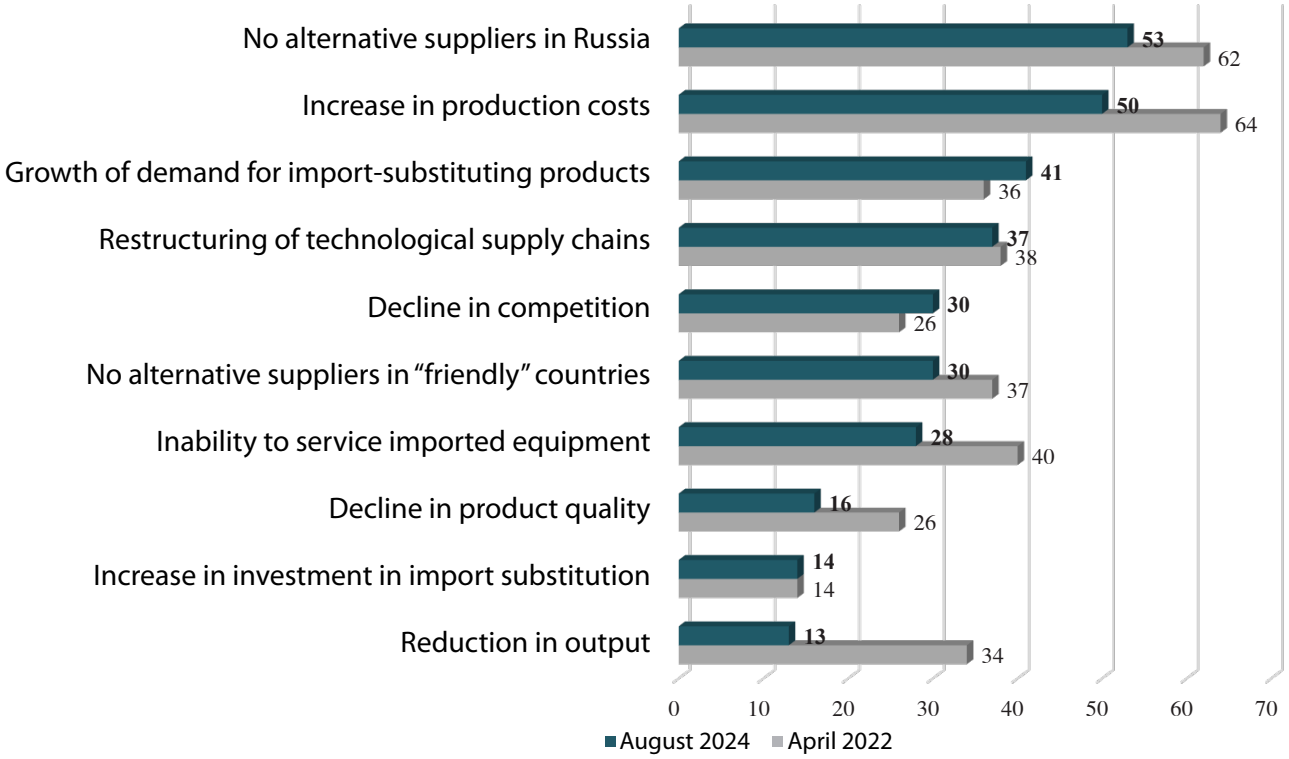

Fig. 1. **The Consequences of Import Restrictions, which Affected Enterprises, % of Russian Industrial Enterprises**

Source: Compiled by the authors according to [17].

from the market. An additional factor intensifying inflationary pressure has been the supply of products from partners in so-called "friendly" countries, which is often accompanied by inflated pricing.

Thus, according to the survey results, despite certain positive shifts toward import substitution, structural constraints and price-related risks continue to represent serious challenges for Russian producers.

According to official statistics, in 2023 the share of expenditures on imported products within the overall structure of production costs amounted to 7.6%, whereas in 2021 this indicator reached 12.1%. However, it should be emphasized that this trend exhibits a differentiated character across industrial sectors (*Fig. 2*).

The greatest progress in reducing import dependence has been observed in sectors that simultaneously demonstrated substantial growth rates in industrial production. The most pronounced positive changes were recorded in the computer manufacturing sector: in 2023, the level of import dependence declined by 17.5 percentage points, indicating significant structural shifts in the production base.

However, in a number of industries, a persistently high — and in some cases increasing — level of dependence on external supplies has been noted. This applies, for example, to the coal industry, where mining equipment is produced in insufficient volumes. The pharmaceutical sector also remains among the most sensitive to external technological constraints. The industry continues to exhibit a high dependence on imports of pharmaceutical substances, laboratory equipment, and packaging materials [18].

In addition to the challenges identified above, the need to intensify industrial support measures is driven by the following crisis-generating factors:

• the longstanding priority given to the dominant development of the fuel and energy complex compared with manufacturing sectors

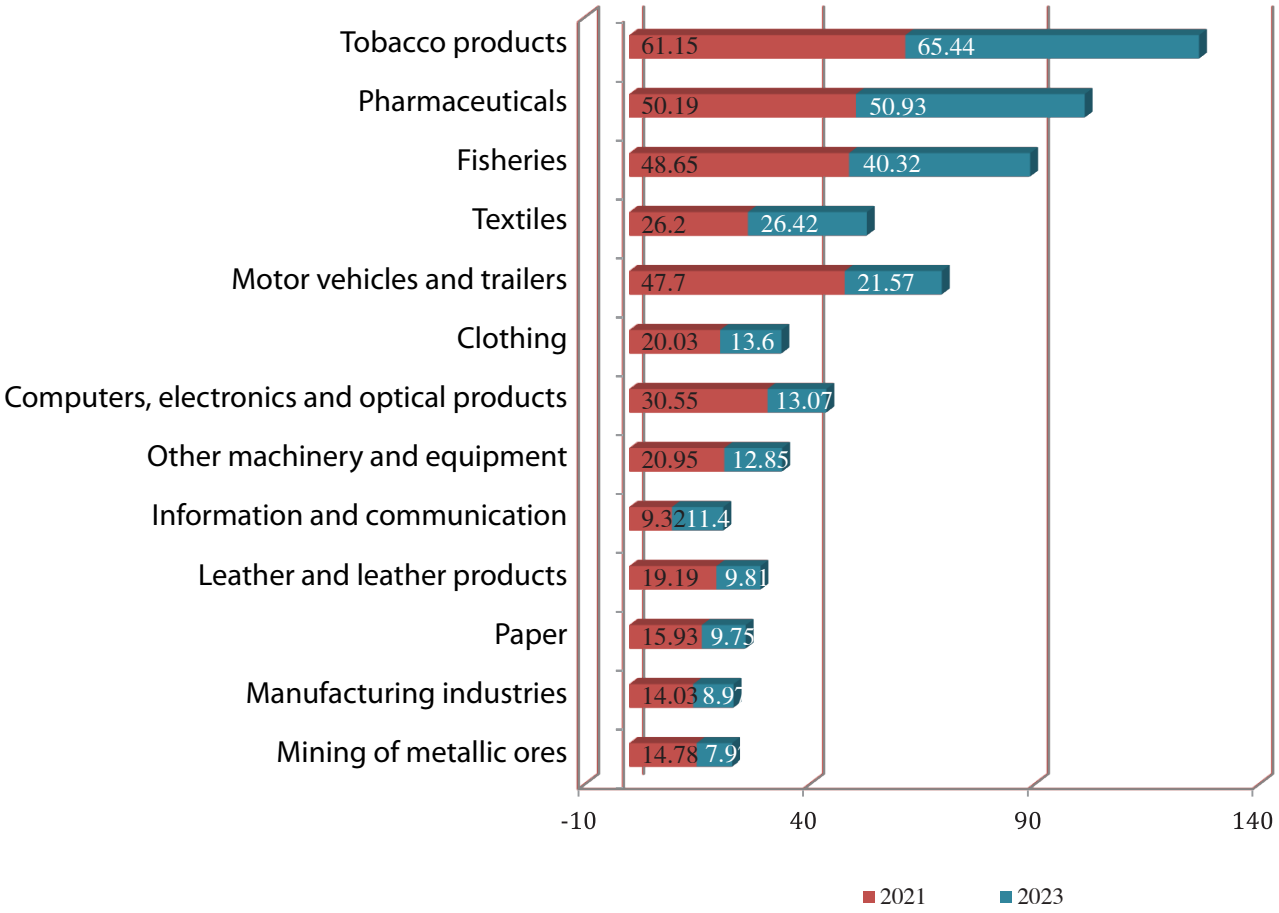

Fig 2. **Changing Import Dependence in the Sectors of the Russian Economy, in %**

Source: [18].

under the previous model of the international division of labour;

- the insufficient level of innovative production within the structure of the national economy, which limits further opportunities for import substitution;
- the slow pace of renewal of obsolete production assets, particularly their active components;
- inadequate volumes of real investment in high-technology sectors;
- sluggish dynamics in the development of high-tech industries and a shortage of labour possessing the required skills;
- the emergence of strong destabilizing external factors and challenges that require both timely and constructive intervention by public authorities and an active response from business structures in order to strengthen the country's technological sovereignty.

WAYS FOR ENHANCING STATE SUPPORT FOR RUSSIA'S TECHNOLOGICAL INDEPENDENCE UNDER SANCTIONS PRESSURE

Under the current conditions, state support for domestic industrial enterprises — which often face a shortage of accessible financial resources necessary for technological modernization — has become a strategically important direction of the economic policy of the Russian Federation. In order to mitigate the limitations associated with replacing lost imported supplies and to reduce technological dependence on external sources, the state is developing and implementing a comprehensive set of measures that

includes financial-credit and institutional instruments.

Among these, particular attention should be given to the Special Investment Contract (SPIC), which represents a public–private partnership mechanism aimed at stimulating investment inflows into the national industrial sector and involves the conclusion of a long-term agreement between an investor and the state. Under this framework, the investor assumes obligations to implement an investment project focused on the creation, development, or introduction of industrial products in Russia using advanced technologies. In return, the state commits to ensuring the stability of the regulatory environment and providing corresponding support measures. The initial version — SPIC 1.0 — was introduced at the end of 2014 as an anti-crisis measure in response to deteriorating external economic conditions. In 2019, it was transformed into SPIC 2.0, which is primarily oriented toward the introduction and development of high-technology production, as well as the localization of critically significant technologies. At present, both versions of the contract operate in parallel, allowing for the consideration of the specific features and implementation stages of previously concluded agreements[2].

Special attention within state support measures is devoted to the development of R&D through the reimbursement of industrial enterprise expenditures. Subsidy programs are also provided, targeting innovative projects characterized by a high degree of scientific novelty and technological complexity. This includes support for projects implemented in partnership with research organizations and higher education institutions[3].

Programmatic policy documents confirm that a key objective of the state policy of the Russian Federation remains a focus on systematic support for R&D, which is regarded as the most effective instrument for stimulating industrial development and for creating high-technology, competitive products with a high degree of localization. For instance, under a Government Order of the Russian Federation, enterprises developing innovative projects in priority industrial sectors were allocated 5 billion rubles from the reserve fund. This financing provides for the reimbursement of a portion of expenditures associated with all stages of the innovation-driven production cycle, from procurement to the market introduction of products[4]. Particular emphasis is placed on the development of products capable of substituting imports under external constraints.

APPROACHES TO DEVELOPING A MECHANISM FOR IMPLEMENTING TECHNOLOGICAL SECURITY SUPPORT MEASURES

When considering the stimulation of technological development in the context of ensuring national technological security, it should be emphasized that this is a complex and multi-level process, the implementation of which depends on consistent efforts in three key directions:

- the identification and priority development of critical industrial sectors with the greatest potential;
- the development and accelerated deployment of competitive domestic technologies;
- the strategic interaction between science and production, ensuring technological leadership under conditions of external constraints [3].

Accordingly, the establishment of an effective mechanism for implementing technological security support measures is associated with the need for:

- the concentration of substantial volumes of diverse resources in knowledge-intensive industries that are critically important for the economy;

[2] Support measures. Ministry of Industry and Trade of the Russian Federation. URL: https://minpromtorg.gov.ru/merpod (date of access: 15.05.2025).

[3] Ibid.

[4] Order of the Government of the Russian Federation of 18 October 2023 № 2887-r. URL http://static.government.ru/media/files/6JD6YkGDstpVGO66rjZ4W7ajlNHrZDPq.pdf

• breakthroughs in R&D and the scaling of results (prototype solutions) to serial production;

• further digital transformation;

• organizational reforms aimed at creating innovative production capacities, overcoming bureaucratization, and ensuring that the human resource base meets new technological requirements;

• state support for the development of advanced technologies and high-value industrial products;

• legal protection of intellectual activity, among other measures.

At the same time, large-scale progressive transformations in the industrial sector are associated with a wide range of risks related to scientific, technical, and technological security, including financial, organizational, legal, political, social, and environmental risks, as well as the potential relocation of scientific research abroad. This requires highly professional efforts aimed at preventing such risks and minimizing adverse consequences.

A separate and highly important task is the assessment of technological security through the application of relevant instruments and measures that make it possible to determine the degree of vulnerability and resilience of technical systems to risks and threats. At the level of companies and large industrial enterprises, local regulatory acts are typically adopted to define and govern procedures for assessing technological risks and technological security. As a methodological approach, the systematic implementation of the following stages may be proposed: 1) analysis of the condition of the material and technical base and industrial-technological infrastructure; 2) assessment of human resource capacity for technological security and the level of competencies of responsible personnel; 3) analysis of financing measures and expenditure dynamics related to equipment protection, insurance, and certification in the field of technological security, in particular in accordance with standards such as GOST 12.3.002–75 "Production Processes. General Safety Requirements" and GOST 12.3.047–98 "Fire Safety of Technological Processes," which regulate requirements for technological documentation and the training of responsible staff; 4) assessment of the operational effectiveness of technological security systems; 5) ensuring technological compliance; 6) determination of the overall risk level based on qualitative and quantitative assessments (typically ranked as high, medium, low, or negligible).

Contemporary approaches also include the assessment of the maturity of technologies and technical systems, which is recommended particularly in cases where an enterprise has implemented a technological security compliance system. Key aspects of such an assessment include, first, the collection, analysis, and synthesis of data (including information obtained through monitoring); second, comparison with approved regulations and standards (including those established by Rostekhnadzor); and third, the development of recommendations to support decision-making aimed at enhancing the level of technological security. The practical application of this methodology enables proactive responses, the identification of vulnerabilities and additional threats, and the elaboration of measures to minimize or sustainably eliminate them.

The methodological principles for determining the level of technological security include:

1. a preliminary assessment of the degree of critical technology utilization and technological development within industrial enterprises;

2. the development of alternative options and scenarios;

3. the comprehensiveness and integrative character of the evaluation;

4. the potential emergence of new technological threats, including global ones;

5. the availability of the necessary expert competencies.

Thus, ensuring the technological security of Russian industry is possible only through the comprehensive implementation of state policy — integrating the efforts of manufacturers, technology developers, and the scientific community — together with financial support for innovation, which will contribute to the formation of a favourable institutional environment.

CONCLUSION

The analysis conducted within the framework of this study demonstrates that state policy in the fields of industrial growth, import substitution, and technological sovereignty is based on a comprehensive approach that includes the implementation of support measures for research and development activities in priority sectors and their systematic stimulation. The current vector of Russia's industrial policy is aimed at ensuring a rapid response to external constraints and at forming a resilient domestic scientific and technological base.

Statistical data confirm the presence of positive shifts, including an increase in industrial output and a reduction in import dependence. However, in certain sectors — particularly pharmaceuticals and extractive industries — a high level of technological vulnerability persists, requiring the continuation of targeted modernization and localization policies. Therefore, strengthening technological sovereignty is possible through the activation of such development factors as innovation, digital sovereignty, the formation of small technology companies, increased budgetary financing of industrial projects aimed at technological independence, the provision of preferential technological loans, special support measures for technological start-ups, and the localization of industrial production.

Taking into account contemporary problems, challenges, and threats, the Government of Russia has adjusted the national strategy for scientific and technological development, on the basis of which national projects aimed at technological sovereignty are being formulated.

The theoretical significance of the present study lies in its contribution to the advancement of knowledge regarding the formation and implementation of programs to ensure the technological security of Russian industry under current economic conditions. The results obtained are of practical value for managerial personnel at various levels, members of the academic community, and business-sector specialists involved in the development of the industrial complex.

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Regulatory Management: Weaknesses and Potential for Improvement

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ABSTRACT

Designing and implementing a regulatory management system (RMS) that both promotes a country's socio-economic development and is perceived as legitimate is a fundamental aspect of good governance. This analytical study reviews historical and contemporary theoretical works on the interaction between economic, institutional, and social factors of regulation, with a particular focus on developing countries. It argues that, alongside economic factors, both formal and informal institutional elements must be considered when designing and implementing an RMS — an issue of even greater significance for developing economies. **The purpose of the study** is to identify key elements and constraints in implementing regulatory governance, including those specific to developing countries, and to situate these within broader governance and management contexts. The research uses both quantitative and qualitative methods, resulting in the ability to triangulate the results. As a result, it proposes an analytical framework that integrates theoretical and practical insights to highlight the weaknesses and potential for improvement in designing and implementing effective regulatory management systems. **The research outcome**, the confirmation of including formal and informal institutional factors, beyond the purely economic factors, benefits both theory of regulation as well as the regulatory management practitioners.
Keywords: regulatory management system; socio-economic development; developing countries; institutional environment; transparency

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INTRODUCTION

A regulatory management system (RMS) is a systematic approach to improving the quality of regulation within a country. It involves the coordinated, collaborative, and transparent design and implementation of regulatory policies, institutions, processes, and instruments, as well as the measurement of their results. The implementation of an RMS should incorporate lessons drawn from both theory and practice, addressing weaknesses identified in existing academic research and practical experience. This article expands the study of RMS by focusing on elements that are particularly relevant to developing countries. Its main objective is to identify and systematize the key elements and principles of an effective RMS and, based on this analysis, to propose an analytical framework for designing and implementing systems that deliver inclusive socio-economic benefits. The study also integrates into the RMS several cross-cutting factors such as governance quality, management capacity, and administrative competence and situates them within the broader principles of good governance. This makes the research relevant to contemporary regulatory management challenges faced by both developed and developing countries. The article further contributes to the literature by addressing existing gaps concerning both what and how to analyze when examining the influence of the institutional environment on regulation. Building on these conceptual foundations, the subsequent sections develop an analytical framework for assessing the impact of institutional factors on regulation and apply it to the case of Bangladesh. The analysis reveals that adherence to RMS meta-principles in Bangla-

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desh has been largely superficial. Although there have been noticeable improvements in infrastructure regulation, they remain limited compared to those in developed countries. Moreover, these improvements are often de jure rather than de facto, as enforcement and practical implementation continue to lag behind OECD standards.

The literature review identifies several gaps that inform the development of an analytical framework capable of capturing the effects of institutional environments on regulation. As previous research suggests [1–6], understanding institutional context is crucial for designing appropriate regulatory frameworks for developing economies. However, because levels of institutional development and resource availability vary widely across countries, there can be no universal approach to regulation. Instead, analytical frameworks must be adapted to each country's specific institutional and regulatory context. Consequently, this article develops such a framework, drawing on elements of the "ideal model" of RMS, insights from regulatory practice, and factors specific to developing countries

METHODOLOGY

To achieve the stated objectives, the study employed several complementary research methods and analytical approaches. A historical analysis was used to trace the evolution of regulatory management and to systematize the principles of RMS as presented in earlier research. This was combined with comparative and qualitative analyses to evaluate how different constitutive elements influence the effectiveness of RMS implementation and its contribution to socio-economic development. After identifying these elements, a tailored analytical approach was developed to account for the specific characteristics of each country's regulatory and institutional framework. The study then designed an analytical framework aimed at addressing the identified gaps in the literature and capturing the impact of the institutional environment on regulation. This framework was subsequently applied to the case of Bangladesh, allowing for an empirical assessment of its practical relevance and explanatory potential. The analysis also incorporated the meta-principles of good regulation, operationalized through three dimensions (*Table 1*):

Development of regulatory content — examined through the historical evolution of regulatory models and institutions, their independence, effectiveness, and resulting regulatory outcomes.

Formal institutional context — analyzed in terms of the role of government, the judicial system, predictability, and institutional capacity.

Informal institutional context — evaluated through social factors such as equality, transparency, accountability, trust, customs, participation, and public consultation.

RESULTS

Based on the selected methodology, the results identify the key elements, principles, and building blocks of an analytical framework designed to achieve effective regulatory outcomes. The construction of the RMS framework draws on theories of regulation and institutions, the concept of the "ideal regulatory system," practical regulatory experience, and elements specific to developing countries. These components are elaborated in the following subsections.

Elements of Theories of Regulation and Institutions

A review of regulatory theories reveals a persistent gap in academic research an excessive focus on economic principles at the expense of institutional considerations. Infrastructure governance refers to the processes, instruments, and norms guiding interaction, decision-making, and monitoring by governments or independent regulatory authorities (IRAs) in delivering infrastructure to the public. It encompasses both the internal operations of public institutions and their interactions with the private sector, users, and citizens.[1] Governance thus spans the entire cycle of infrastructure provision, from planning to decision-making [7].

[1] Organisation for Economic Co-operation and Development (OECD). 2015. *Internal interactions of state institutions and their interactions with the private sector, users, and citizens*.

Table 1

Elements for Achieving Regulatory Legitimacy

Elements of achieving regulatory legitimacy	Development of the content of Regulations	Formal institutional context	Informal institutional context
High-level meta-principles	Efficiency	Opportunities, Obligations	Balanced social interests, equality, trust
Key principles of regulation	Economic principles of introducing market forces and competition into regulated sectors	Role of government, the judicial system, predictability of regulation, capacity	Social factors, equality, transparency, accountability, participation.
Possible indicators	Efficiency, independence, regulatory results	Government corruption, bureaucratic capacity, government stability	Accountability and voice, social risks, inequality, consultation.

Source: compiled by the authors.

The regulatory system extends beyond the formally appointed regulatory body. It is a broader construct comprising institutions, laws, and mechanisms of government control over the operational and investment decisions of enterprises. The primary and most fundamental task of new infrastructure regulators remains economic regulation [8]. Within the domain of regulatory content or economic regulation, the main objectives include oversight of tariff structures, service quality standards, network access conditions, market entry and exit rules, and investment obligations for both existing and new participants [8].

Beyond normative content, regulatory tasks also involve regulatory governance — the organizational characteristics, institutional rules, procedures, and practices that guide regulatory decision-making and behavior [9]. The purpose of this article is therefore to define the constituent elements of an analytical framework that reflects the influence of regulatory structure, regulatory content, and regulatory management on overall regulatory performance (*Fig. 1*).

This part of the research focuses on identifying the key design, content, and governance elements that underpin regulation across all aspects of its substantive content and procedural processes [9–13].

In light of the broader literature, this article proposes that an analytical framework for examining regulation in developing countries should incorporate additional elements such as regulatory capacity building, protection of property rights (as part of formal institutional components), and anti-corruption measures, along with participation and consultation of all stakeholders, including service users (as part of informal institutional components).

Elements of the "Ideal Model" of the Regulatory System

High-Level Principles of the Regulatory Management System

The overall objectives of a regulatory system are to establish a framework that is effective, efficient, transparent, and accessible. The European Commission's Principles of Good Governance emphasize openness, participation, accountability, efficiency, and consistency as key principles. Similarly, the UK Better Regulation Task Force (BRTF)[2] identifies five "principles of good regulation": transparency, consistency, proportionality, targeting, and accountability [8, 11, 14]. The Australian Competition and Consumer Commission (ACCC) also codifies a set of best-practice principles for sound regulation (*Annex, Table*).

Operating Principles of the "Ideal Model" of the Regulatory System

Regardless of the institutional structure a regulatory system adopts, it can only be effective if it adheres to three fundamental meta-principles of regulatory governance [8]:

Meta-principle 1: Credibility. Investors must

[2] BRTF. Principles of Good Regulation. European Business Review. DOI: 10.1108/ebr.1998.05498cab.002

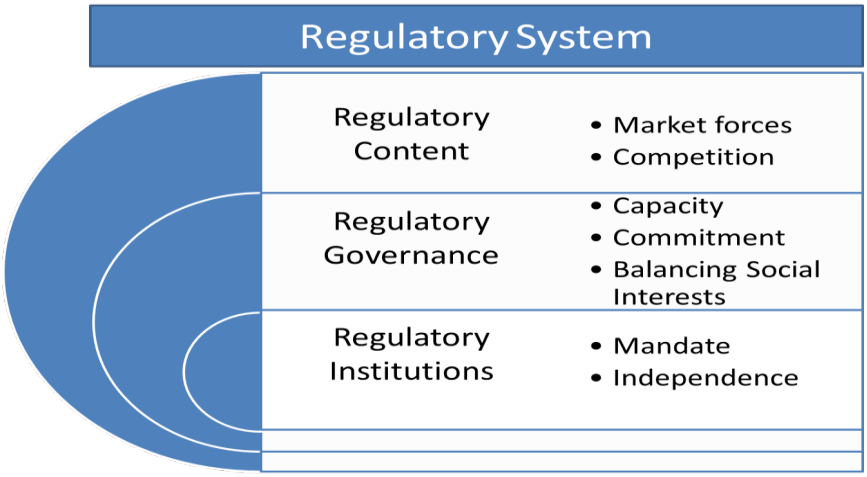


Fig. 1. **Key structural Elements of the Regulatory System**

Source: compiled by the authors.

have confidence that the regulatory system will fulfill its commitments.

Meta-principle 2: Legitimacy. Consumers must trust that the regulatory system will protect them from monopoly power, whether manifested in high prices, poor service quality, or both.

Meta-principle 3: Transparency. The system must operate openly so that investors and consumers understand the terms and conditions of transactions.

In addition to these governance principles, the normative content of regulation should include a fourth meta-principle:

Meta-principle 4: Efficiency. The regulatory system should promote both pricing and production efficiency, ensuring that economic resources are used optimally.

Relationship Between High-Level Meta-Principles and Operational Principles of Regulation

While meta-principles represent the overarching standards that any effective and sustainable infrastructure regulatory system must satisfy [8], the operational principles derived from them (*Table 2*) correspond to specific dimensions of the regulatory framework. These operational principles can be applied in empirical analysis and serve as practical guidelines for evaluating the performance and effectiveness of regulatory systems across different institutional contexts.

The three meta-principles, when fully satisfied, provide a regulatory system with the overall legitimacy necessary for its survival — without which it cannot endure, even if it is technically competent. Legitimacy depends on consumers' and investors' trust that the regulatory system upholds their shared values and interests. Even when regulators act in good faith to protect consumer welfare, public confidence is undermined if stakeholders do not clearly understand what the regulator or the government has agreed upon [8]. Transparency, accountability, participation, and consultation are therefore essential principles for building and maintaining consumer trust. They are equally vital for the long-term sustainability of any regulatory system, as "transparency is the first step toward a nation's confidence and well-being and its ability to compete" [15].

Elements of Regulatory Practice — Operationalizing the Three Principles of RMS

The operating principles of the RMS influence all three core components of the regulatory system: regulatory content, regulatory governance, and regulatory structure (*Table 3*).

Regulatory Content — Economic Principles of Regulation

Regulatory content refers to the substantive scope of regulation, encompassing decisions and standards related to tariff levels and structures, service quality, social obligations, and customer complaint mechanisms. It also includes requirements governing investment and connection obligations, conditions for network access by new and existing participants, metering systems, periodic reporting, and the assessment of regulatory

Table 2

General and Operational Principles of Regulation

Meta-principles of high-level regulation	Key operational principles of regulation
• *Meta-principle 1: Credibility* • *Meta-principle 2: Legitimacy* • *Meta-principle 3: Transparency* • *Meta-principle 4: Efficiency*	Independence
	Accountability
	Transparency and public participation
	Predictability
	Clarity of roles
	Completeness and clarity of rules
	Capacity
	Necessary powers
	Relevant institutional characteristics
	Honesty

Source: compiled by the authors based on [8].

impacts on both customers and utilities (*Fig. 2*). Regulatory content represents the outcome of decisions made by the regulator or other government authorities [8]. One of the fundamental challenges associated with regulatory content lies in the mechanisms of regulatory control, which determine the extent of discretion that regulators possess over areas such as tariff setting.

Authors of [16] argue that, in most developing countries, clearly defined mechanisms should be established to limit regulatory discretion, particularly during the early stages of a regulator's operation when entering into regulatory contracts and concessions to ensure consistency and predictability. Conversely, other scholars contend that a certain degree of regulatory discretion is both inevitable and desirable. As A. Eberhard notes [17], "the fundamental problem is therefore how to design governance mechanisms and procedures that allow a non-trivial degree of constrained and accountable discretion."

Regulatory Governance — Processes

Regulatory governance refers to the institutional arrangements and decision-making processes that define how regulation is carried out within a

Table 3

Principles of Regulation — Content, Management and Institutions

Normative Content	Regulatory Management	Regulatory Agencies
Tariff levels.	Independence and accountability of the regulator.	Independence
Tariff structures.	Relationship between regulator and politicians.	Mandate
Automatic and non-automatic cost transfer mechanisms.	Autonomy of the regulator.	Efficiency
Quality of service standards.	The processes — formal and informal — through which decisions are made.	Organizational structure
Handling consumer complaints.	Transparency of decision-making by the regulator or other organizations making regulatory decisions.	Staffing
Investment or connection commitments and reviews.	Predictability of regulatory decision making.	Financial stability
Network access conditions for new and existing customers.	Accessibility of regulatory decision-making.	
Accounting systems.	Organizational structure and resources available to the regulator.	
Social obligations.		

Source: compiled by the authors based on [8].

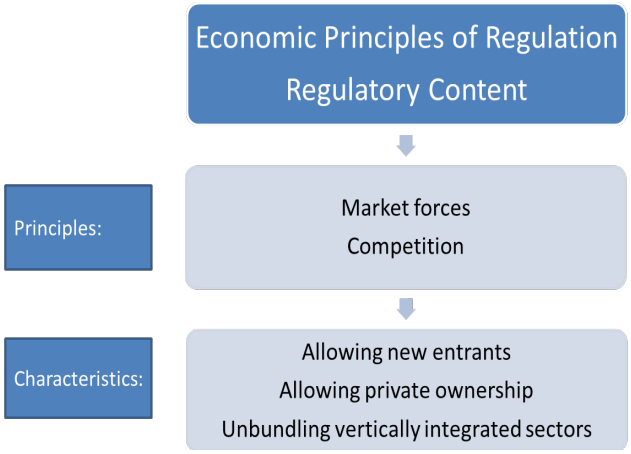


Fig. 2. **Normative Content**

Source: compiled by the authors.

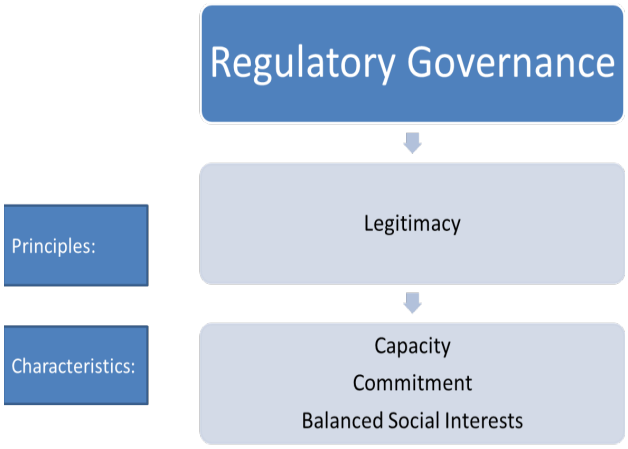


Fig.3. **Regulatory Governance**

Source: compiled by the authors.

regulatory system [8]. It encompasses several key dimensions: the relationship between the regulator and policymakers (including the regulator's independence, autonomy, and accountability); the formal and informal processes through which decisions are made; the transparency and accessibility of regulatory decision-making; and the organizational structure and resources available to the regulator.

Regulatory governance is shaped by the laws, procedures, and administrative practices that guide regulatory actions (*Fig. 3*). Effective regulatory governance ensures that improving the quality of regulation is a continuous governmental responsibility rather than a one-time reform effort. As Ladegaard and Jacobs emphasize [18], "institutional capacity must be built around a clear vision of the proper use of regulation in society."

Regulatory Institutions — Regulatory Structure

This section examines the elements of the institutional environment that influence regulation as essential factors in implementing the economic principles of regulation, which form the substantive content of regulatory systems. Regulatory effectiveness can be enhanced by improving the regulatory structure so that investors, operators, and consumers all benefit from a system in which governance aligns with the degree of regulatory discretion, the level of regulatory commitment, and the quality of the institutional environment. Effectiveness can also be strengthened through independent evaluations of regulators and sustained initiatives aimed at building long-term regulatory capacity.

A key distinction between regulation by an independent regulatory authority (IRA) and regulation by government agencies lies in the IRA's statutory mandate to promote market forces, competition, and private-sector participation, as well as its legislative independence in fulfilling that mandate (*Fig. 4*).

However, regulators may exist in different institutional forms either as departments within government ministries or as autonomous entities. This study analyzes the external economic and governance principles affecting regulators, regardless of their institutional form, emphasizing that

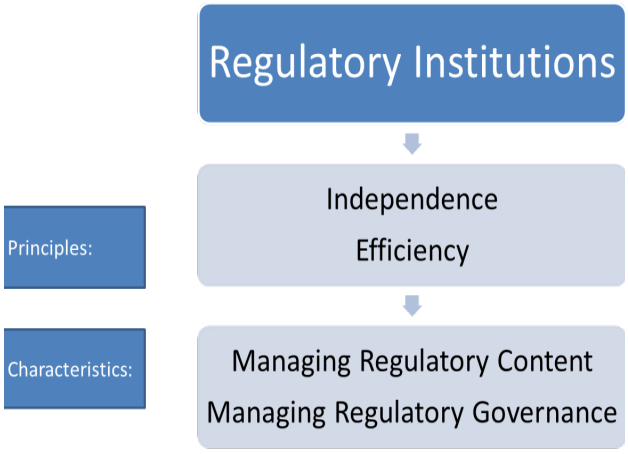


Fig.4. **Regulatory Institutions — Regulatory Design**

Source: compiled by the authors.

the core determinant of effectiveness is regulatory independence. While high levels of independence are typically expected in developed countries due to stronger safeguards against regulatory capture, one of the major weaknesses of the IRA model in developing contexts remains the lack of genuine independence [8].

Elements Specific to Developing Countries

Regulatory reform in developing countries has often been unstable and uneven [19]. Many post-privatization regulatory reforms are still in the process of being designed or implemented, and in some cases, their effectiveness has yet to be fully assessed. The main institutional failures constraining regulation in developing economies can be grouped into four broad categories: limited regulatory capacity, limited commitment, limited accountability, and limited fiscal efficiency. While similar challenges can also appear in developed countries, they are generally secondary. In contrast, in developing contexts, the scale and severity of these constraints often dominate regulatory outcomes.

The OECD's ETRC indicators[3] provide a structured approach to operationalizing the channels through which regulation affects infrastructure outcomes. These indicators capture the quality of regulation and regulatory policy across key areas such as entry conditions, public–private ownership structures, market unbundling, and overall market structure, offering valuable comparative data for assessing regulatory performance and reform progress.

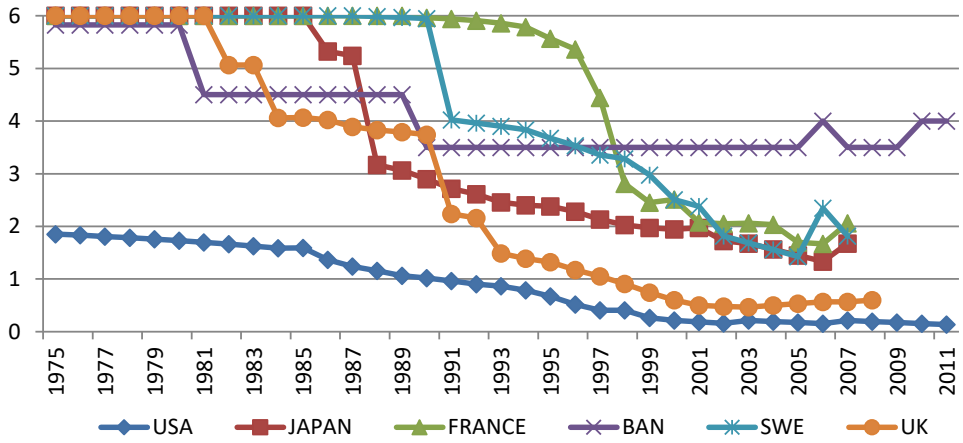
The independent regulatory agencies examined in this study in the energy and telecommunications sectors are the Bangladesh Telecommunication Regulatory Commission (BTRC) and the Bangladesh Energy Regulatory Commission (BERC). Comparing the development curves of these sectors in Bangladesh (*Fig. 5 and Annex, Fig.*) reveals a pattern common to many developing countries: regulatory simplification processes begin relatively late but proceed rapidly in an apparent effort to catch up with the developed world. Similar trajectories have been observed in countries such as the United Kingdom, Canada, and New Zealand, while Japan and Sweden initiated reforms slightly later, in the late 1980s and early 1990s. Once the effectiveness of these models in improving service delivery was recognized, they became a blueprint promoted to developing countries by international development organizations.

Traditional regulatory theories, as embedded in international organizations' recommendations, emphasize economic principles of regulation as key to successful reforms. However, the impact of these principles on regulatory outcomes, investment, and output in developing countries remains poorly understood. Laffont (2005) highlights the risk of collusion and critiques the assumption that regulators and governments act as benevolent welfare maximizers, underscoring the importance of considering the institutional environment when implementing regulation in developing contexts.

In addition to general implementation challenges, developing countries face specific institutional constraints:

- Limited regulatory capacity: Regulatory agencies often lack the ability to recruit and retain qualified staff, which hampers policy development and implementation [20].
- Limited commitment: Institutional frameworks in many developing countries do not support reliance on contracts, as evidenced by frequent renegotiations [21]. Regulatory discipline often includes intangible elements, making depoliticization difficult [22]. Fears of politicization and future contract renegotiation discourage private sector participation.
- Limited accountability: Regulatory institutions in developing countries are often less accountable than those in developed nations. Weak accountability increases the risk of collusion between government actors and interest groups, including regulated firms [23, 24]. Evidence of corruption in both privatization and regulatory processes is widespread [25].
- Limited independence: IRAs in developing countries frequently lack genuine independence

[3] URL: https://www.oecd.org/content/dam/oecd/en/topics/policy-sub-issues/product-market-regulation/DRAFT%20ETCR%20Explainer.pdf



Units for vertical axis are between 0 – least restriction and 6 – most restriction in the corresponding infrastructure sector. This is now made clear in the figures.

Fig.5. **Bangladesh Telecommunication Sector Regulation Historical Data in comparison with OECD countries**

Source: compiled by the authors based on OECD indicators and own indicators on Bangladesh.

due to interference by government and special interests. This problem is compounded by insufficient protection of property rights, limited resources, inadequate technical expertise, and restricted ability to exercise regulatory powers effectively [8].

The Analytical Framework for Designing and Implementing RMS

To visualize the systematized elements, principles, structures, actors, and relationships, an analytical framework is presented here (*Fig. 6*) to capture the impact of the institutional environment on regulation in Bangladesh. The framework achieves this by: 1) examining the development of infrastructure regulation based on economic principles promoted by international organizations; 2) analyzing the formal institutional environment and the principles that facilitate the implementation of these economic regulatory principles; and 3) exploring the influence of informal institutions on the application of economic principles in regulation.

This framework was developed specifically for the case study of Bangladesh and builds on previous work by Sumkoski (2016a, 2016b, 2016c), providing a structured approach to designing and implementing regulatory management systems that account for both formal and informal institutional factors.

ANALYSIS AND DISCUSSION

This study systematizes RMS theoretical principles into an operational analytical framework for designing and implementing regulatory management systems. While grounded in economic principles, the framework also ensures legitimacy by incorporating formal and informal institutions within IRA bodies, regulatory processes, and the development of trust, which collectively reinforce the legitimacy of the RMS. The limited success of many liberalization and privatization initiatives in developing countries can be attributed to "the recognition that in many cases the problem was that reformers ignored the functioning of regulatory institutions, implicitly assuming that they would work as in developed countries" [2]. Although the IRA model has become the standard approach, it is not the only legal or operational model capable of satisfying meta-principles, as a range of institutional arrangements can be "compatible with higher-order regulatory principles" [26]. For legal, political, cultural, and practical reasons, it is unrealistic to expect many developing and transition countries to automatically establish fully functioning independent regulators [8].

Differences Between State Regulation and Regulation Through Independent Agencies

In some countries, regulatory functions remain within government ministries, as governments either directly own or exert significant control over infrastructure companies. Typically, sectoral ministries exercise broad and sometimes arbi-

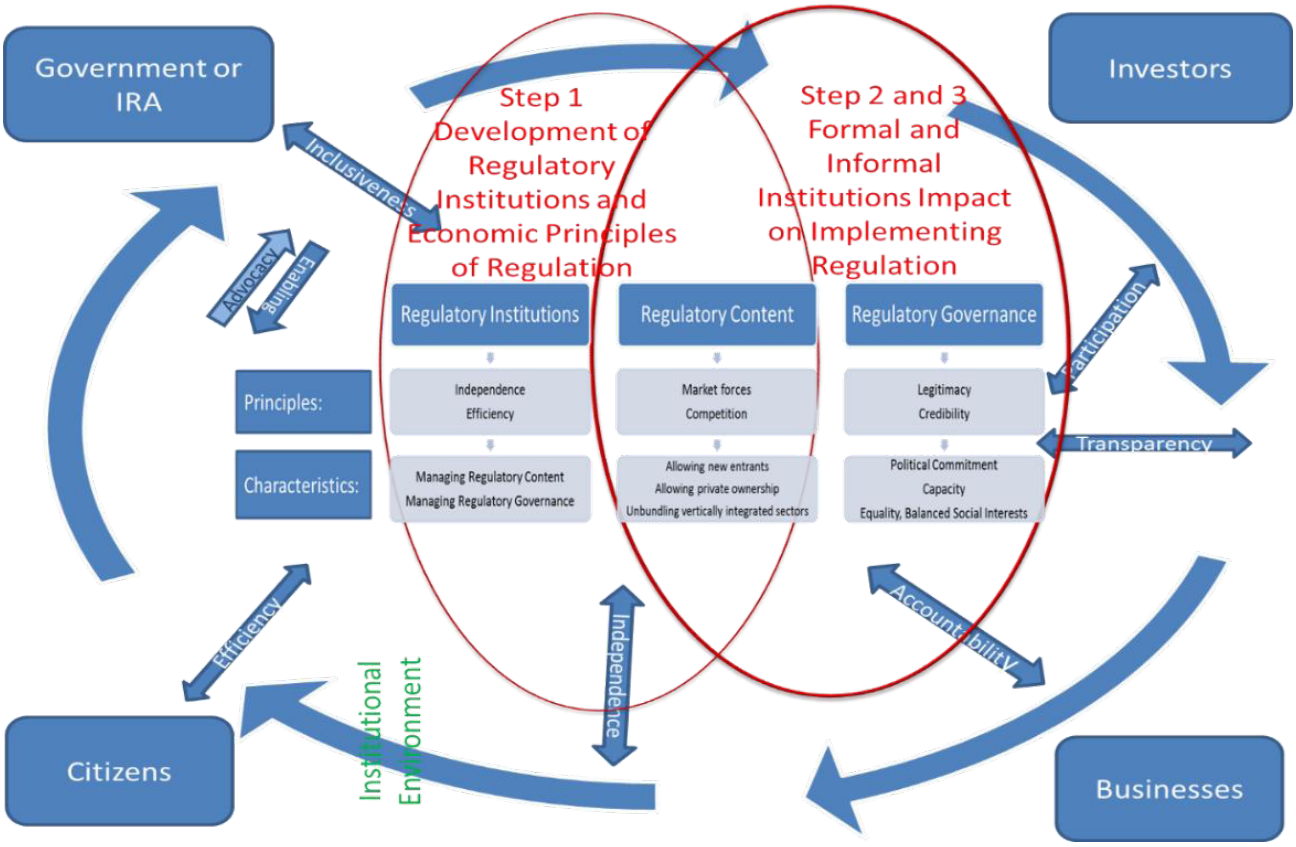


Fig.6. **Operationalizing the Analytical Framework for Designing and Implementing RMS in Bangladesh**

Source: compiled by the authors.

trary authority over one or more state-owned infrastructure entities. The absence of competition and bureaucratic inefficiencies often leads to declining service quality and rising costs. This traditional model is deeply entrenched in developing countries and is unlikely to be replaced quickly.

With the expansion of private sector participation in infrastructure since the early 1980s, a new regulatory model based on independent regulatory agencies (IRAs) has emerged. IRAs generally operate as separate bodies with a degree of autonomous decision-making over traditional regulatory tasks. One of the most significant contributions of IRAs is the opening of decision-making processes that were previously closed to public scrutiny [27]. They introduce procedures such as consultation documents, solicitation of stakeholder comments, and public debates, which increase transparency, disseminate knowledge about regulation, and promote more participatory and accountable governance.

Good Regulation for Higher Investment in Regulated Sectors

A notable observation is that, contrary to the common assumption that improved regulation drives investment and economic growth, evidence from multiple countries indicates that investment often declines in the 1–5 years preceding infrastructure regulatory reform (*Fig. 7*). This decline frequently triggers and accelerates regulatory reform, as governments seek to prevent prolonged reductions in infrastructure investment. This pattern suggests that regulatory reform is not merely a matter of strategic choice or visionary planning, although these factors play a role. Rather, it reflects the necessity for governments to secure political support and maintain goodwill by attracting or at least demonstrating a willingness to attract investment in infrastructure that benefits citizens.

The process is further complicated by the absence of immediate investment inflows following

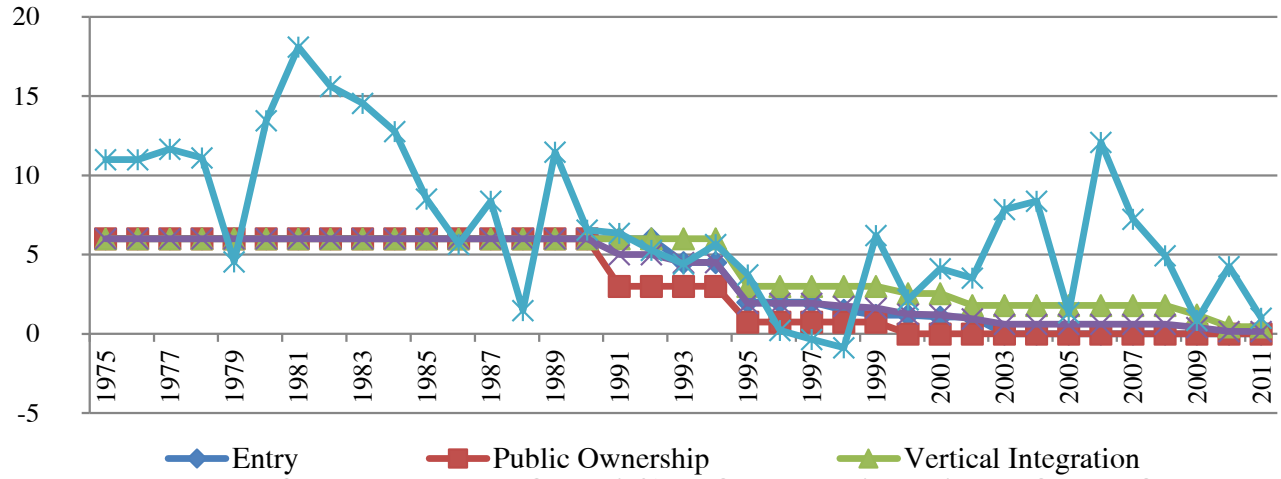


Fig. 7. **Investment Growth Rates, Annual Growth in% and Standard Indicators in the US Energy Sector**

Source: compiled by the authors based on OECD indicators and investment data from the IMF, OECD, WDI.

reforms, indicating that investors are not always ready to respond instantly to regulatory changes. In practice, simplified regulations alone are insufficient to generate an immediate surge in investment; other complementary factors are required to stimulate investor confidence and engagement.

Investors seek continuous improvements in de jure regulation that are reflected in reality. They expect a long-term commitment to maintaining reforms and want to see whether regulators deliver tangible improvements in the regulatory environment, reinforcing confidence in real progress. A significant challenge in developing countries, including Bangladesh, is the mismatch between de jure and de facto regulation. Limited political commitment, institutional capacity, and enforcement mechanisms hinder the full implementation of reforms. Although regulatory improvements in Bangladesh's three main infrastructure sectors are noticeable, they still lag behind developed countries, as many reforms remain largely on paper and are only partially implemented in practice compared to OECD standards [28][4] (*Fig. 5 and Annex, Fig.*).

The Lack of Success of RMS Through IRAs in Developing Countries

Despite the theoretical benefits of transparency, independence, and public engagement, RMS often fail in developing countries due to interconnected political, institutional, and structural challenges [29]. IRAs in these contexts frequently lack insulation from political influence, preventing them from functioning as neutral, technocratic bodies, as envisioned in Thatcher's model. Key factors contributing to these difficulties include:

a) weak political and institutional independence: IRA leadership is often appointed by political actors, and regulatory outcomes may reflect government agendas rather than public interest;

b) short tenures or insecure employment for IRA leaders: These conditions undermine the ability to resist political pressure and implement consistent long-term policies;

c) regulatory capture: Corporate or political interests can influence IRAs through "revolving door" dynamics or patronage-based appointments, compromising the meritocratic selection of regulators;

d) capacity constraints and resource limitations: Staff may lack the technical expertise required for effective regulation;

e) low transparency and weak public participation: Minimal or symbolic mechanisms exacerbate information asymmetries, reducing accountability.

[4] The OECD infrastructure model has been used in research on developing countries to show relations between regulation and investment, but has been hampered by having only a single year data available. URL: https://clck.ru/3Q56du; URL: https://www.greaterauckland.org.nz/wp-content/uploads/2010/02/OECD-infrastructure-study.pdfSutherland; URL: https://ec.europa.eu/economy_finance/events/2011/2011-11-21-annual-research-conference_en/pdf/session012_crafts_en.pdf/

Table 4

Principles of Good Governance

The EU Commission's principles of «good governance» (CEC, 2001)*	(ADB, 2009)**	(UN ESCAP, 2009)***	UK Better Regulation Task Force (BRTF) ****
Accountability	Accountability	Accountable	Transparency
Participation	Participation	Joint	Accountability
Coherence	Predictability	Responsive	Proportionality
Openness	Transparency	Transparent	Consistency
Efficiency		Effective	Targeting
		Inclusive	
		Fair	
		Consensus-Oriented	

Source: compiled by the authors.

Note: * — European Governance: A White Paper. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52001DC 0428
** — Sustainability Report. Asian Development Bank (ADB). 2009& https://www.adb.org/sites/default/files/institutional-document/31390/sr2009.pdf; *** —) *What is good governance?* UN.ESCAP. 2009. URL: https://hdl.handle.net/20.500.12870/3794;
**** — BRTF — Better-Regulation-Task-Force. Principles of Good Regulation. European Business Review. URL: https://www.emerald.com/ebr/article/doi/10.1108/ebr.1998.05498cab.002/98967/Better-Regulation-Task-Force-publishes-critic-s

A fundamental reason for RMS failures in developing countries is the mismatch between imported regulatory models and local realities. The European IRA model often does not align with the institutional and political contexts of developing countries. Externally imposed structures, such as those promoted by international donors or privatization agreements, are frequently adopted on paper without genuine empowerment or support. International organizations, including the World Bank and IMF, have historically encouraged the adoption of IRAs as part of broader economic reform programs. However, these models are often transplanted without sufficient adaptation to local contexts, resulting in regulatory bodies that exist formally but lack authority, resources, or legitimacy. Dubash and Morgan describe such institutions as "hollow institutional shells", highlighting their superficial establishment without substantive operational capacity [30].

Regulatory reforms in Bangladesh confirm these findings. Although the country has adopted international regulatory models and principles, the expected outcomes have yet to materialize [29]. Despite continuous economic growth, Bangladesh's administrative and political apparatus remains bureaucratic, clientelist, and susceptible to capture. Structural gaps persist between de jure and de facto regulatory policies due to incomplete enforcement of government rules [31, 32].

RMS and Cross-Cutting Governance Issues

Management and Good Governance

The concept of good governance is essential for ensuring three fundamental prerequisites: collective action, contract enforcement, and protection of property rights [33]. Good governance is generally characterized by participation, consensus-orientation, accountability, transparency, responsiveness, effectiveness and efficiency, fairness and inclusiveness, and the promotion of the rule of law.

Definitions of governance vary according to social and economic structures.[5] Fukuyama (2013)

[5] World bank. Reforming public institutions and strengthening governance. URL: https://documents.worldbank.org/en/publication/documents-reports/documentdeta

provides a narrower definition, viewing governance as the capacity of government to set and enforce rules and deliver services. In mainstream academic discourse, governance is understood as the process of making and implementing decisions, emphasizing the role of actors involved in decision-making and implementation [34]. Kaufmann, Kraay, and Mastruzzi define governance as the traditions and institutions through which power is exercised in a country [35]. Their World Governance Indicators (WGI) measure:

- the process by which those in power are selected, supervised, and replaced;
- the ability of government to formulate and implement sound policies and deliver public services effectively;
- the respect of citizens and the state for institutions governing economic and social interactions.

Good governance also encompasses the role of public authorities in shaping the environment in which economic actors operate, determining the distribution of benefits, and managing the relationship between the ruler and the governed.[6] According to the World Bank, good governance is reflected in predictable, open, and informed policies; a professional and impartial bureaucracy; an accountable executive branch; and a strong civil society participating in public affairs, all under the framework of the rule of law.[7]

Dixit emphasizes that good economic governance ensures the same three prerequisites — collective action, enforcement of contracts, and security of property rights which help minimize corruption, consider minority views, and ensure the voices of the most vulnerable are included in decision-making [33] and for comparison we list the principles of good governance adopted by various international organizations (*Table 4*).

Principles of Good Infrastructure Regulation

According to Andres et al. (2008), the literature on good governance emphasizes three main aspects of regulatory systems:

1. Independence from political authorities and autonomy in management.
2. Accountability mechanisms, both to other branches of government and to the public.
3. Transparency in rule-making and decision-making procedures.

Within these categories, indicators range from simple measures, such as the legal instruments establishing the agency, to more complex mechanisms designed to improve regulatory quality [36]. Strengthening governance can enhance regulatory outcomes, reduce the burden on regulated entities through better administration, improve compliance, and enable targeted enforcement. It also mitigates actions by actors working against community interests [37].

According to the OECD,[8] good governance provides the following benefits for regulation:

- strengthening the legitimacy and integrity of regulators by aligning with high-level policy objectives, leading to better outcomes;
- ensuring transparency of the regulatory system within national governance structures;
- improving overall efficiency of regulation;
- promoting coordinated efforts and supporting the legitimacy of necessary enforcement actions.

In conclusion, for RMS to succeed in developing countries, reforms must go beyond simply copying institutional forms from Europe or the West. Successful regulatory reform requires careful consideration of both formal and informal local institutional environments, ensuring that regulation reflects the specific institutional reali-

il/994411468766776323/reforming-public-institutions-and-strengthening-governance-a-world-bank-strategy

[6] Organisation for Economic Co-operation and Development (OECD). *Internal interactions of state institutions and their interactions with the private sector, users, and citizens*. 2015.URL: https://www.oecd.org/en/about/legal/text-of-the-convention-on-the-organisation-for-economic-co-operation-and-development.html

[7] World Development Report 1994: Infrastructure for Development.URL: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/687361468340136928/world-development-report-1994-

[8] OECD. Principles for the Governance of Regulators, Public Consultation. Draft 2013.

ties of the country. The inclusion of these factors in regulatory changes or reforms is essential for achieving the legitimacy of the RMS.

CONCLUSION

The analytical framework presented in this study provides a foundation for designing and implementing RMS in developing countries, capturing the impact of the institutional environment on regulation. By examining the historical development of regulatory models and the formal and informal institutional contexts, the framework aims to help countries achieve regulatory legitimacy.

Applying high-level principles of good regulation, alongside key operational principles, can improve the effectiveness, independence, and outcomes of regulatory systems. Further research on key indicators in these areas will support transparency, accountability, and inclusiveness in regulatory governance, ultimately ensuring that RMS delivers tangible benefits for all stakeholders and is recognized as legitimate by citizens and businesses alike.

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ANNEX

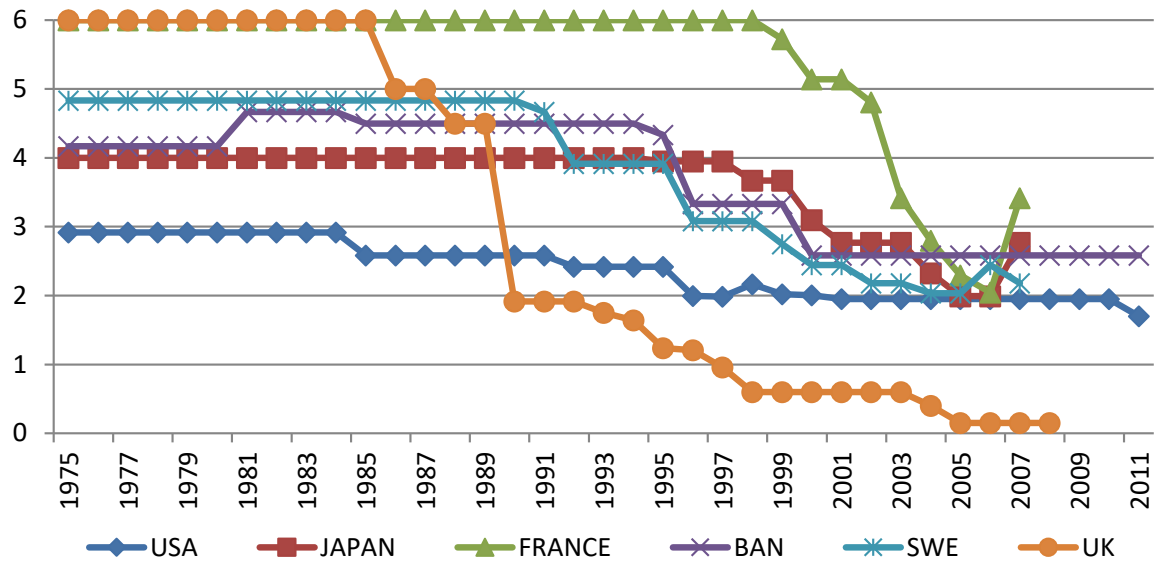

Fig. **Bangladesh Energy Sector Regulation Historical Data in comparison with OECD countries**

Source: compiled by the authors based on OECD indicators and own indicators on Bangladesh.

Table

Elements of an Ideal Control System

OECD * 2013	Stern, Brown and Tenenbaum (2006)	UK Better Regulation Task Force (BRTF) **	The Australian Competition Commission's Good Practice Principles for Good Regulation	The EU Commission's Principles of Good Governance	Jacobs (2003) Features of the modern regulatory system	Berg (2000) lists five components of a sound regulatory system.	Andres, Guasch and Azumendi (2008)
Clarity of roles	• *Meta-principle 1: Credibility*	Transparency	Communication (information to stakeholders in a timely and accessible manner)	Openness	Safety	Coherence	Autonomy
Preventing undue influence and maintaining trust	• *Meta-principle 2: Legitimacy*	Accountability	Consultations (participation of stakeholders in meetings)	Participation	Transparency	Creativity	Accountability
Structure of the management and decision-making bodies of the IRA	• *Meta-principle 3: Transparency*	Proportionality	Consistency (between market participants and over time)	Accountability	Legitimacy	Communication	Transparency
Accountability and transparency	• *Meta-principle 4: Efficiency*	Subsequence	Predictability (a reputation that facilitates planning by suppliers and customers)	Efficiency	Efficiency	Cooperation	
Engagement		Targeting	Flexibility (by using appropriate tools in response to changing conditions)	Coherence	Expertise	Trust	
Financing			Independence (autonomy in that decisions are free from undue political influence)				
Evaluation of effectiveness			Efficiency and effectiveness (cost effectiveness is emphasized in data collection and policy)				
			Accountability (clearly defined processes and rationale for decisions, including appeals)				
			Transparency (openness of the process)				

Source: compiled by the authors.

Note: * — OECD. Principles for the governance of regulators, public consultation. Draft. 2013; Regulatory Impact Analysis. OESD. URL: https://www.oecd.org/content/dam/oecd/en/publications/reports/2009/09/regulatory-impact-analysis_g1ghb202/9789264067110-en.pdf; ** — BRTF. Principles of Good Regulation. European Business Review. DOI: 10.1108/ebr.1998.05498cab.002

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Assessment of the Sustainability of Urban Transport System Management Based on Structural-Synergetic Modeling

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ABSTRACT

The transport complex, which ensures the vital functioning of territories and settlements across the country, requires new analytical tools capable of supporting managerial decision-making under conditions of decentralized governance and the influence of demographic, institutional, and natural–climatic constraints. The relevance of this study is determined by the importance of sustainable development in Arctic cities and urban agglomerations as strategic territories that ensure national security and socio-economic resilience. The **purpose** of this research is to model the dynamic structure of economic subprocesses within the public transport subsystem of an urban or metropolitan transport system in order to assess its performance and identify deviations from the trajectory of sustainable development. The study employs a structural–synergetic modeling method, which allows for both quantitative and qualitative evaluation of interdependencies in complex urban transport systems. Using the example of Murmansk over the period 2013–2022, models were developed to reflect the annual changes in the structure of the city's public transport functioning. This structure includes four types of subprocesses: core, auxiliary, life-supporting, and development-constraining. The study **resulted** in an assessment of the impact of decentralized decisions made by key stakeholders on the sustainability of Murmansk's public transport system, as well as the identification of the nature and direction of synergetic effects. Directions for further modernization of the methodology and techniques of structural modeling are proposed, focusing on the improvement of statistical accounting for relevant indicators. The developed approaches can serve as diagnostic and monitoring tools for assessing the sustainability of transport systems in Arctic regions. The results obtained are of practical interest to federal, regional, and municipal authorities, analytical centers, and infrastructure companies involved in the implementation of sustainable transport and urban mobility policies.

Keywords: sustainable development; Arctic urban systems; transport system; public transport; structural-synergetic modeling; sustainability; system dynamics; stakeholder coordination; urban mobility; regional governance

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INTRODUCTION

In the socio-economic life of cities and urban agglomerations in the Russian Federation, public transport performs one of the most important public functions by ensuring citizens' freedom of movement. At the same time, the volume and quality of transport services provided to the population depend on a wide range of external and internal factors influencing the efficiency of passenger transportation. The governance and regulation of public transport are organized in different ways across cities and urban agglomerations. In recent years, the involvement of private operators has become a widespread practice. Municipal administrations have established single-customer services responsible for organizing transport services for the population, and dedicated funds have been created to finance such service provision. Approaches to the operational control of public transport also vary significantly. On the one hand, many functions are carried out by enterprises subordinate to city administrations; on the other hand, rolling stock operators are granted a high degree of autonomy in carrying out commercial activities. The financing of urban passenger transport is differentiated and takes into account a number of factors, including the historically formed topology of the street and road network; the intermodal configuration of rolling stock used for passenger services; demographic and migration processes; natural and climatic operating conditions, as well as the income levels and lifestyles of urban residents.

The formation of an integrated public transport management system in each city or urban agglomeration constitutes a significant challenge. Addressing this challenge requires robust information and analytical tools capable of producing reliable assessments of the effectiveness of both intentional and unintended actions undertaken by participants within the public transport subsystem of a city or urban agglomeration.

Methods and tools for the optimal planning of transport system operations have been extensively studied and are widely applied in practice. System-based modeling of transport systems is tailored to addressing different classes of problems. For example, various modifications of the gravity model are used to identify optimal transport links in passenger transport planning. At the same time, optimization methods and calculations applied to complex systems do not always adequately account for the specific features of interaction among elements that differ in functions and organizational structures. Factors such as randomness and nonlinearity can significantly reduce the effectiveness of optimization methods, even in highly deterministic systems. Errors associated with the application of queuing theory methods to forecasting the required level of transport infrastructure development may reach 30–50% [1]. The application of life-cycle methodologies and simulation modeling techniques can substantially improve the quality of design and analytical work; however, their effectiveness is constrained by the spatial and temporal characteristics of the objects to which they are applied [2–4].

Program-based and project-oriented management is also not without shortcomings, as it requires coordination and synchronization of actions among stakeholders whose composition, capacities, and strategic objectives may deviate significantly from the sustainable development trajectory of a complex system. For example, improving the transport complex of territories and settlements in the Arctic Zone of the Russian Federation (AZRF) necessitates the alignment of decisions taken at the municipal, regional, and national levels, taking into account ongoing geopolitical and geoeconomic processes. Ensuring solvent demand for transport services in the AZRF cannot be achieved solely through the managerial competencies of local authorities or through the actions of institutional and individual operators of transport infrastructure and rolling stock. The introduction of a balanced scorecard system through the establishment of key performance indicators for stakeholders involved in the formation of transport complexes in this territory cannot fully capture the specific

features of the development stages of its constituent entities [5]. At the same time, management theory indicates that maintaining proportionality among system components during transitions from periods of quantitative growth to stages of qualitative development constitutes a critical management task. Moreover, in decentralized systems, developmental imbalances tend to be significantly greater than in centralized ones, as a result of the higher degree of freedom granted to participants. In addition to the inherent levels of self-organization and governance within the transport system itself [6], it becomes necessary to take into account information flows from all other participants interested in receiving transport services. Consequently, in the absence of synchronization of their decisions and actions, organizational links among participants undergo qualitative and quantitative transformation, primarily driven by the most inert elements — those characterized by particularly long adaptation periods. In urban transport systems, such elements include the public transport subsystem serving urban and suburban populations. A gradual decline in service quality is compensated by an increasing share of private passenger vehicles, which in turn leads to a progressive deterioration in the utilization of the urban street and road network and a decline in the overall quality of the urban environment [7,8].

The advancement of methods for assessing the performance of public transport operations in cities of the Russian Federation has increasingly relied on the application of sociometric approaches. For instance, since 2021, experts from the Association of Transport Engineers and the company SIMETRA have compiled a ranking of Russian cities[1] based on the quality of public transport services provided to the population. This ranking is derived from indicator groups such as physical and fare accessibility, transport system functionality, comfort and convenience, safety, and sustainable development.[2] At the Institute for Transport Economics and Transport Policy of the National Research University Higher School of Economics, a methodology for auditing the condition of public transport transport systems has been developed and tested in 50 cities across the country. This methodology is based on an assessment of a set of indicators [5] reflecting the structure of rolling stock, including capacity classes, the share of electric transport and dedicated lanes for MPT, route duplication, and rolling stock capacity across different times of day and transport modes.

It should be noted that, despite their considerable value, existing research studies do not fully account for the full range of factors influencing the operation of transport systems in cities and urban agglomerations. These include, for example, the level of budgetary funding allocated to public transport operators; trends in real household incomes and population dinamics; the presence and scale of competition from private automobiles (including motorization rates, fuel prices, parking policies, and the prioritization of public transport in urban traffic); the renewal of street and road network infrastructure within cities or urban agglomerations; and the systematic planning of route network development. The interests of urban residents can be adequately addressed by municipal authorities and both private and public transport operators only through a comprehensive analysis of the effects generated by the functioning of the transport system.

Within the framework of the intellectual economy — understood as an economic model based on the primacy of knowledge, innovation, and the advancement of methodologies for studying complex systems — the aggregate economic processes occurring in the public transport subsystem of a city or urban agglomeration should be examined through the lens of an ecosystem-based organization of transport production. Accordingly, the use of the term "intellectual economy"

[1] The 2023 ranking of Russian cities in terms of public transport quality URL: https://publictransport.simetragroup.ru/rating.

[2] URL: http:// publictransport.simetragroup.ru/rating

implies the need to consider not only traditional aspects of economic activity and stakeholder decision-making related to the development of the subsystem in question, but also the synergistic effects arising from interactions among participants within the urban transport ecosystem. According to G.B. Kleiner, intelligence in socio-economic systems is understood as "the ability to form, analyze, and present an adequate systemic picture of the world that reflects the structure of functioning and the dynamics of systems that are substantially interconnected with a given system" [9]. Consequently, the analytical toolkit used to study the behavior of the public transport subsystem of a city or urban agglomeration-which plays a significant role in achieving United Nations Sustainable Development Goal No. 11, "Make cities and human settlements inclusive, safe, resilient and sustainable[3]" — must account for the properties of complex spatially distributed systems and the requirements imposed on them.

The considerations outlined above determined the choice of the public transport subsystem within the transport system of Murmansk as the object of this study. This subsystem is examined as a set of interrelated processes arising from the activities of key operators — JSC Elektrotransport and JSC Murmanskavtotrans — as well as users and owners of private motor vehicles and regulatory authorities, through indicators influencing the key parameters of its internal and external environment. The subject of the study comprises the dynamic aspects of organizational relationships that determine the nature of the functioning and development of the public transport subsystem.

METHODOLOGY AND RESEARCH METHODS

According to contemporary views on interactions within living, non-living, and organizational environments, functional and linear relationships are regarded as the fundamental forms of organizational linkages. Functional relationships specify goals, objectives, decisions, and the allocation of responsibility within processes and systems, both in relation to objective reality and to subjective activity, while linear relationships ensure their consolidation and integration.

The structural configuration of these relationships may be formed in time and space either sequentially or in parallel. This inevitably leads to duplication, the creation of reserves, and, consequently, the consolidation of specific quantitative proportions within organizational relationships among the parts of a whole. These proportions determine the level of organization of processes and systems and reflect their underlying essence. Thus, through the distribution of functions, it becomes possible both to identify the system as a whole and to assess the resulting synergistic effect.

A whole that has goals, objectives, functions, decisions, and responsibilities embedded (or assigned) acts as an element — or one of the elements — of an organizational unit and occupies a specific position and role within its structure. An increase in the number of elements and organizational units leads to greater structural complexity, while stability and resilience are ensured through feedback mechanisms.

Although feedback mechanisms shape the dynamics of relationships within the processes and systems of objective reality and subjective activity, for a long time their role was largely limited to restoring organizations to a state of equilibrium. This was due to the fact that equilibrium in the natural, humanitarian, and socio-economic sciences was traditionally regarded as the desired final state of functioning and development. In socio-economic organizations, however, equilibrium — understood as homeostasis or self-sufficiency — meant the attainment of a state at which all tasks had been completed and productive capacity had been expended on reducing uncertainty (entropy). As a result, further change was considered meaningless.

Thus, self-sufficiency treated as a goal rather than as a necessary condition gave rise to ideas

[3] URL: https://www.un.org/sustainabledevelopment/ru/cities/

about the inevitability of decline, the "end of history," societal disintegration, and the closure of systems. Any form of present stagnation was therefore perceived as preferable to a guaranteed deterioration in the future.

The emergence of concepts of dynamic equilibrium in open systems made it possible to reconsider earlier pessimistic assessments of the development prospects of complex systems [10]. The proposition that "matter, energy, information, and the dynamic properties of a system, as well as its structure, are so interrelated that any change in one of these components entails corresponding functional-structural quantitative and qualitative changes in the state of the others" [11] has come to be regarded as the law of internal dynamic equilibrium.

Thus, the role and significance of the dynamic aspects of organization have come to be recognized: the potential of organizational functioning is determined by the totality of static factors discussed above, which, in their unity and interaction, ensure the responsiveness and flexibility of processes and systems. Stability, uniformity, and optimal development of the latter within socioeconomic organizations are achieved through continuity and rhythmicity, which together form the necessary level of internal self-organization. The maintenance of continuity and rhythmicity is ensured through the division and cooperation in form of joint, goal-oriented activity, which serves as a mechanism for generating diverse organizational forms [12–14].

Open systems actively exchange resources and the outputs of their activities. Since any interaction presupposes certain relationships among the participants in a process, its effectiveness depends on the current state of the system itself. An organization endowed with an adequate self-regulation mechanism is capable of compensating for emerging counteractions by neutralizing them or by generating new elements required for adaptation to changing conditions. Accordingly, the urban public transport subsystem, as an open system, interacts not only with passengers and transport operators but also with road infrastructure under prevailing financial-economic conditions and regulatory constraints. Therefore, an adequate assessment of the synchronicity of processes occurring both within this subsystem (e.g., the volume of transport work, the development of the route network, and fleet renewal) and in the city's external environment (growth in motorization, changes in budgetary funding, demographic shifts, etc.) is key to understanding its sustainability and efficiency.

Interaction with the external environment may take not only a linear but also nonlinear forms. In the latter case, even minor changes in the parameters of a single element may lead to significant fluctuations or deviations in other elements and affect the entire chain of processes. Consequently, the principal challenge is not the pursuit of absolute stability or flawless operational reliability, but rather the maintenance of a dynamic equilibrium that reflects the desired state of the system — in this case, movement toward Sustainable Development Goal No. 11.

Addressing this challenge appears feasible through an analysis of the structure of the aggregate economic process of providing public transport services in a city or urban agglomeration. According to O.A. Biyakov, such a process constitutes a complex system of interrelated subprocesses (production, consumption, infrastructure-related, and others) operating within a unified economic space and determining the overall dynamics and development outcomes of a territory [15]. In other words, the aggregate economic process encompasses all stages of resource formation and utilization, taking into account factors that facilitate or hinder development. Structural modeling, through the decomposition of this process, makes it possible to identify the degree of collinearity among the target development vectors of key stakeholders in urban and agglomeration transport systems, as well as the direction of the resulting synergistic effect. This method was tested by the author in a previous study [16] and is therefore not described in detail in the present paper.

In the course of the study, the decomposition of the aggregate economic process of the public transport subsystem within Murmansk's transport system was decomposed into four types of subprocesses, each evaluated on the basis of three indicators. The integral values of these indicators were constructed using weighting coefficients and their position within the hierarchy of subprocesses. A significant constraint on the selection of indicators was imposed by the requirements of the structural process modeling method, specifically the availability of statistical observations over an extended time period. Accordingly, the study employed data covering the period from 2013 to 2022.

To analyze the core subprocesses, three indicators were selected: the number of passengers carried (M1), passenger turnover (M2), and the total length of public transport routes (M3). These indicators reflect the achieved performance outcomes of the main public transport operators in Murmansk. Supporting subprocesses were examined using indicators such as the average age of the vehicle fleet operating on routes (S 1), employment in public transport (S 2), and the level of budgetary financial support allocated to the public transport development (S 3), which together characterize the capacity of the city's public transport subsystem to provide transport services to the population. When analyzing life-supporting subprocesses, consideration was given to the city's population size (LS 1), the regional real wage level (LS 2), and the cost of the consumer basket (LS 3). These indicators define the operating conditions of the urban public transport subsystem. Finally, to characterize subprocesses that hinder development, the following indicators were selected: the number of privately owned passenger cars per 1,000 residents (P1), the regional inflation rate (P2), and the price of electricity for industrial consumers (P3). The selection of these indicators is justified by their substantial influence on the capacity of the urban road network and on the feasibility of transitioning to new energy sources, given the natural, climatic and topographical characteristics of the city's transport system.

MODELING THE DYNAMIC STRUCTURE OF ECONOMIC SUBPROCESSES IN THE TRANSPORT SYSTEM OF THE HERO CITY OF MURMANSK

Table 1 presents the normalized values of the indicators characterizing the aggregate economic development process of the public transport subsystem within Murmansk's transport system. These values were obtained by applying a median smoothing procedure to the time series, as this approach reduces statistical noise when calculating the accelerations of indicator dynamics used to describe the structure of the subprocesses of the aggregate economic process.

Table 2 presents the calculated values of accelerations (and decelerations) of the components of the aggregate economic process underlying the development of Murmansk's transport system. These values are used to assess the effectiveness of potential utilization and to model the dynamic structure of its economic subprocesses.

This method makes it possible to compare subprocesses that differ in nature and in the speed of their dynamics.

For example, since 2021, Murmansk has demonstrated a sharp acceleration in passenger transport dynamics, which has led to a convergence between the observed indicator dynamics of public transport subprocesses and the target vector.

This is evident from the data presented in *Table 3*, which shows the actual and target ranking of the subprocesses of the aggregate economic process underlying the development of this subsystem. At the same time, in the 2021 and 2022 models, the effects of the administrative decision to establish the Murmansk agglomeration[4] has not yet evident. This effect is expected to manifest in the alignment of the M2 and M3 with the target

[4] The Murmansk agglomeration includes the city of Murmansk, the closed administrative — territorial formation (CATF) of Severomorsk, as well as the Kola District. Its population amounts to 352 thousand people as of 1st January 2023.

Table 1

Normalized Values of Indicators of the Aggregate Economic Development Process in the Public Transport Subsystem of the Hero City Murmansk

Structure of the Aggregate Economic Process		2015	2016	2017	2018	2019	2020	2021	2022
Core Subprocesses	M1	-1.4	-13.4	17.1	5.8	-25.7	-66.6	56.7	125.4
	M2	10.6	-28.2	8.6	38.3	-35.5	-74.1	97.0	-12.3
	M3	-1.5	11.6	3.6	-23.4	-17.1	-6.4	16.2	-5.7
Supporting Subprocesses	S1	-0.4	3.1	-4.0	0.4	5.5	-11.8	-64.9	17.6
	S2	7.0	-4.6	1.4	-4.9	-3.2	10.6	5.4	-1.3
	S3	110.2	-100.2	-28.7	-7.1	33.8	0.0	3.7	44.4
Life-Supporting Subprocesses	LS1	22.8	-23.0	-0.2	1.2	-1.0	-5.8	-46.6	34.5
	LS2	-3.8	5.5	-7.7	6.2	-2.3	-1.4	2.3	3.4
	LS3	13.1	1.8	-2.7	-12.1	-4.9	8.0	2.5	2.9
Subprocesses Hindering Development	P1	-19.7	3.3	-0.1	7.5	-15.1	-0.7	10.0	10.5
	P2	-10.0	-55.6	18.2	32.6	-21.2	14.0	21.8	29.2
	P2	7.8	-0.2	-0.2	18.3	-65.4	94.3	43.6	-157.4

Source: Calculated by the author.

Table 2

Calculated Values of Accelerations (Decelerations) of the Components of the Aggregate Economic Development Process in the Public Transport Subsystem of the Murmansk Transport System

Structure of the Aggregate Economic Process		2015	2016	2017	2018	2019	2020	2021	2022
Core Subprocesses	M1	-1.4	-13.4	17.1	5.8	-25.7	-66.6	56.7	125.4
	M2	10.6	-28.2	8.6	38.3	-35.5	-74.1	97.0	-12.3
	M3	-17.5	11.6	3.6	-23.4	-17.1	-6.4	16.2	-5.7
Supporting Subprocesses	S1	-0.4	3.1	-4.0	0.4	5.5	-11.8	-64.9	17.6
	S2	7.0	-4.6	1.4	-4.9	-3.2	10.6	5.4	-1.3
	S3	110.2	-100.2	-28.7	-7.1	33.8	0.0	3.7	44.4
Life-Supporting Subprocesses	LS1	22.8	-23.0	-0.2	1.2	-1.0	-5.8	-46.6	34.5
	LS2	-3.8	5.5	-7.7	6,2	-2.3	-1.4	2.3	3.4
	LS3	13.1	1.8	-2.7	-12.1	-4.9	8.0	2.5	2.9
Subprocesses Hindering Development	P1	-19.7	3.3	-0.1	7.5	-15.1	-0.7	10.0	10.5
	P2	-10.0	-55.6	18.2	32.6	-21.2	14.0	21.8	29.2
	P3	7.8	-0.2	-0.2	18.3	-65.4	94.3	43.6	-157.4

Source: Calculated by the author.

vector, reflecting the objective of achieving a synergistic effect from agglomeration processes and changes in the length and structure of the public transport route network.

This is evident from the data presented in Table 3, which shows the actual and target rankings of subprocesses within the aggregate economic process underlying the development of the public transport subsystem. The slowdown in the acceleration of electricity prices for the industrial consumers (P3) had a positive effect, alleviating some of the constraints that had been hindering the development of the city's trolleybus network. At the same time, the positive trend observed in previous years, associated with the deceleration of motorization, came to an end: the growth of private car ownership per 1,000 residents (P1) began to accelerate again. Moreover, the acceleration of regional inflation rates (P2) continues to impede the development of public transport within the city's transport system. This trend is inconsistent with the target vector, which reflects progress toward achieving Sustainable Development Goal No. 11.

The quantitative assessment of the synchronicity of changes in the subprocesses of the public transport subsystem in Murmansk (*Fig. 1*) was conducted by comparing the actual and target structures of indicator dynamics used to model the aggregate economic process of this subsystem. Two rank correlation coefficients — Spearman's and Kendall's — were applied. The target vector reflects the desired positive changes in public transport, both in terms of passenger volumes and average trip length, including the total length of the route network. The attractiveness of public transport is largely determined by the quality of services provided.

Table 3

Actual and Target Ranking of Subprocesses in the Aggregate Economic Development Process of the Public Transport Subsystem of the Hero City Murmansk

Структура совокупного экономического процесса		2015	2016	2017	2018	2019	2020	2021	2022	Целевой вектор
Основные подпроцессы	M1	8	8	2	6	10	11	3	1	1
	M2	4	10	3	1	11	12	1	10	2
	M3	11	1	5	12	8	10	6	9	3
Вспомогательные подпроцессы	S 1	7	6	4	8	6	3	2	11	4
	S 2	6	7	6	9	4	4	8	8	5
	S 3	1	12	12	10	1	6	9	2	6
Жизнеобеспечивающие подпроцессы	LS 1	2	9	9	7	2	9	12	3	7
	LS 2	9	2	11	5	3	8	11	6	8
	LS 3	3	4	10	11	5	5	10	7	9
Подпроцессы, препятствующие развитию	P1	12	3	7	4	7	7	7	5	10
	P2	10	11	1	2	9	2	5	4	11
	P3	5	5	8	3	12	1	4	12	12

Source: Calculated by the author.

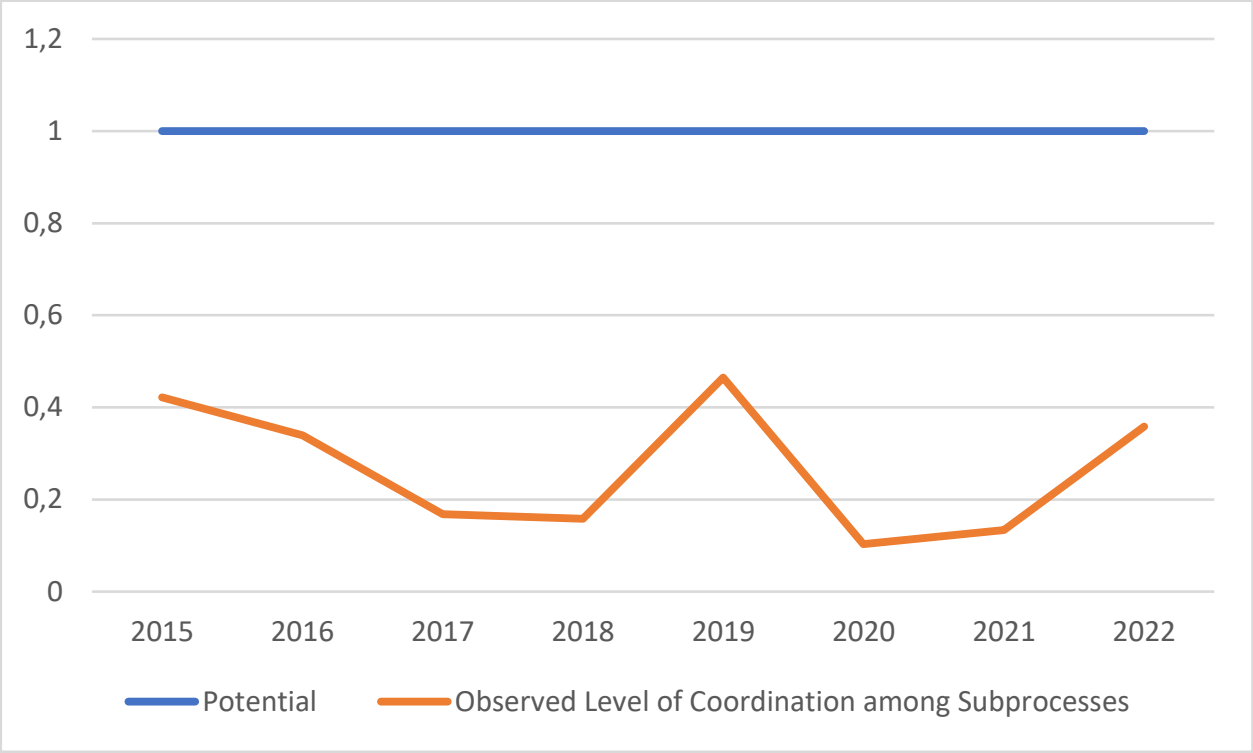

Fig. 1. **Transport Subsystem of the Murmansk Transport System in Utilizing Its Potential**

Source: Modelled by the author.

In this model, this condition is accounted for indirectly through indicators of supporting subprocesses. The fourth position in the target vector is occupied by indicator S 1, which characterizes the average age of the vehicle fleet operating on routes. The renewal of this fleet, which began in 2021, is reflected in the 2022 model. A substantial increase in budgetary financial support for this process (S 3), combined with a slowdown in the growth of public transport employment (S 2) (*Table 2*), distorted the actual indicators dynamics relative to the target values and affected the efficiency of utilizing the potential of the city's transport system. The group of life-supporting subprocesses (LS 1–LS 3) ranks third in terms of priority for indicators acceleration, as it reflects the long-term development goals of Arctic territories. Their implementation, despite the critical importance of demographic policy, depends on the creation of a favorable living environment over the short term.

Murmansk is characterized by a high level of motorization, elevated electricity prices for industrial consumers, and noticeable inflation. Therefore, it appears reasonable to explore ways to curb the growth of these indicators, which occupy positions 9–11 in the target ranking.

Considering the ranking logic and the actual structure of indicator dynamics by subprocess groups over the period from 2013 to 2022, the average effectiveness of the decisions taken, in accordance with goal priorities, reached only about one-third of the potentially achievable level (0.356). Consequently, the efforts of the city's main public transport operators, together with support from municipal, regional, and federal authorities, proved insufficient to counteract adverse migration trends, increasing private car ownership, and rising electricity costs for industrial consumers. As a result, the synergistic effect of interactions among the stakeholders included in the model, as well as the organizational and individual decisions made during the study pe-

Table 4

Qualitative Assessment of the Aggregate Economic Process in the Public Transport Subsystem of the Murmansk Transport System

Acceleration (+) / Deceleration (–) of Subprocesses	Core Subprocesses	Supporting Subprocesses	Life-Supporting Subprocesses	Subprocesses Hindering Development	Dynamic Structure of Economic Processes	Type of Development	Type of Aggregate Economic Process
2015	-1.846	28.864	12.818	-10.282	MS>LS>P	Stable Growth	Effective with Development Improvement
2016	-11.566	-27.039	-8.863	-14.396	LS>P>MS	Unstable Decline	Ineffective with Development Improvement
2017	11.415	-4.681	-2.958	5.120	MS>P>LS	Unstable Growth	Effective with Maintenance of Development Level
2018	8.027	-3.307	-0.601	17.310	P>MS>LS	Unstable Decline	Ineffective with Maintenance of Development Level
2019	-26.407	4.678	-2.306	-29.033	LS>MS>P	Unstable Growth	Effective with Decline in Development Level
2020	-54.180	8.616	-1.197	26.490	P>LS>MS	Unstable Decline	Ineffective with Decline in Development Level
2021	58.464	33.079	-20.716	21.483	MS>P>LS	Unstable Growth	Effective with Maintenance of Development Level
2022	54.289	2.056	17.989	-24.769	MS>LS>P	Stable Growth	Effective with Development Improvement

Source: Calculated by the author.

riod, remained relatively low, ranging from 10% to 40% of the maximum achievable level.

It should be noted that, during the period from 2019 to 2021, all cities faced the consequences of measures aimed at preventing the spread of COVID-19, which significantly reduced the utilization of the potential of their public transport subsystems.

Figure 2 presents models of the dynamic structure of the economic subprocesses underlying the development of Murmansk's public transport subsystem, supplemented by a qualitative assessment of the direction of the synergistic effect resulting from stakeholder interactions (*Table 4*). Based on the analysis of the acceleration or deceleration of indicator movements in each subprocess, it is

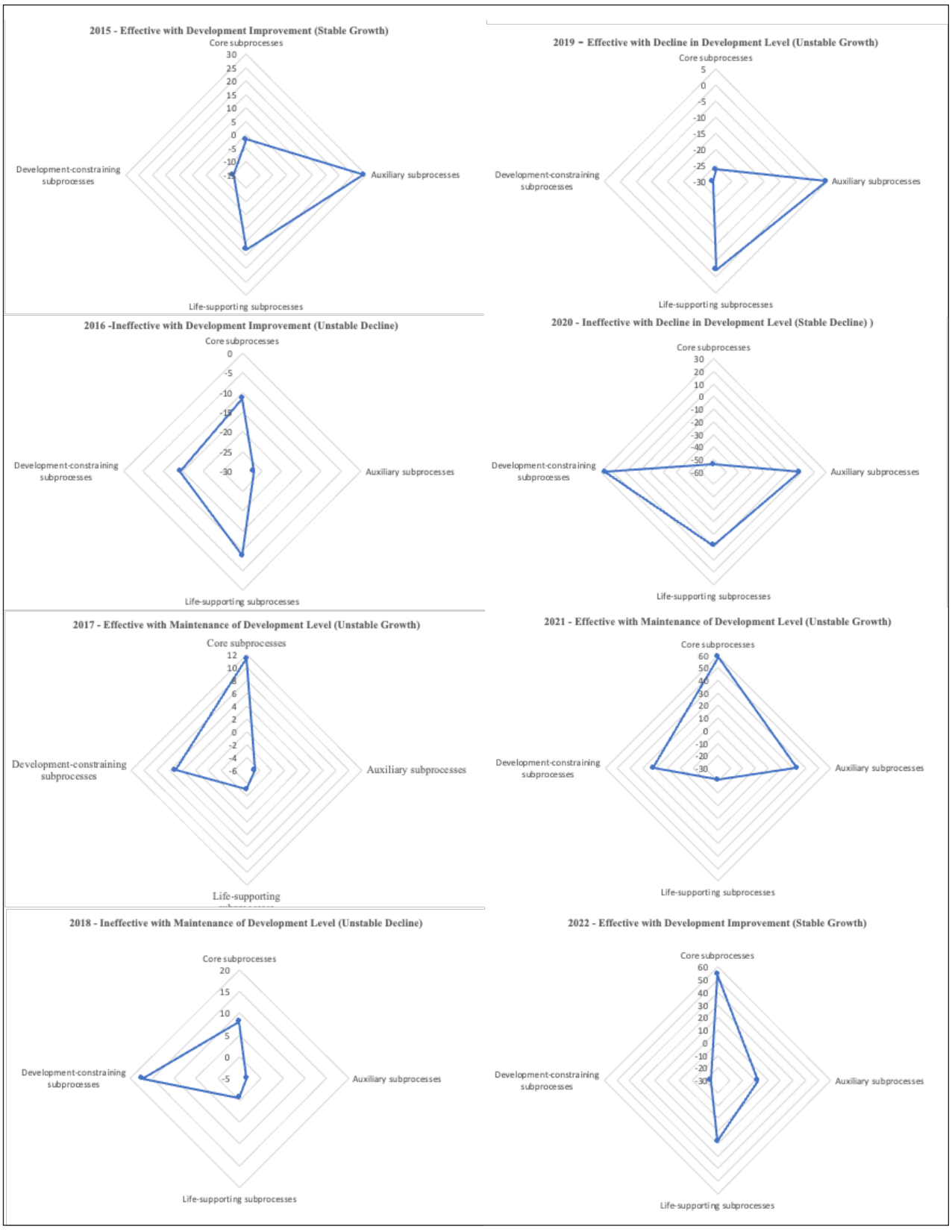

Fig. 2. **Models of the Dynamic Structure of Economic Subprocesses in the Public Transport Subsystem of the Hero City Murmansk Transport System**

Source: Modelled by the author.

possible to draw conclusions about the type of development of the public transport subsystem and the effectiveness of its operational regime in each year of the study period.

The analysis of the dynamic structure of economic subprocesses revealed significant fluctuations between unstable decline and growth within the aggregate economic process of the public transport subsystem. Improvement in performance became noticeable only from 2021 onwards. This finding is consistent with city-level rankings of public transport service quality [9], according to which Murmansk rose from 17th place in 2022 (61.5 points out of 100) to 10th place (71.8 points out of 100). According to SIMETRA data, between 2022 and 2023 improvements were observed in indicators such as public transport sustainability and safety (from 44 to 55), fare affordability (from 51 to 68), transport network functionality (from 59 to 76), and comfort and convenience (from 70 to 77).

RESULTS OF STRUCTURAL MODELING OF ECONOMIC PROCESSES IN URBAN PUBLIC TRANSPORT SYSTEMS

At the same time, physical accessibility deteriorated, decreasing from 80 80 in 2022 to 77 in 2023, reflecting a slight reduction in route network coverage and an increase in travel time to stops and destinations.

Within the group of supporting subprocesses, the average age of the rolling stock (S 1) was selected as one of the key parameters for analyzing service quality in Murmansk's public transport system. The study assumes a significant correlation between S 1 and the quality of services provided by the key operators — JSC "Electrotransport" and JSC "Murmanskavtotrans[5]" — such that a decrease in the average age of rolling stock corresponds to an improvement in service quality. In line with the Federal Project "Modernization of Passenger Transport in Urban Agglomerations,[6]" approximately 50% of the buses and trolleybuses serving the Murmansk agglomeration were renewed. This trend is reflected in the 2021 and 2022 models. Although the expert community recognizes the average age of rolling stock as a valid indicator [5], a more precise assessment of supporting subprocesses quality would require the use of fleet technical readiness as a model parameter. However, the current level of data disclosure in published statistical sources does not allow this indicator to be calculated.

The second indicator within the group of supporting subprocesses — the number of employees in public transport (S 2) — indirectly reflects the level of development and intensity of use of the city's route network. However, S 2 has limitations in capturing the degree of route duplication, which is a key factor for refining the structural modeling of economic processes in public transport systems of cities and urban agglomerations, as it indicates the synchronicity of transport service development between central and peripheral areas.

The complexity of the route network, as well as the reliability of technological accessibility of public transport services for the population, is determined by the number of routes, their length, and service frequency. These characteristics reflect the degree of self-organization of the public transport subsystem and its capacity to adapt to changes in passenger demand and the city's spatial development. At the same time, the public transport route network is characterized by a high degree of inertia, as changes in its structure require substantial capital investment and long-term planning. This constrains the ability of public transport systems to respond rapidly to shifts in passenger demand and urban development priorities.

The third indicator within the group of supporting subprocesses is the level of budgetary financial support allocated for public transport development (S 3). An increase in S 3 reflects the active involvement of public authorities in supporting the public transport system; however, the effectiveness of such support depends on the de-

[5] URL: https://транспортсевера.рф/#/

[6] The federal project profile "Modernization of Passenger Transport in Urban Agglomerations" file:///Users/tatana/Downloads/FP_Passazhirskij_transport.pdf

gree of coordination between financial inputs and other supporting and core subprocesses. In the absence of such coordination, additional budgetary funding may distort the dynamic structure of economic subprocesses rather than contribute to the achievement of the target development vector. This effect is particularly evident in the 2021 and 2022 models, where a substantial increase in budgetary support was not accompanied by a proportional acceleration of core performance indicators. Throughout the study period in the Murmansk agglomeration, insufficient funding for public transport development coincided with high rates of private car ownership, indicating the substitution of public transport services by private mobility. This relationship is captured in the dynamic structure models through the inclusion of indicator P1 (private passenger cars per 1,000 residents) among the subprocesses hindering public transport development.

The compensation of lost revenue from passenger transportation observed in 2015–2017 was followed by an almost complete absence of budgetary support in 2018–2020. The co-financing mechanism for fleet renewal through infrastructure loans provided by VEB.RF began operating in 2021. This change is reflected in the 2021 and 2022 models through a shift in the type of aggregate economic process — from "effective with maintenance of the development level" to "effective with development improvement." In 2020, a trend toward a transition from stable decline to stable growth began to emerge. This shift was facilitated by a decrease in electricity costs for industrial consumers (P3). As a result, the effectiveness of public transport potential utilization in the Murmansk agglomeration began to recover, reaching 36% of the maximum achievable level. Despite rising regional inflation (P2) and the continuing trend of population decline (LS 1), real wages (LS 2) and the cost of the consumer basket (LS 3) increased at an accelerated rate.

State policy concerning the territories and settlements of the Russian federation Arctic Zone (RFAZ), as well as the instruments for its development, is undergoing significant transformation. In the case of public transport in the Murmansk agglomeration, a key implication of this shift is that future development will no longer be determined solely by population-based criteria. Instead, it will increasingly depend on the functional role of the territories within the agglomeration in ensuring national security, including their significance as the base of Russia's largest Arctic international port, a northern supply hub, and one of the country's two maritime search and rescue coordination centers. In addition, large-scale infrastructure and logistics projects, together with the development of major educational and scientific centers of the Russian Arctic,[7] are expected to exert a substantial influence on the trajectory of public transport development.

At present, transport activity within the Murmansk agglomeration remains highly concentrated within the city boundaries, while peripheral territories exhibit substantially lower levels of accessibility and service intensity. This spatial imbalance limits the potential for sustainable development of the agglomeration as an integrated transport system. In this context, indicator M3—the total length of public transport routes — plays a critical role, as it reflects the capacity of the route network to ensure territorial coverage and connectivity between central and peripheral areas.[8] The expansion and restructuring of the route network, combined with the coordination of traffic management regimes and parking policies, can enhance the attractiveness of public transport and reduce dependence on private vehicles. Such measures are particularly important for Arctic agglomerations, where climatic conditions and settlement patterns amplify the costs of spatial fragmentation.

[7] Key settlement as the backbone of the Russian Arctic URL: https://nashsever51.ru/storage/temporary/24/03/06/156462/47cdd109–1303–48df-a944–0d4ae3334461.pdf

[8] By the end of the modeling period, coordinated measures for regulating public transport operating regimes in the Murmansk agglomeration had not yet been implemented.

Improvements in the efficiency of public transport can be achieved by involving local self-government bodies and residents in the development of corporate and regional strategic plans for the Murmansk agglomeration. An analysis of accumulated experience in this area [17] revealed a low level of effectiveness in attempts to coordinate the actions of key stakeholders (see Figures 1 and 2). According to studies on the social sustainability of Arctic cities, including those by A. D. Volkov [18], one of the key drivers of population outflow is the decline in the social embeddedness of major city-forming companies and the decreasing role of social benefit agreements. A critical contributing factor has been the growing trend toward extraterritorial management of city-forming enterprises during the 2010s. The relocation of decision-making centers outside Arctic cities and the implementation of restructuring programs — often involving workforce reductions — frequently resulted in income losses for local residents, with no available compensation mechanisms other than relocation outside the Arctic [19].

As a result, insufficient collinearity between the business objectives of key stakeholders and the interests of the local community contributes to a decline in both the effectiveness of public transport utilization and the development potential of this subsystem. At the same time, the identified shortcomings form a basis for further development in this area. This is evidenced by emerging examples of socio-economic partnerships involving major vertically integrated companies in the Russian Arctic Zone, as well as by coordinated priority projects included in the strategic plan "The North is a Place to Live![9]" and in the master plans for Far Eastern and Arctic cities developed on its basis. The effects of these initiatives are expected to be reflected in models for subsequent observation periods.

[9] Strategic Plan "The North is a Place to Live!". URL: https://nashsever51.ru/projects/pnszh

CONCLUSION

The study has demonstrated that the effectiveness of public transport development in Arctic cities and urban agglomerations depends not only on quantitative indicators of demand and funding, but also on the degree of coordination among key stakeholders involved in the aggregate economic process. Using the example of the Murmansk agglomeration, the results of structural modeling revealed a persistent misalignment between the target and actual dynamics of economic subprocesses, limiting the realization of the system's development potential.

The application of the structural process modeling approach made it possible to assess the synchronicity of changes across heterogeneous subprocesses, identify factors hindering development, and evaluate the magnitude of the resulting synergistic effect. The findings indicate that, during the study period, this effect remained relatively low, reflecting insufficient collinearity between the strategic objectives of public authorities, transport operators, business actors, and the local community.

At the same time, the results highlight the presence of institutional and managerial prerequisites for improving the effectiveness of public transport systems in Arctic agglomerations. In particular, the expansion and restructuring of route networks, the coordination of operating regimes, and the involvement of local self-government bodies and residents in strategic planning processes can contribute to enhancing system coherence and reducing dependence on private mobility.

The proposed methodological framework can be applied to the analysis of public transport systems in other cities and urban agglomerations characterized by complex spatial structures and high sensitivity to external socio-economic factors. Further research may focus on extending the observation period, refining indicators of service quality and institutional coordination, and assessing the long-term effects of emerging socio-economic partnerships and strategic development initiatives.

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Formation of the Concept of a Socially Responsible University

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ABSTRACT

In the modern world, the role of universities is gradually changing: increasing importance is being placed on their participation in social life and engagement in socio-economic processes. The **aim of this study** is to substantiate the concept of a socially responsible university and to reveal the contemporary understanding of the phenomenon of social responsibility within educational institutions. The **methodological basis** of the research includes system analysis, the evaluation of regulatory documents, and expert data assessment. The study defines the concept of a socially responsible university and systematizes its practices in terms of addressing socially significant issues. It also describes various levels of university social responsibility, substantiates the principles of their activity, and uses an economic-mathematical model to summarize the resulting positive effects. Additionally, criteria for assessing the level of social responsibility of universities are considered. The research **findings** can be used by the Ministry of Science and Higher Education of the Russian Federation to classify universities based on their capacity to implement the concept of a socially responsible university. They may also be applied by university management to objectively assess the prerequisites for developing strategies aimed at creating conditions conducive to research and development activities.

Keywords: university; governance; socially responsible university; business ethics; social responsibility; loyalty

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INTRODUCTION

In the contemporary world, the importance of universities' participation in societal development is steadily increasing, particularly in terms of their engagement in socio-economic processes [1, 2].

As generators of innovation and developers of new technologies, higher education institutions represent a key driving force of the economy. They provide professional training for highly qualified specialists who are in demand on the labor market and ensure cooperation with industrial partners [3–5]. At present, universities face new challenges, including achieving technological leadership, ensuring import substitution, increasing the scale and quality of research activity, and accelerating the commercialization of its results [6–9].

The traditional model of a classical university no longer fully meets the demands of the modern era and requires transformation, one of the most effective directions of which is the development of a socially responsible university.

THE ESSENCE OF A SOCIALLY RESPONSIBLE UNIVERSITY

It appears appropriate to explore the potential for developing a new conceptual model of the university based on the practices of corporate social responsibility (CSR) of an economic entity, since the content of these practices is inherently oriented toward addressing the contemporary problems and challenges facing higher education institutions.

Corporate social responsibility (CSR) (the terms "corporate responsibility" and "business social responsibility" are also sometimes used) is a concept according to which an organization takes into account the interests of society by "assuming responsibility for the impact of its activities on all stakeholders within the public sphere" [10]. In essence, an economic entity, "guided by the principles of corporate social responsibility, undertakes obligations in the course of its business activity that go beyond those established by legislation, and voluntarily adopts additional measures to improve the quality of life of its employees and their families, to address socially significant problems of local communities, and of society as a whole" [11].

The ideas of CSR began to be widely applied in the activities of business structures in the early 1970s, when business ethics started to develop as "a form of applied ethics that examines ethical principles and moral or ethical problems that may arise in a business environment" [12]. It should be noted that over time, under the influence of the scientific and technological revolution, the range of issues associated with corporate social responsibility has expanded significantly. Whereas in the twentieth century CSR primarily implied responsible labor and business practices, today it encompasses "the recognition of responsibility for environmental protection, addressing socio-economic challenges, improving the quality of life of local communities, ensuring human rights compliance, combating corruption, and a number of other issues whose importance is acknowledged by society[1]" [12, 13].

The practical implementation of corporate social responsibility provisions in the economic activity of organizations remains a subject of debate. Some researchers argue that the adoption of CSR principles provides companies with economic benefits and competitive advantages (such as high customer and employee loyalty, increased market share, growth in revenue and profit, etc.), although these outcomes can be fully realized only in the long term. In this view, CSR-oriented activity is grounded in strong economic motivations [11, 14]. Other scholars contend that this is not always the case and define the primary purpose of CSR as the implementation of environmentally responsible business practices and the avoidance of violations of the rights of other stakeholders [12]. Under contemporary conditions, the challenges of integrating corporate social responsibility principles into business

[1] Business Social Responsibility. Monitoring. URL: https://wciom.ru/analytical-reviews/analiticheskii-obzor/socialnaja-otvetstvennost-biznesa-monitoring (date of access: 16.02.2024).

practice are becoming increasingly relevant and in demand.

Taking into account the key ideas of corporate social responsibility, a socially responsible university may be defined as a higher education institution that, within the framework of its core activities (training professionals and conducting research), is oriented toward making a voluntary contribution to societal development. This contribution is directly related to its primary mission and goes beyond the minimum requirements established by law, encompassing social, economic, political, spiritual, and environmental domains. The socially significant problems addressed by an educational institution may pertain to such areas as ethics, ecology, charity, humanitarianism, compassion, and others.

The concept of a socially responsible university implies that, in its activities, it undertakes additional obligations toward society, demonstrates concern for employees and their families, the environment, and the broader community as a whole [14–17].

AREAS OF SOCIALLY RESPONSIBLE UNIVERSITY PRACTICES

Table 1 systematizes the areas of socially responsible practices of universities according to the spheres in which a synergistic effect arises when addressing socially significant problems of society.

The data presented in *Table 1* indicate that there are numerous spheres involving socially significant challenges in which universities may be effectively engaged. However, the key domain is scientific and technological development, as it is this sphere that can serve as a solid foundation for technological leadership. In all other areas, universities do not possess substantial competitive advantages over other economic actors, such as business organizations, public authorities, and institutions in healthcare, culture, or sport.

At present, the application of corporate social responsibility (CSR) principles in university activities appears particularly relevant. Previously, most universities, as state-funded institutions, regarded their primary mission solely as fulfilling government mandates, namely the training of specialists and the conduct of fundamental research. At the same time, issues related to the effective utilization of their substantial material and technical infrastructure and highly qualified workforce were not given sufficient attention.

In Russia, the challenge of improving the efficiency of public sector institutions and organizations became especially acute after the 2008 crisis, when decisions aimed at the rational use of state and municipal resources were developed at all levels of government. The transition of institutions from the budgetary organizational and legal form to autonomous status may also be considered a step toward CSR-oriented development.

Given their significant resource base, universities are capable of operating under conditions of self-financing, thereby reducing the burden on the state budget. At the same time, the move toward autonomy may enable both the expansion of fee-based student enrollment in the short term (tactical horizon) and the development of research activities and enhancement of their effectiveness in the long term (strategic horizon).

LEVELS OF UNIVERSITY SOCIAL RESPONSIBILITY

As noted above, the university mission in its classical understanding was traditionally associated with training personnel for fundamental science and supporting its development. Under contemporary conditions, however, this perspective no longer corresponds to the demands of the modern era, as society increasingly requires the outcomes of applied research and innovative developments that can be integrated into socio-economic life.

The fundamental distinction between applied and basic research lies not only in the possibility of rapid returns and the production of new technologies and products, but also in the nature of research motivation. Fundamental research requires primarily internal incentives, whereas applied research depends on external drivers initiated by commissioning actors, including business

Table 1

Directions of Socially Responsible Practices of Universities

№	The scope of the emergence of a synergistic effect in solving socially significant problems of society	Characteristics of the direction of socially responsible practices of universities	Examples
1	Scientific and Technological Development (as the foundation of technological leadership)	•Accelerating the introduction of innovations into society; •Developing students' practical skills in science and technology; •Promoting science and public educational outreach; •Creating conditions for academic mobility; •Supporting university-based academic entrepreneurship	РТУ МИРЭА: мегалаборатории HSE University: public lecture series and research in digital transformation and social policy; FEFU: free educational courses and mentoring system for school students preparing for academic competitions; MIPT: "StudFabLab" startup workshop; MTUCI: Research Laboratory NIL-24 "Cryptography and Protection of IP Systems"; RTU MIREA: mega-laboratories
2	Strengthening the Foundations of Russian Statehood	•Preserving traditional Russian spiritual and moral values; •Civic and patriotic education; •Strengthening unity within the student community	RSUH: systematic implementation of patriotic education projects, inclusive education, student self-governance; MGIK: promotion of Russian culture in Abkhazia
3	Volunteering	Engagement of students and staff in solving socially significant problems through volunteering, including: •Support for vulnerable individuals and those in need; •Promotion of compassion, humanitarianism, and social solidarity	EFU: university volunteer corps; USAAA: student-designed projects for seven social facilities (commissioned by the Sverdlovsk Regional Construction Authority); RUDN: veterinary assistance in Uzbekistan; RGSU: socialization of children with disabilities in Kyrgyzstan; RGAUU: veterinary support for cattle farming in India
4	Sport	Implementation of the principle "Sport as a Norm of Life," producing socially beneficial outcomes such as: •Strengthening the health of students and staff; •Promoting discipline and personal development; •Productive use of leisure time; •Opportunities for self-realization; •Popularization of sport (GTO programmes); •Organizing GTO norm assessment	GCOLIFK: "Sporting Vertical" project aimed at developing knowledge and practical skills among students in grades 5–9 in the field of physical education and sport, supporting their successful self-realization in athletic activities and various domains of sports practice. The All-Russian Olympiad "I Am a Professional" is conducted for university students across a wide range of academic disciplines; University-based GTO testing centers; universities awarding additional admission points for GTO badges
5	Health	•Research and development in the medical field; •Blood donation campaigns; •Psychological support initiatives	Lobachevsky State University of Nizhny Novgorod: development of the hardware "Active Longevity", based on a "smart-home" model for older adults, aimed at supporting daily living and monitoring health status through biofeedback methods; Demidov Yaroslavl State University: organization of a Mental Health Week for residents of the Yaroslavl Region, implemented by university students and faculty in cooperation with the Russian Academy of Education; Kosygin Russian State University: development by technology students of adaptive clothing sets designed to facilitate patients' rehabilitation periods; Ivanovo State Polytechnic University: creation by students of a device that significantly reduces injury risk among individuals with visual impairments

Table 1 (continued)

№	The scope of the emergence of a synergistic effect in solving socially significant problems of society	Characteristics of the direction of socially responsible practices of universities	Examples
6	Environmental Challenges	•Environmental projects (clean-up campaigns, waste separation, clothing recycling, etc.); •Environmental education and awareness-raising	FEFU: projects supporting Arctic and Far East development; TSU: "Green Campus" initiative and creation of eco-zones
7	Charity and Civic Engagement	•Support and participation in socially significant programmes aimed at protecting vulnerable groups and creating a favorable social and cultural environment; •Use of university infrastructure for public cultural, sports, business, and social events; •Free legal assistance to the population; •Organization of clubs and educational activities for children	FEFU: engagement with social start-ups; MSU: MSU Legal Clinic; RSUH: Legal Clinic Portal; MUIV: Center for Legal Assistance; Participation of Moscow universities in the "Moscow Longevity" programme; MSU: children's educational clubs (Faculty of Philosophy, Faculty of Biology); HSE University: youth engineering club within the national project "First in Science"

Source: Compiled by the authors.

Table 2

University Social responsibility Levels

Name of the level of social responsibility	Characteristics of the level of social responsibility	University models
Basic	The university's activities are focused solely on compliance with the requirements of regulatory legal acts (legislation) of the Russian Federation Training of specialists	Classical university model (oriented toward educational activity based on the results of fundamental research) [18]
Extended	The university's activities are aimed not only at compliance with the requirements of regulatory legal acts (legislation) of the Russian Federation, but also at implementing projects designed to improve employees' working conditions and develop effective competitive motivation programmes. University infrastructure is actively used to organize public events (cultural, sports, business, and social). Training of specialists in demand on the labor market. Integration with industrial partners	Pragmatic university model (oriented toward increasing entrepreneurial activity and strategic planning of institutional development) [19, 20].
Higher	The university is oriented toward active participation in addressing socially significant problems and implementing public programmes. University infrastructure is actively used to organize public events (cultural, sports, business, and social). The university: - conducts research and experimental development commissioned by society - trains specialists in accordance with future labor market needs, - and integrates education, science, and business	Socially responsible university model (characterized by the capacity to conduct large-scale research activity and to commercialize the results obtained through research). Lomonosov Moscow State University, Higher School of Economics

Source: Compiled by the authors.

companies, state and regional authorities, public organizations, consumers of educational services, and other stakeholders whose interests become central. Under such conditions, the priorities of the external commissioning party come to the forefront. It is evident that the implementation of applied research and innovation enables universities, on the one hand, to integrate into the economic and social life of the region and the country, and on the other hand, to secure additional funding.

Universities, like business organizations, are characterized by different levels of social responsibility: basic, advanced, and highest [10] (*Table 2*).

The main university models — classical, pragmatic, and socially responsible — are presented in *Figure*. They are positioned in different areas depending on the balance between the social and economic benefits generated through their activities.

The classical university model is generally regarded as one primarily oriented toward achieving economic benefits; the pragmatic model is characterized by a certain degree of social impact, whereas the socially responsible model is focused on generating outcomes that are significant from the perspective of society.

In *Figure*, the blue triangle highlights the area representing an optimal balance of social and economic benefits that is attainable at the current stage of development.

The core mission of universities should be the achievement of the objectives set forth in the decrees of the President of the Russian Federation. However, the results attained by higher education institutions, which largely depend on their material and technical infrastructure and human resources, will vary.

Table 3 presents the capacities of educational organizations with different levels of social responsibility in terms of achieving the national development goals of the Russian Federation up to 2030, with a longer-term outlook extending to 2036.[2]

MODEL OF A SOCIALLY RESPONSIBLE UNIVERSITY

The results of the analysis of the operating principles of a socially responsible university are presented in *Table 4* [12].

The transition of universities to this model may generate the following positive effects:

1. Increased loyalty among prospective applicants, students, and their parents, creating

[2] Decree of the president of the Russian Federation dated 7 May 2024 № 309 "On the National Development Goals of the Russian Federation up to 2030 and for the Perspective up to 2036". URL: http://www.kremlin.ru/acts/bank/50542

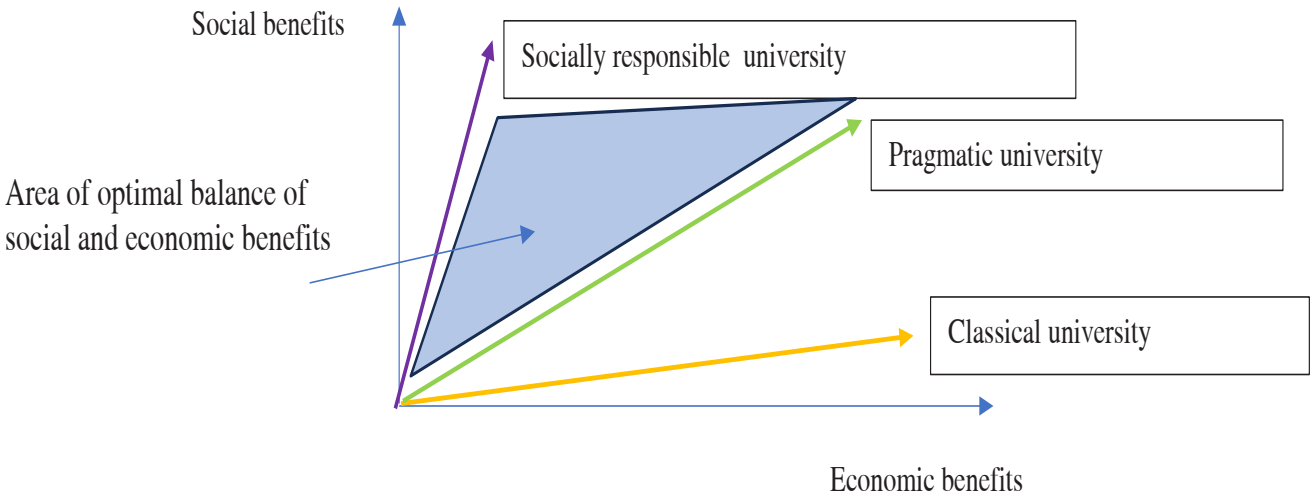

Fig. **Basic University Models**

Source: Compiled by the authors.

Table 3

University Capacity to Meet National Development Targets

National Development Goals of the Russian Federation	Level of social responsibility		
	Basic	Advanced	Higher
Population preservation, health strengthening, improvement of people's well—being, and family support	X	X	X
Realization of individual potential, development of talents, and fostering a patriotic and socially responsible personality	–	X	X
A comfortable and safe living environment	X	X	X
Environmental well—being	X	X	X
A sustainable and dynamic economy	–	X	X
Technological leadership	–	–	X
Digital transformation of state and municipal governance, the economy, and the social sphere	–	–	X

Source: Compiled by the authors.

conditions for expanding market share, increasing the volume of fee-based contractual services, and enhancing profitability.

2. Greater employee loyalty — the creation of attractive working conditions and opportunities for professional and career development will contribute to the retention of promising qualified personnel, strengthen staff motivation, and facilitate the recruitment of new specialists.

3. Commercialization of innovations — an understanding of stakeholder needs enables universities to offer products, services, and technologies that are in demand by society.

4. Opportunities to obtain support from the state and various foundations, as well as simplified access to investors, which promotes the growth of external funding sources.

5. Growth of intangible assets, strengthened brand reputation, the formation of a positive public image, and increased public trust, which in turn promotes the expansion of fee-based contractual services and improves interaction with stakeholders.

6. The development of stakeholder relationships fosters a favorable environment that enhances institutional performance through a clearer understanding of the interests of all participants.

Under contemporary conditions, a sustained trend toward the implementation of corporate social responsibility principles is observed, making the issue of evaluating the effectiveness of this process increasingly relevant. In the case of business organizations, CSR levels are assessed using three quantitative indicators: the index of per-employee social investment; the ratio (share) of a company's social investments to sales volume; and the ratio (share) of social investments to total profit. "All three types of quantitative social investment indices are not standardized and may take any positive value. The higher the index, the greater the company's social activity" [10, 12, 14].

Table 4

Principles of Socially Responsible University

№	Principle	Content of the principle
Basic Principles		
1	Publicity and transparency	The university's activities should be clear, accessible, and public (to the greatest extent possible reflected in the media); information about the institution should be available to all stakeholders.
2	Reliability	The university's operations should be transparent and truthful.
3	Regularity (systematic approach)	The development and implementation of socially significant projects and programmes should be carried out on an ongoing basis.
4	Relevance and significance (social orientation)	Socially significant projects and programmes should correspond to the current needs of society.
5	Political neutrality	The university's activities and policies should not infringe upon the interests of any stakeholders.
Implementation Principles:		
6	Employee engagement	A key requirement of institutional operations is the maximum possible involvement of employees in achieving the university's goals and objectives (primarily through a KPI system), taking into account staff opinions.
7	Partnership	The establishment and development of relationships with industrial partners and public authorities.
8	Ethical conduct	A fundamental requirement of institutional operations is compliance with the norms of business and universal human ethics.

Source: Compiled by the authors.

The first of three indicators (per-employee social investment index) reflects the qualitative dimension, whereas the other two represent the quantitative dimension, i.e., the scale. Moreover, analysis of the temporal dynamics of the second indicator (the ratio of social investments to sales volume) enables forecasting of its changes, since company turnover (sales volume) is always non-negative, and therefore the value of this index does not experience sharp fluctuations. Company profit, however, may take both positive and negative values; accordingly, the third indicator (the ratio of social investments to total profit) may be subject to substantial variation, which complicates its use for forecasting purposes. Therefore, only the second index — the ratio (share) of social investments to sales volume — can be applied to characterize the quantitative dimension.

It is reasonable to adhere to this approach with respect to educational organizations as well, while taking into account the specific nature of their socially oriented activities, namely the priority of research and the rapid transfer of innovations from the scientific to the industrial sphere, primarily through the effective commercialization of the results of universities' core activities.

Table 5 presents the correspondence between CSR performance indicators for business organizations and universities.

The model of a socially responsible university may be based on the following factors:

Table 5

Methods of Corporate Social Responsibility Assessment of Business Structures and Educational Organizations

Corporate Social Responsibility Assessment Criteria	
in business organizations	**in educational institutions**
Index of social investment per employee	Average income from research activity per member of academic staff (rubles per person)
Share of a company's social investments relative to sales volume	Share of non-budgetary revenues in total research-related income

Source: Compiled by the authors.

• the volume of income from research activity, adjusted for the achieved level of social responsibility, serving as the *objective function*;

• the volume of non-budgetary revenues from research activity and the average research income per member of academic staff, serving as *explanatory variables*.

To construct an economic and mathematical model of a socially responsible university, the above data were used for ten universities under the jurisdiction of the Ministry of Science and Higher Education of the Russian Federation.[3] These institutions were identified as leading performers in research activity in the ranking of the best universities in Russia compiled by the RAEX agency,[4] for the period 2016–2022.

The model of a socially responsible university is presented as follows [21]:

$$\begin{cases} SR = SI_{R.A.}, \\ I_{R.A.} = 933563,2 + 0,646\ X_1 + 128,3X_2 \\ I_{NB} \geq 50\%, \\ I_Q > 1{,}15 \text{ normative value of the indicator} \end{cases}, \quad (1)$$

where:

SR denotes the volume of income from research activity adjusted for the achieved level of social responsibility;

S is a binary variable reflecting whether the university meets the requirements for implementing social practices;

$I_{R.A.}$ denotes the volume of income from research activity (rubles);

X_1 represents non-budgetary research income (rubles);

X_2 represents the average income from research activity per member of academic staff (rubles per person);

I_{NB} — denotes the share of non-budgetary revenues in total research-related income (%);

I_Q — represents research income per employee (rubles per person).

To strengthen the proposed model, the binary variable *S*, was introduced to reflect the university's compliance with requirements for implementing social practices: $S = 0$ corresponds to the basic (or lower) level of social responsibility, whereas $S = 1$, indicates an advanced (or higher) level.

The characteristics of university social responsibility levels are presented *in Table 2.*

Model quality assessment

Model quality assessment included the following results:

1) explanatory power — 86% (a good level, exceeding 70%);

2) *p*- statistics — acceptable for all variables (all values must be below 0.05);

3) *t*- statistics for testing the significance of each factor — acceptable values for all variables ($t_{crit} = 2{,}04$ —Student's t-test criterion);

[3] University monitoring data from FGASNI "Sociocenter" URL: https://sociocenter.info/

[4] URL: https://raex-rr.com/education/russian_universities/top-100_universities/2024/

4) correlation testing — good level
5) *F*- statistic — good level;
6) residual analysis was conducted graphically; for this model, the hypothesis of heteroskedasticity was rejected [21].

CONCLUSION

The article demonstrates that the previously applied classical university model no longer fully meets contemporary challenges and therefore requires transformation. It is shown that one of the most promising directions of such transformation is the development of a socially responsible university.

Taking into account the key ideas of corporate social responsibility, the authors define a socially responsible university as a higher education institution that, within the framework of its core activities (training professionals and conducting research), is oriented toward making a voluntary contribution to societal development. This contribution is directly related to its primary mission and goes beyond the minimum requirements established by law, encompassing social, economic, political, spiritual, and environmental domains. The study systematizes the areas of socially responsible university practices according to the spheres in which a synergistic effect arises in addressing socially significant problems. It is substantiated that the sphere of scientific and technological development is of primary importance, as it can serve as a solid foundation for achieving technological leadership. Universities are characterized by different levels of social responsibility — basic, advanced, and highest — and the authors propose criteria for their assessment. The article also presents an economic and mathematical model of a socially responsible university, which enables evaluation of the positive effects associated with implementing this concept.

The findings of the study may be used by the Ministry of Science and Higher Education of the Russian Federation to systematize subordinate universities on the basis of the proposed economic and mathematical model, as well as in the development of state policy in the field of science and education. This may enhance the effectiveness and justification of managerial decisions. In addition, the results may be applied by higher education management for the objective evaluation of institutional development strategies oriented toward the prioritized advancement of research and development.

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Features of Education Management for First Year and Graduate University Students

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ABSTRACT

This article explores the management of education at different stages of university training with the aim of attracting more applicants and preparing highly qualified professionals capable of adapting to the evolving labor market. The **relevance of the study** stems from the ongoing demand for specialists who can apply innovative approaches aligned with the development of the digital economy. Additionally, a growing trend has been observed: graduates increasingly work in fields unrelated to their university degrees. The primary **goal** of the study was to develop recommendations for university administrators to modernize educational programs in order to increase applicant numbers and enhance graduate employability. The main **research method** was an anonymous survey conducted among both first-year students and graduates of Moscow City University (MCU). The survey questions focused on the key factors influencing students' perception of the educational process. The collected responses helped identify the strengths and weaknesses of current academic programs. Based on the **results**, a set of recommendations was formulated for university administrators and academic program developers to improve the effectiveness of education and attract prospective students.

Keywords: higher education; first-year students; graduates; learning characteristics; education management; education; academic programs

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INTRODUCTION

The contemporary higher education system in the Russian Federation is undergoing dynamic changes driven, among other factors, by the demands of the digital economy and the ongoing need to modernise educational programmes. A number of challenges have emerged, particularly with regard to staffing provision and the tendency of students to change their chosen field of study during the course of their education.

In 2024, an anonymous survey was conducted among first-year students and graduating bachelor's and master's students enrolled in socio-economic and pedagogical programmes at the Moscow City Pedagogical University. The survey aimed to examine students' perspectives on various aspects of the educational process. The respondents included young people aged 17–25 studying in such fields as law, public and municipal administration, human resource management, and teacher education. The relevance of the present study is determined by the need to develop scientifically grounded approaches to managing the educational process in order to enhance the effectiveness of professional training and specialist preparation.

The aim of this study was to formulate recommendations for improving academic curricula and managerial decision-making in the field of education.

SURVEY QUESTIONS AND RESULTS

The Influence of External Factors on Applicants' Choice of University and Educational Programme

The most significant factors influencing first-year students' decision to enrol at Moscow City Pedagogical University were: "the opportunity to combine work and study" (9%), "the high position of the university in national rankings" (8%), "a convenient class schedule" (7%), and "the geographical proximity of the institution to my place of residence or work" (5%). These findings suggest that when selecting a higher education institution, students are primarily guided by practical considerations and the university's reputation rather than by personal interests or individual academic inclinations (*Fig. 1*). Based on this, it can be concluded that first-year students place substantial emphasis on convenience and institutional prestige when making decisions about university enrolment.

Modern higher education is experiencing a crisis largely due to the mismatch between the qualifications of university graduates and labour market requirements. This discrepancy encourages students to shift towards more flexible forms of study [1], such as part-time or distance education, which allows them to combine academic training with employment [2]. This tendency is further supported by the growing interest of young people in using tools such as chatbots and artificial intelligence (AI), which provide opportunities for personalised learning while also taking labour market trends into account [3]. The integration of these technologies into the educational process is currently being actively discussed and explored [4].

Such an orientation toward external factors may be associated with the dominance of the so-called consumerist model in higher education. This model assumes that the student acts as a consumer, while education itself is treated as a service that must meet certain predefined requirements. Supporters of this approach argue that learning should correspond to "declared quality standards," whereas critics claim that it may instead undermine educational quality [5].

Such attention to external factors when choosing an educational institution reflects a broader issue related to the need to improve the quality of specialist training across various sectors, including the development of both flexible intellectual potential and a more conscious approach to selecting a field of study.

For a more in-depth analysis, the responses of first-year students and graduating students should be compared (*Fig. 2*).

Based on the 2024 survey of graduating students, several key factors influencing their choice of university can be identified. The most significant factor, as in the case of first-year students,

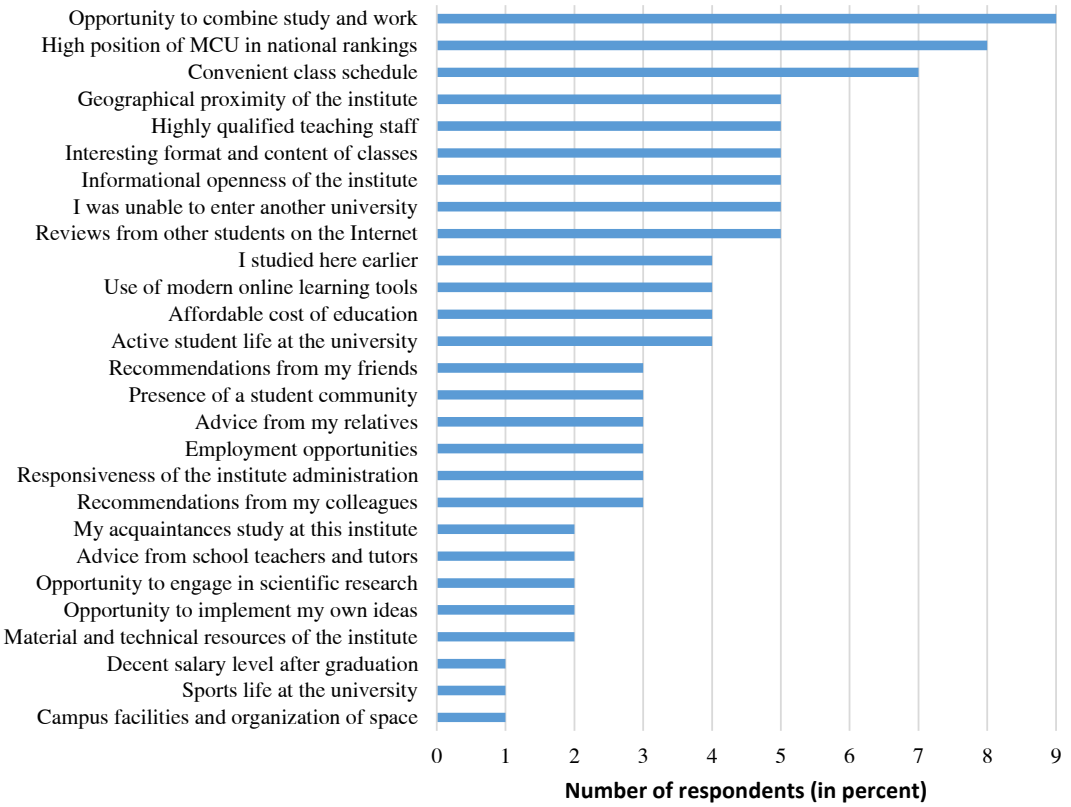

Fig. 1. **Responses from first-year students to the question: "Why did you choose the Institute of Economics, Management and Law at Moscow City University as your place of higher education?"**

Source: Compiled by the authors.

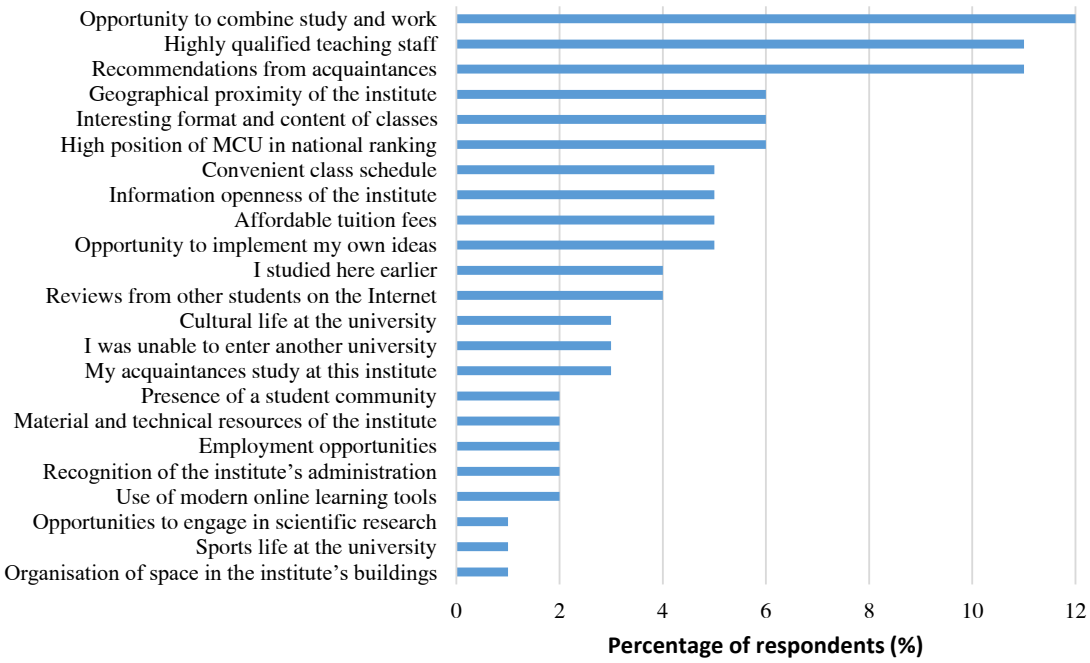

Fig. 2. **Responses from graduates to the question: "Why did you choose the Institute of Economics, Management and Law at Moscow City University as your place of higher education?"**

Source: Compiled by the authors.

was the opportunity to combine study and work (12% of respondents). This highlights the growing demand for flexible educational programmes that allow students to pursue higher education while simultaneously gaining practical experience. In the context of today's labour market, where the importance of professional skills continues to increase, such flexibility becomes an essential condition for successful learning.

The next most important factor was the high qualification of the university's teaching staff, as indicated by 11% of respondents. This demonstrates the importance of instructors' professionalism and competence in shaping the attractiveness of an educational institution, since they are able to provide knowledge and skills that meet contemporary requirements.

In addition, 11% of graduates noted that advice from supervisors, colleagues, friends, relatives, and teachers played a significant role in their decision. This points to the importance of social networks and the opinions of others in the university selection process. Recommendations may serve as an important indicator of educational quality and institutional reputation, which underlines the need for universities to maintain active engagement with professional communities and alumni.

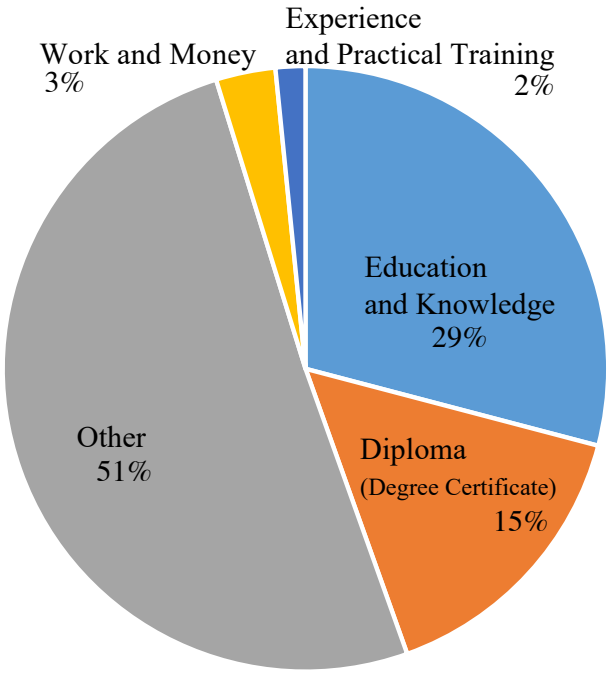

Fig. 3. **Responses from first-year students to the question: "What is your goal, what do you hope to achieve by studying at the Institute of Economics, Management and Law of Moscow City University?"**

Source: Compiled by the authors.

Other factors, such as the geographical proximity of the educational institution to the place of residence or work (6%) and a convenient class schedule (5%), are also relevant. However, their influence is less pronounced, which confirms that both graduates and first-year students are primarily guided by practical considerations. At the same time, applicants appear to approach the choice of university more consciously, taking into account not only convenience but also the quality of education.

The survey results confirm the need for a comprehensive approach to managing educational programmes, one that accounts for the required flexibility, the high qualifications of teaching staff, and the importance of recommendations.

Based on the diagram presented in *Fig. 3*, it is possible to draw conclusions about the goals students pursue in the process of obtaining higher education. Only 29% of respondents identified education itself, as well as the acquisition of knowledge, as the primary objective of their studies. Among other goals reported by participants was the desire to obtain a diploma (15%), which may indicate an emphasis among young people not so much on learning itself, but rather on the formal credential confirming their qualifications.

This is most likely related to social and economic factors, as possession of a diploma has become a necessary condition for employment rather than the result of a genuine pursuit of knowledge. At the same time, 51% of survey participants reported other objectives that are not directly connected with acquiring high-quality knowledge and are not focused on the educational process.

In order to develop an individual strategy for managing the learning process, it is necessary to take into account the real interests of consumers of educational services [1]. This is supported by the

fact that students often experience financial difficulties and seek opportunities to combine work with study, which requires universities to demonstrate flexibility in organising the academic process [6].

It is important to create conditions that foster a conscious and engaged approach to learning among students, which may in turn improve the quality of education and support more successful integration of graduates into the labour market. Researchers examining students' motivations for pursuing higher professional education at different stages of study have found that bachelor's students are primarily driven by the desire to acquire knowledge and master a profession, whereas master's students are more often motivated by the intention to obtain a diploma [7]. This suggests that student engagement should be strengthened at the initial stage of university education, when interest in learning remains relatively high.

Academic literature also notes that recent secondary school graduates are often unprepared for the university style of teaching [6]. Therefore, at the early stage of study it is essential to adapt the educational process to students' expectations, gradually developing their independent learning skills.

Sources of information used by applicants to learn about university educational programmes

Based on the data presented in *Fig. 4*, the primary source of information is the official university website, which was cited by 33% of respondents. This indicates that the online resource fulfils its main function: attracting prospective students and providing up-to-date information about the educational programmes offered. However, attention should also be paid to other sources — for example, 19% of respondents obtain information through search queries in Yandex, Google, and other search engines. This suggests that young people seek additional data and compare it with the information already available.

In addition, 10% of respondents rely on online articles about university programmes, while 7% receive information from friends, acquaintances, or relatives who study at the institution. Thus, the importance of informal communication channels and personal recommendations in the process of choosing a place of study is confirmed.

For comparative purposes, the results of the graduate survey are presented in *Fig. 5*.

The most significant source of information, cited by 34% of respondents, was the official website

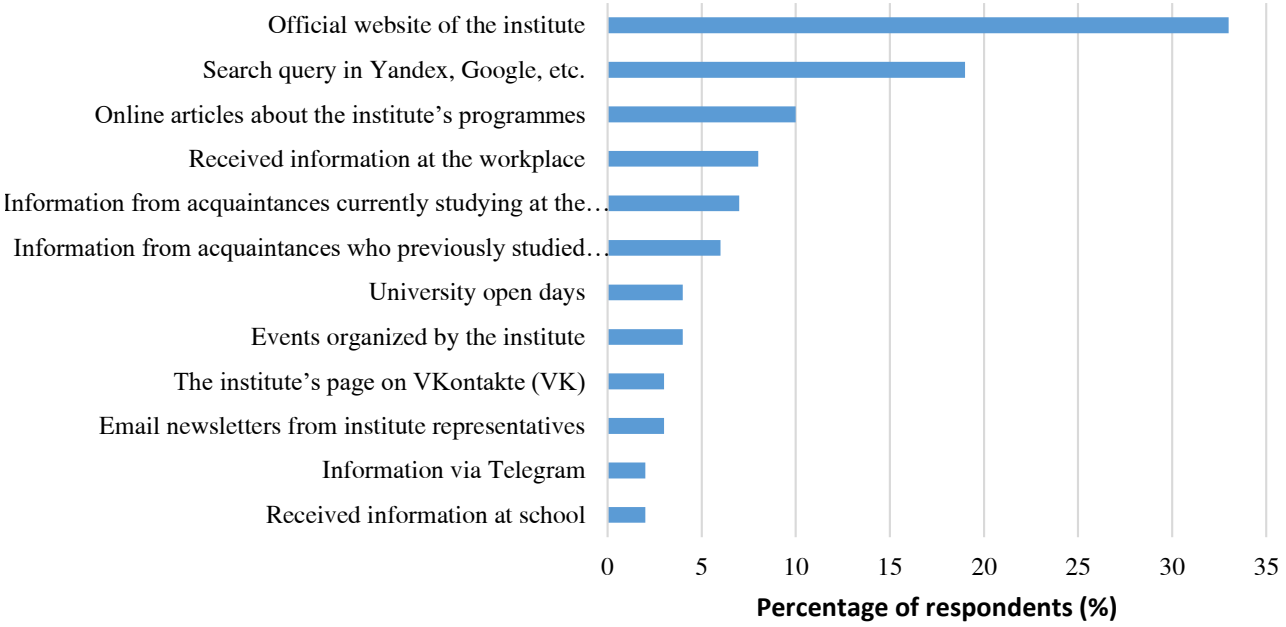

Fig. 4. **Responses from first-year students to the question: "How did you learn about the educational programs of the Institute of Economics, Management and Law of Moscow City University?"**

Source: Compiled by the authors.

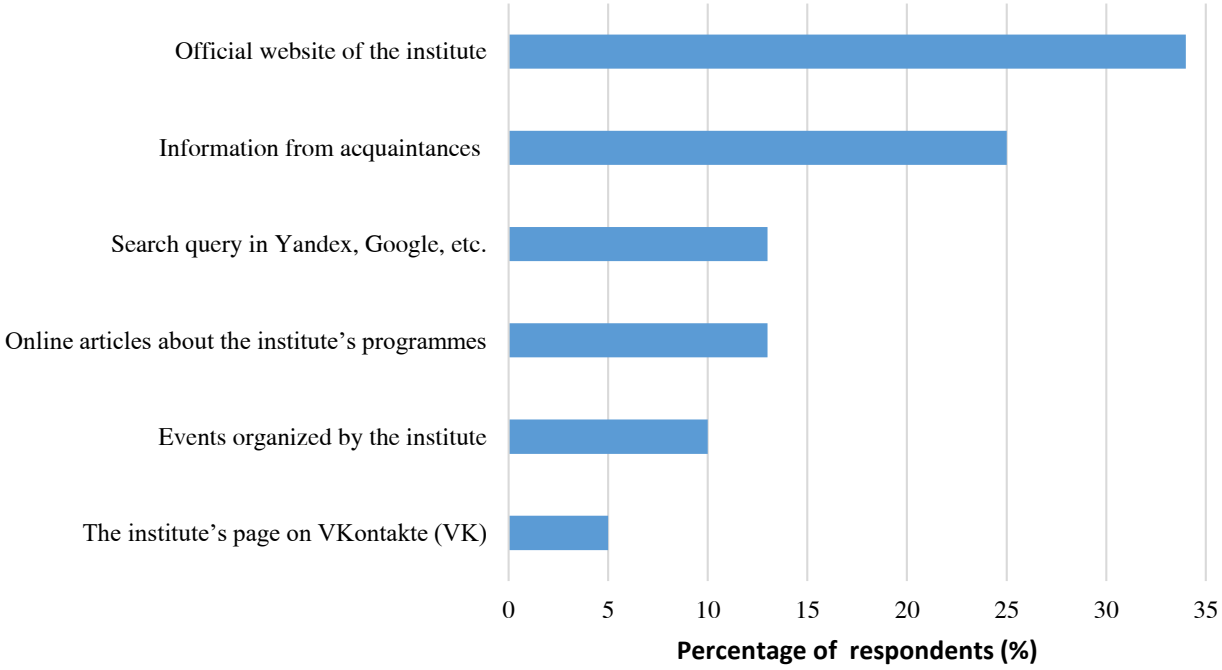

Fig. 5. **Responses from graduates to the question: "How did you learn about the educational programs of the Institute of Economics, Management and Law of Moscow City University?"**

Source: Compiled by the authors.

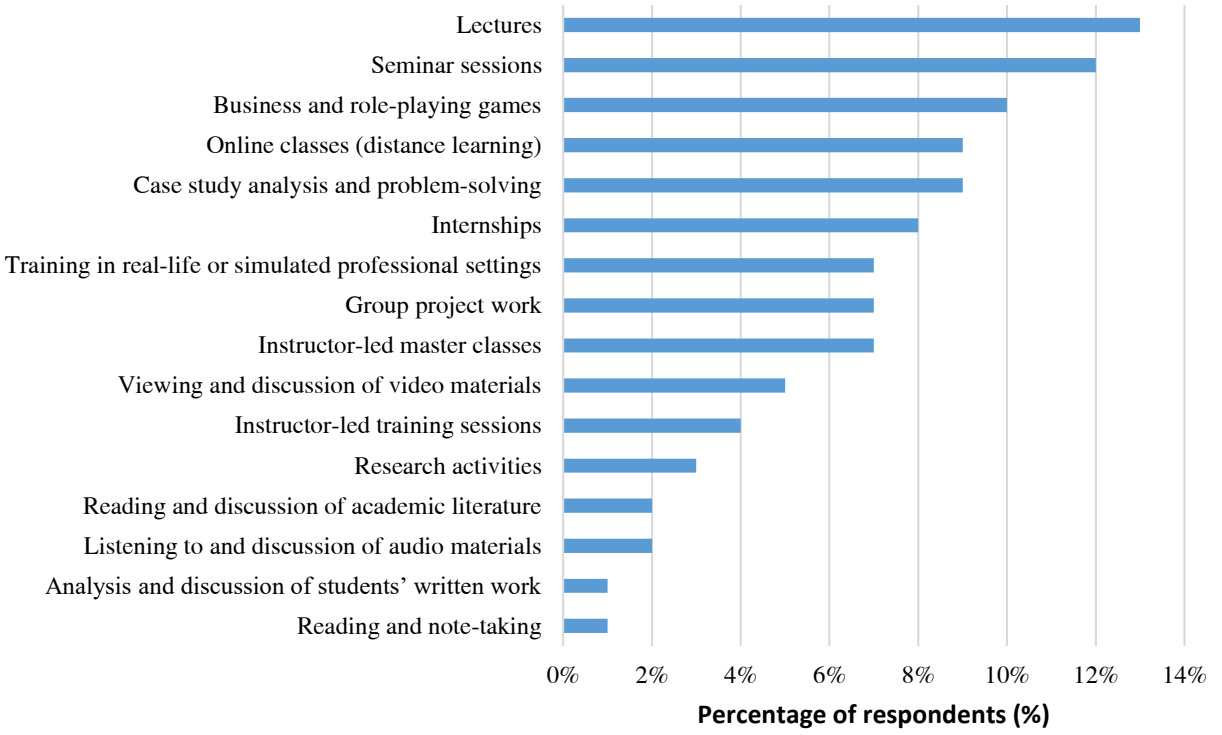

Fig. 6. **Responses from first-year students to the question: "Please indicate which format of study you find most appealing and beneficial?"**

Source: Compiled by the authors.

of the Institute of Economics, Management, and Law, which highlights a high level of trust in the information published there. Search queries in Yandex, Google, and other search engines were also important (13% of respondents). This indicates that prospective students actively use the internet to obtain information about educational institutions, making the optimisation of the institute's online presence particularly necessary.

In addition, 13% of respondents noted that they obtained information about the university's programmes from online articles, while 25% reported receiving such information from friends, relatives, colleagues, and teachers. These findings underscore the importance of social connections in informing applicants.

Based on the results presented, it can be concluded that the channels through which graduates and students obtain information are almost identical.

Nevertheless, although the official university website remains the primary source of information, there is a need to further develop other dissemination methods in order to strengthen the university's positive image within the educational environment. Potential approaches include more active promotion of academic programmes through social media, participation in educational exhibitions and career fairs, and the creation of content that is engaging and useful for prospective students.

Demand for different learning formats among first-year and graduating students

Based on the diagram presented in *Fig. 6*, it is possible to draw conclusions about students' preferences regarding learning formats. Lectures and seminar sessions received approximately similar proportions of responses-13% and 12%, respectively. This indicates that, despite current trends toward the digitalisation of education and the introduction of new technologies, young people continue to favour traditional methods of instruction. These findings highlight the continuing importance of classical formats. Lectures, which involve a structured and substantive presenta-

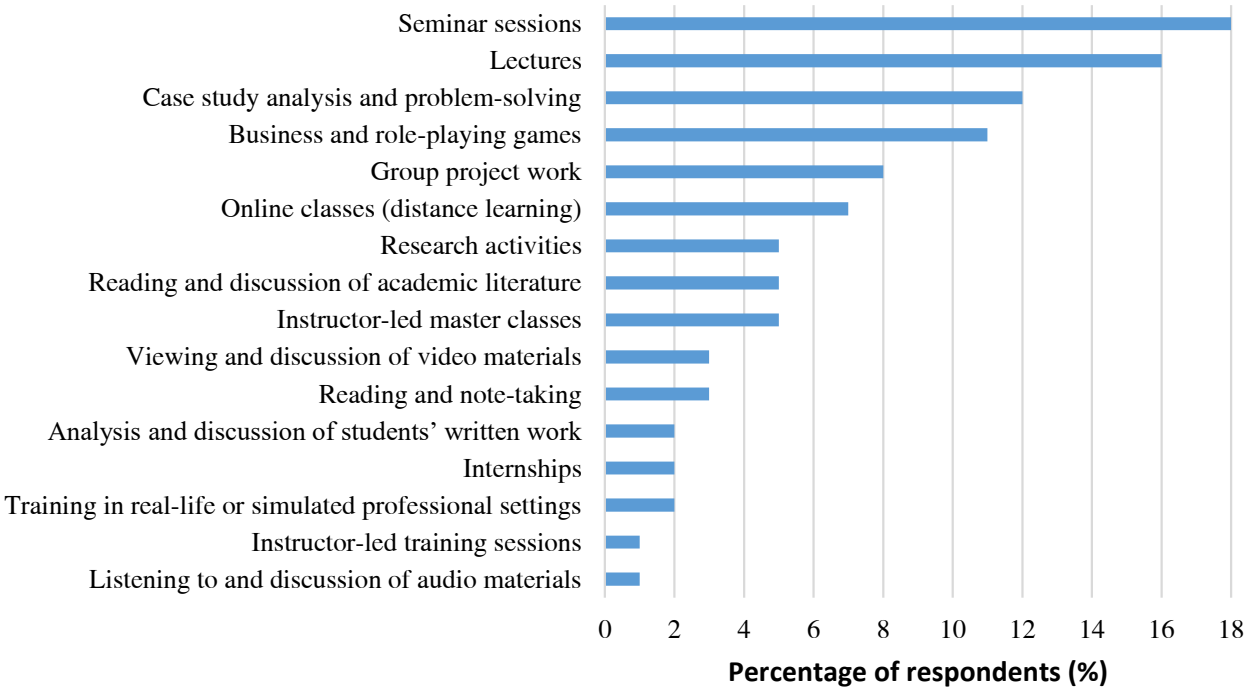

Fig. 7. **Responses from graduates to the question: "Which format of study was most useful for you?"**

Source: Compiled by the authors.

tion by the instructor, enable students to acquire systematised knowledge and a coherent understanding of the subject. Seminar sessions, in turn, promote active student engagement by allowing learners to present, discuss, and analyse course material, which is also a key aspect of developing critical thinking and communication skills.

Nevertheless, 9% of respondents preferred online classes conducted via MS Teams, while 10% favoured business and role-playing games. This points to the growing popularity of newer learning formats characterised by greater interactivity and practice-oriented approaches.

It is therefore important to focus on improving the quality of lectures and seminar sessions. In this context, the traditional instructionist approach, in which the teacher serves as the primary source of knowledge, should be reconsidered, and elements of constructivism should be introduced by involving students in active discussion and critical analysis of the material [5].

The need to use modern technologies in the educational process is particularly relevant in the context of digitalisation, which has affected all spheres of life. At present, such skills are required by almost all students, regardless of their field of study. The advantages of digital technologies include the presentation of academic materials in an accessible format, enhanced interaction between students and teachers, reduced educational costs, and improved quality, flexibility, and accessibility of learning [8].

It is therefore worth considering the integration of online formats and role-playing activities into traditional classroom instruction in order to promote deeper understanding of the material and increase student engagement in learning [1].

AI-based chatbots, as one example of modern educational technologies, have the potential to automate administrative tasks, provide immediate feedback, improve communication between learners and instructors, and offer personalised student support, thereby contributing to greater effectiveness of the educational process [3, 4]. When designing educational programmes, it is important to take students' own perspectives into account, as their participation can significantly enhance both the relevance of these programmes

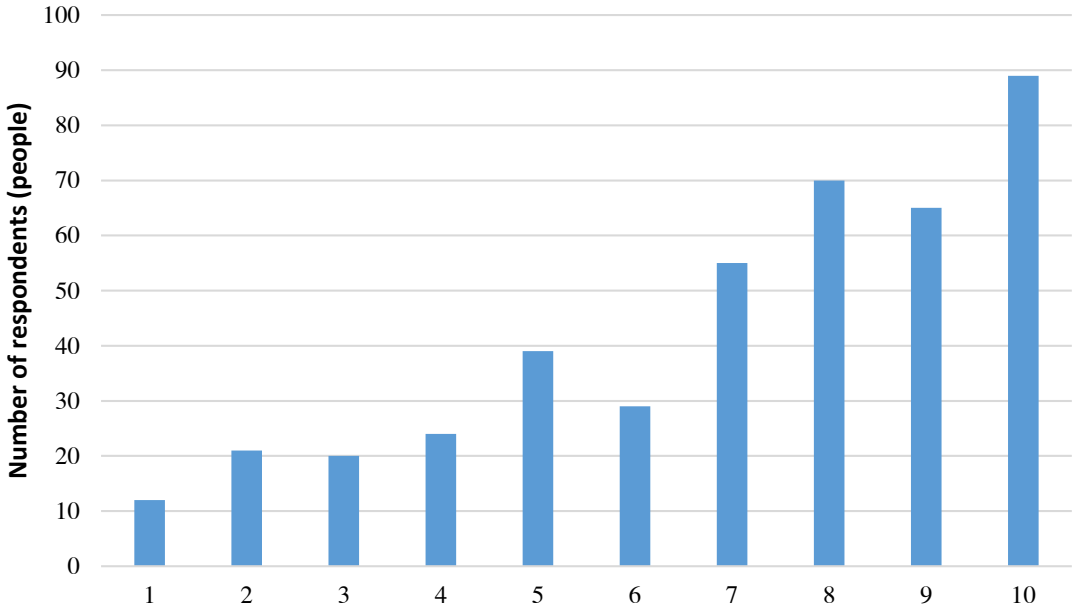

Fig. 8. **Responses from first-year students to the question: "On a scale of 1 to 10, how satisfied are you with the format and content of the classes at the Institute of Economics, Management and Law at of the Moscow City University?"**

Source: Compiled by the authors.

and their alignment with labour market requirements [9]. In addition, it should be recognised that the expectations of students and teachers regarding the learning process may differ substantially, making regular surveys and consultations with all stakeholders essential [6].

The diagram presented in *Fig. 7* illustrates young people's preferences regarding learning formats. Seminar sessions proved to be the most popular option, selected by 18% of respondents. This indicates that students value interactive and practice-oriented forms of education that promote deeper understanding of the material and the development of critical thinking skills. Lectures ranked second (16% of votes), suggesting that they are not the preferred format for the majority of students, who are more interested in active and engaging methods of learning through seminars and practical classes. Case-based problem solving received 12% of responses, further confirming students' desire to examine real-life situations they may encounter in their professional careers.

The survey results demonstrate the importance of placing greater emphasis on seminars and practical case studies, which may serve as a foundation for the continued development and improvement of academic courses, contribute to more effective management of the educational process, and better satisfy students' needs.

The analysis of differences between the opinions of first-year and graduating students allows the following conclusions to be drawn:

- Increasing value of seminars and case studies. Over time, students begin to attach greater importance to active learning formats such as seminars, case studies, independent reading followed by classroom discussion, and participation in research activities. This suggests that during the learning process they become more aware of the importance of practical skills and critical thinking.
- Declining attractiveness of passive formats. Students gradually lose interest in lectures, master classes, and in-class video viewing both at the initial and final stages of study.

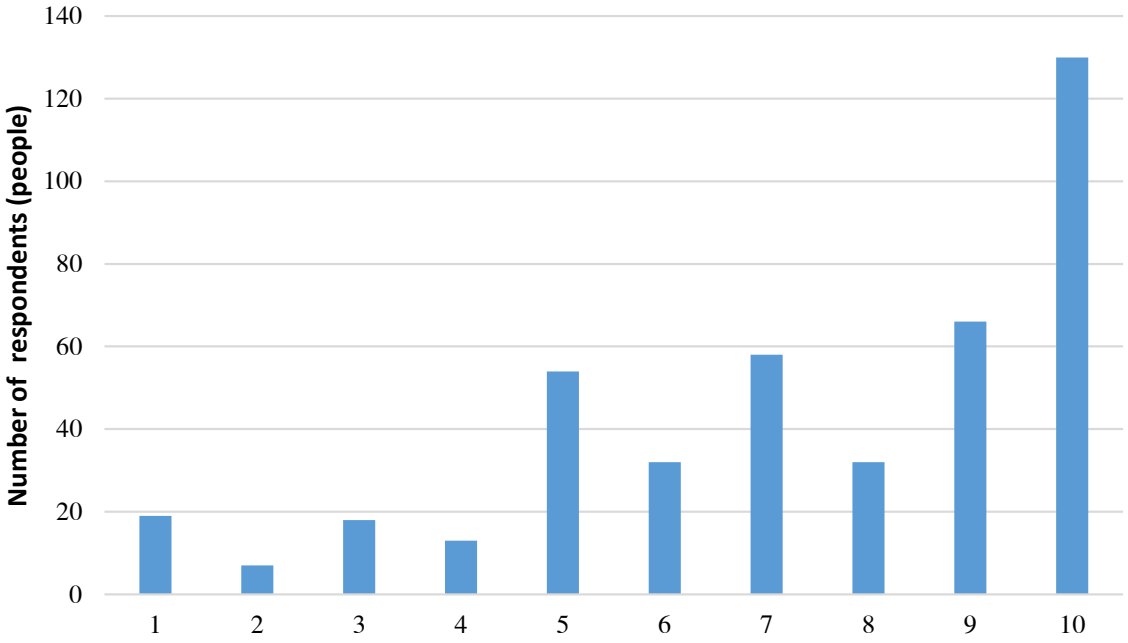

Fig. 9. **Responses from first-year students to the question: "On a scale of 1 to 10, how satisfied are you with the opportunities to implement your own ideas and projects during your studies at the Institute of Economics, Management and Law of Moscow City University?"**

Source: Compiled by the authors.

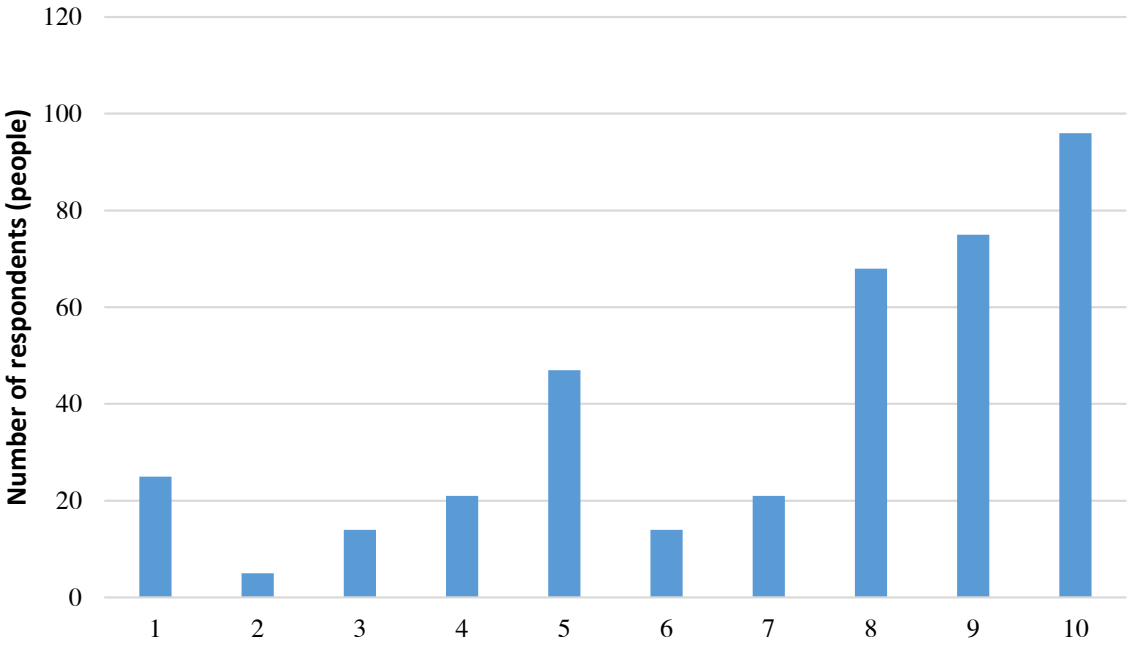

Fig. 10. **Responses from first-year students to the question: "On a scale of 1 to 10, how satisfied are you with the opportunities for employment in your field of study and with your career prospects after graduating from the Institute of Economics, Management and Law of the Moscow City University?"**

Source: Compiled by the authors.

The analysis of the obtained data provides valuable insights into students' preferences and needs at different stages of higher education. Using these findings to improve educational programmes and managerial decision-making can contribute to enhancing both the quality of specialist training and graduates' competitiveness in the labour market.

Student Satisfaction with Various Aspects of the Educational Process

Based on the diagram presented in *Fig. 8*, conclusions can be drawn regarding the level of student satisfaction with the format and content of classes. The results indicate that most respondents assess the quality of the educational process positively; however, it is important to note the substantial number of ratings in the range of 4–6, which may point to certain issues requiring attention and improvement. One possible direction for development is the introduction of a value co-creation model, which involves active collaboration between students and instructors in designing and implementing educational programmes, updating their content, and enhancing the competitiveness of the academic staff [1].

According to another study, students demonstrate a need to develop critical thinking, emotional intelligence, creativity, and communication skills. Respondents suggested such forms of informal education as master classes, training sessions, business games, and round-table discussions. Thus, at present, greater emphasis should be placed on interdisciplinary knowledge and the comprehensive development of the individual [10].

Possible recommendations for improvement in this area may include:

1. Curriculum adaptation — regular revision and updating of study plans to reflect current trends in education and labour market demands. This may also involve introducing new subjects, modernising the content of existing courses, monitoring the relevance of programme components, and removing those that no longer correspond to contemporary developments or fail to provide practically useful knowledge.

2. Development of interactive teaching methods — such as group projects, case-based learning, and role-playing activities to increase student engagement and make the learning process more motivating and dynamic. One potential approach is the implementation of AI-based chatbots, which can not only improve academic performance and communication between teachers and students, but also enhance student motivation through personalised learning and the automation of routine processes [3, 11].

Based on the diagram presented in *Fig. 9*, conclusions can be drawn regarding the degree of student satisfaction with the opportunities to implement their own ideas and projects during the learning process. A considerable number of young people rated their opportunities at the highest level of 10; however, many respondents selected scores of 5 and 7, which may indicate the presence of obstacles preventing them from actively pursuing their ideas. Lower ratings — such as 5 and 6-most likely point to a lack of the necessary resources and platforms for project implementation. In this regard, it is important to establish more effective communication between students and instructors, for example through regular meetings where ideas can be presented and feedback provided. It may also be worthwhile to consider the creation of mentoring programmes in which senior students or faculty members could support newcomers in developing and implementing their initiatives.

Thus, the survey results confirm the need for active measures aimed at improving the conditions for student project development. This would not only increase students' satisfaction with the educational process but also foster the skills required for their future professional success.

These objectives may be achieved through the introduction of a co-production model, in which learners are viewed as partners in the educational process and actively participate in shaping it [5].

The data presented in *Fig. 10* make it possible to draw conclusions about the level of student satisfaction with opportunities for employment in their field of study and with career prospects after graduation. Although most ratings fall within the range of 7–10, the question arises as to how objectively students can assess these opportunities at the early stage of their education. They do not yet possess sufficient experience or information about the actual conditions of employment and career development in their professional domain, and their opinions are therefore based on expectations rather than on practical experience.

In this regard, the university should consider organising activities such as career fairs, master classes, and meetings with employers to help students better understand labour market requirements and prepare for their future professional careers. This approach aligns with the principles of the student engagement model, in which the university actively works to create conditions that support graduates' successful career development [5].

The Impact of Internships and Practical Training on Graduate Employment and Professional Outcomes

At the final stage of their studies, future specialists are expected to have a clear understanding and awareness of their professional prospects. This research question can be further examined through a series of practice-related issues, since practical training plays a crucial linking role between education and career development.

The diagram presented in *Fig. 11* shows students' assessment of the importance of the practical training they completed during their university studies. The results indicate that 72% of respondents consider it important, which reflects a strong recognition of the role of practical experience within the educational process. Nevertheless, 28% of participants expressed a different view, which may point to the need for further development and improvement of practical training activities. This also highlights the importance of continuous evaluation and adaptation of educational programmes to labour market requirements and student expectations.

It should be noted that, despite the large number of positive evaluations, the university should

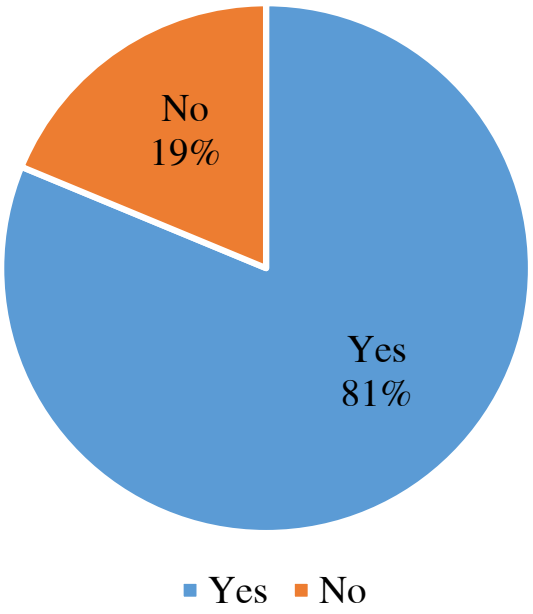

Fig. 11. **Responses from graduates to the question: "How important was your internship during your studies at the Institute for your future career in your chosen field: did it help you assess the scope of your theoretical knowledge?"**

Source: compiled by the authors.

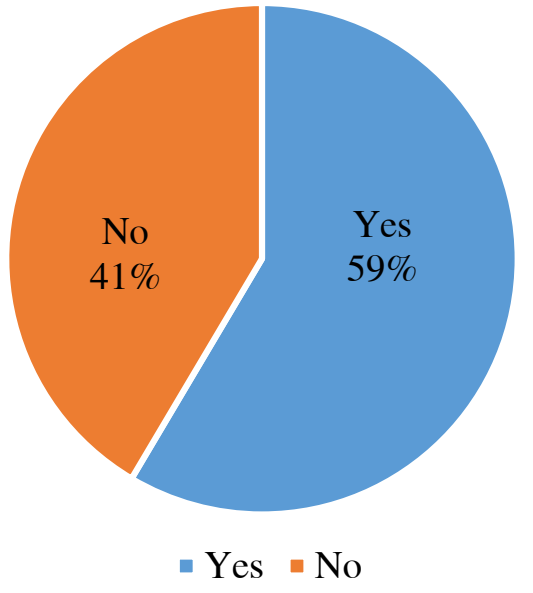

Fig. 12. **Responses from graduates to the question: "How important was your internship during your studies at the Institute for your future career in your chosen field: did it reveal real-world production issues you are likely to encounter?"**

Source: compiled by the authors.

continue its efforts in this area in order not only to enhance the quality of education, but also to strengthen students' preparedness for the challenges they may encounter in their professional careers.

The next diagram (*Fig. 12*) presents students' evaluation of the importance of the practical training undertaken during their studies for their future careers. While 59% of respondents consider such training important, 41% disagree with this statement and do not perceive it as beneficial to their education. This distribution of opinions suggests that practical training does not always correspond to real workplace challenges that graduates may face in their professional lives. Therefore, the programmes included in practical training should be revised in order to place greater emphasis on real working situations, as well as on the current challenges and tasks confronting future specialists.

Further improvement of practical training requires not only moving away from a teacher-centred model, in which practice is treated as a formal supplement to theory, but also progressing toward a value co-creation model, where students, instructors, and industry representatives actively participate in shaping both the content and format of practical training [5].

The diagram presented in *Fig. 13* illustrates students' assessment of the importance of the practical training they completed for their future careers in their chosen field. According to the results, 48% of respondents believe that the internship helped them make a final decision regarding their future workplace, whereas 52% disagree with this statement. This indicates that practical training does not fully fulfil one of its key functions — preparing students for professional employment.

It is therefore important to establish stronger cooperation with companies and organisations so that future graduates can complete internships in conditions that are as close as possible to real professional environments and face fewer difficulties when choosing a place of employment.

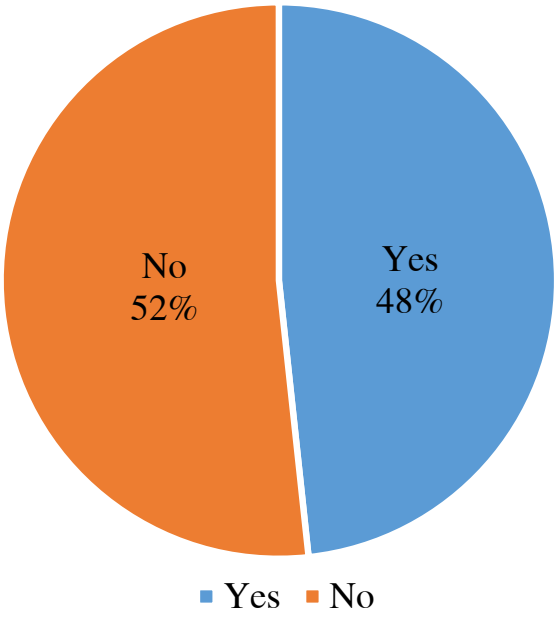

Fig. 13. **Responses from graduates to the question: "How important was your internship during your studies at the Institute for your future career in your chosen field: did it help you make a final decision about your place of employment?"**

Source: compiled by the authors.

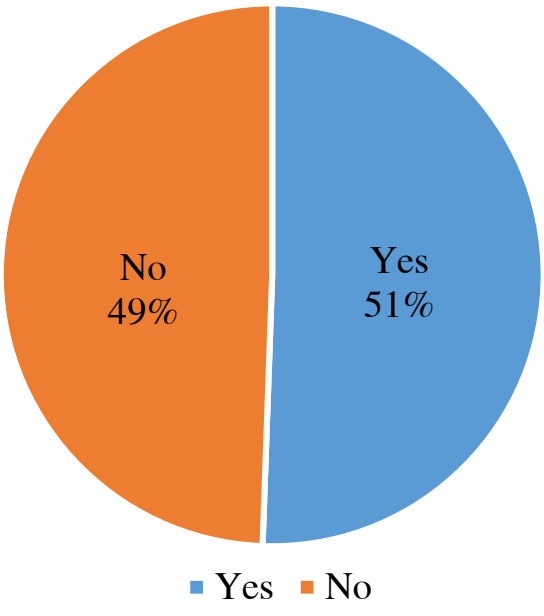

Fig. 14. **Responses from graduates to the question: "How important was your internship during your studies at the Institute for your future career in your chosen field: did it allow you to demonstrate your professionalism and secure a future job offer?"**

Source: compiled by the authors.

In addition, the university may consider organising master classes and seminars involving industry experts. This would allow students not only to gain a more comprehensive understanding of their future profession and the current challenges they may encounter, but also to improve their employment opportunities.

The diagram presented in *Fig. 14* illustrates students' evaluation of the importance of practical training for their future careers. According to the results, 51% of respondents believe that the internship gave them an opportunity to demonstrate themselves as professionals and thereby secure a future workplace. However, 49% disagreed with this statement, meaning that nearly half of the participants did not perceive practical training as providing real value for their professional preparation.

The findings of this section highlight the need to reconsider current approaches to internship organisation in order to increase its effectiveness and better align it with student expectations. This, in turn, would improve graduates' chances of successful employment.

Development of skills and competencies among university graduates and the applied orientation of educational activity

The diagram presented in *Fig. 15* shows the development of various competencies among students throughout their studies, with communication, analytical, and project-related skills being the most highly developed. This indicates that the educational programmes are effective in fostering key abilities required for professional activity. However, attention should be paid to the relatively weaker development of foreign language, economic, and managerial competencies, which are critically important for students in socio-economic fields. Insufficient proficiency in these areas may negatively affect graduates' competitiveness in the labour market.

Fig. 16 presents data on whether the topic and content of graduates' thesis projects were related to the tasks they were expected to address

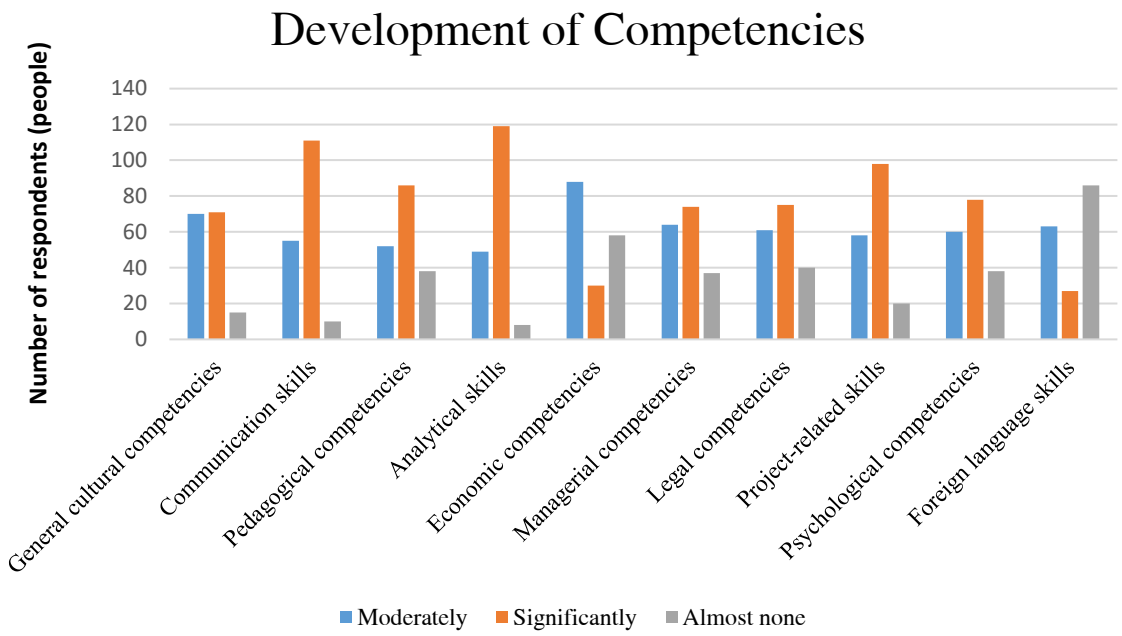

Fig. 15. **Responses from graduates to the question: "Which competencies were you able to develop during your studies at the Institute?"**

Source: Compiled by the authors.

in their future employment. Forty-four percent of respondents answered positively, indicating that the institute's educational programmes are aligned with labour market requirements. However, 30% reported that their thesis work was not related to their future professional activity, while 23% noted that the connection was only indirect. These findings point to the need to strengthen the link between the academic process and real workplace tasks.

Therefore, educational programmes should be further improved in order to more accurately reflect current labour market demands and the challenges graduates face in their professional careers.

Let us consider students' responses to the question of where they would enrol if they were given a second opportunity to choose a university (*Fig. 17*). A total of 53.9% of respondents confirmed their original decision, 33% indicated that they would choose a different specialisation at the same university, and 13% stated that they would prefer a different field of study at another educational institution.

Thus, nearly half of the respondents (46%) consider the possibility of changing their career direction. This result may indicate the presence of certain problems within the educational process.

In this regard, attention should be paid, first, to the need for career guidance activities (such as meetings with professionals from various fields,

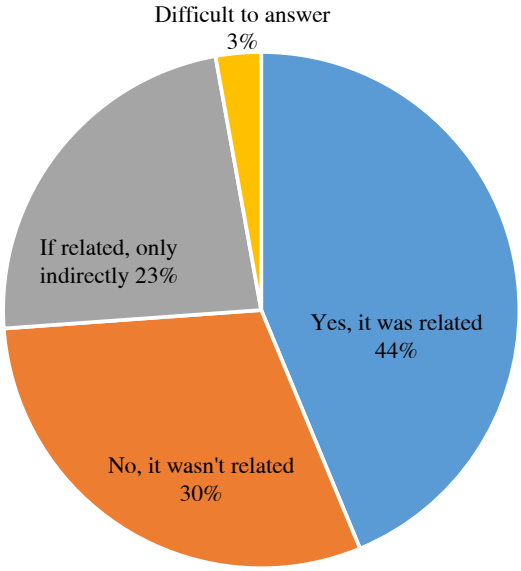

Fig. 16. **Responses from graduates to the question: "Was the topic and content of your thesis related to the tasks you faced in your future job?"**

Source: Compiled by the authors.

master classes, and seminars) that can help students better understand their interests and opportunities, and second, to improving the quality of educational programmes. Universities should actively engage with students and take their needs into account.

Fig. 18 presents the results of graduates' responses to the question of whether they are employed in the field of specialisation obtained at Moscow City University. The findings show that only 48% of respondents work in their professional area. This is a relatively low indicator, pointing to the need to strengthen the connection between the educational process and labour market requirements. Among the challenges are insufficient preparation of students for real working conditions, a lack of practical experience, and limited information about career opportunities in their field.

RECOMMENDATIONS

To improve the management of education at different stages of student training, the following measures may be proposed:

1. Strengthening practical training: incorporating more applied coursework, internships, and project-based activities into curricula in order to provide students with real professional experience. It is important to assess external labour market influences, competitive conditions, and relevant economic and legal factors [5].

2. Career guidance activities: organising regular meetings with industry representatives, career fairs, and seminars where students can learn about employment opportunities and employer expectations.

3. Introduction of mentoring systems: establishing mentoring programmes in which experienced professionals help young specialists adapt to the workplace environment and develop essential skills.

4. Curriculum adaptation: regularly revising and updating academic programmes in response to changes in labour market demand and employer needs, ensuring the relevance of acquired knowledge and competencies.

5. Cooperation with employers: building partnerships with companies to create internship and placement programmes aligned with real professional tasks and requirements.

6. Implementation of interactive teaching methods: integrating group projects, case-based learn-

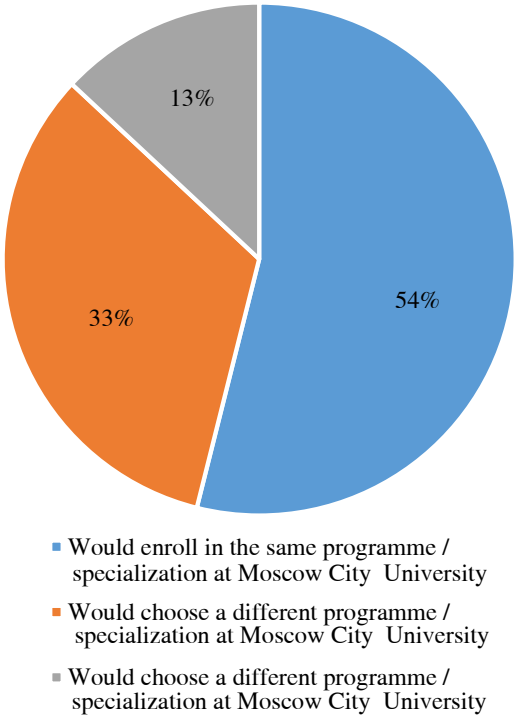

Fig. 17. **Responses from graduates to the question: "If you were to apply to university again... (most popular responses)"**

Source: Compiled by the authors.

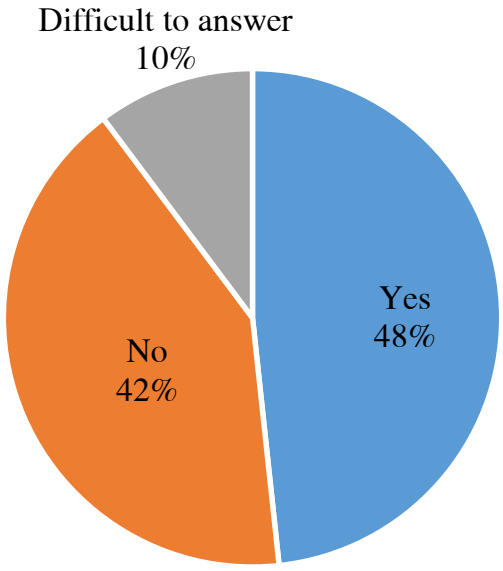

Fig. 18. **Responses ffom graduates to the question: "Are you currently working in the field of your degree from Moscow City University?"**

Source: Compiled by the authors.

ing, and role-playing activities into the educational process, as well as using AI-based chatbots that enhance student motivation and support personalised learning.

CONCLUSION

The analysis of the data obtained in this study made it possible to identify the factors influencing graduates' professional choices, as well as the reasons why students change their educational trajectories during the course of their studies. This information may be used to optimise the learning process and attract prospective applicants. The proposed recommendations aim to increase the attractiveness of educational programmes for students, ensure high-quality assimilation of academic material, and improve graduate employability.

The study revealed several key characteristics of education management at different stages of the learning process. The analysis of such factors as university choice, learning objectives, information sources, preferred instructional formats, and satisfaction with various aspects of educational activity demonstrates significant differences in perception between first-year students and graduates.

The findings indicate the need for a differentiated approach to managing the educational process, taking into account students' needs and expectations at various stages of study. As practical tools for achieving these objectives, the authors propose strengthening career guidance activities, enhancing the applied orientation of educational programmes, introducing interactive teaching methods, and expanding cooperation with employers in order to increase graduates' employment opportunities. Particular attention should be paid to fostering a conscious approach to choosing a field of study and to developing competencies that are in demand in the labour market.

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O.D. Gorbenko — analysis of questionnaires, selection of sources, theoretical framework analysis.
P.E. Gordeeva — systematization of the data obtained, development of the analytical section, interpretation of the results obtained.

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Industry Ecosystems of Digital Platforms in Public Governance

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ABSTRACT

The **relevance** of this study stems from the key role of digital platforms in public governance in the modern world. Transformation of the digital economy's architecture based on industry ecosystems of digital platforms (IEDPs) is outpacing the development of a corresponding theoretical and methodological framework, which necessitates a comprehensive scientific understanding of this issue. The **research objective** was to develop a conceptual framework for the development of IEDPs as a tool for for improving the efficiency of public governance through three interrelated processes: the establishment of new industry standards based on unified digital platforms; the transition to algorithmic regulation and transactional taxation during the integration of IEDPs; and the formation of a metasystem for solving macro-level problems through the synergy of order parameters. The **methodological basis** consists of a comparative and structural-functional analysis. The given article considers conceptual approaches to creating the architecture of the abovementioned ecosystems, demonstrates their effectiveness in a public-private partnership format that maintains a balance between government regulation and the autonomy of digital participants. The **results** obtained can be used by government agencies in developing regulatory policies and designing IEDPs, opening up prospects for scientifically assessing the effectiveness of digital platform types and their impact on the quality of public governance..

Keywords: public governance; state information system; public-private partnership; big data; industry digital platforms; industry ecosystem of digital platforms; labor productivity; technological sovereignty; digital economy

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INTRODUCTION

The active adoption of digital technologies and the expansion of network communication are stimulating the development of the platform economy. A qualitatively new paradigm of economic relations is emerging, based on Internet communications as the infrastructural foundation, distributed computing as the technological core, and big data as the primary productive resource [1–2].

Digital platforms (DPs) [3] enable the real-time integration of participants in digital interaction into a unified information space. They provide opportunities for mutual data exchange, reduce transaction costs, and transform their structure. The proliferation of DPs generates new formats of interaction among users, businesses, and the state; however, their scale and societal impact necessitate government regulation to ensure the security, transparency, and fairness of the digital environment.

Contemporary challenges of digital transformation have underscored the need for a systematic scholarly investigation of such regulation, including: (a) the development of conceptual foundations for state involvement in the evolution of the platform economy; (b) the assessment of the effectiveness of various types of DPs; and (c) the analysis of systemic barriers to their implementation.

As the methodological foundation of the study, the author employed a combination of general scientific and specialized methods aimed at conducting a comprehensive examination of the phenomenon of industry ecosystem digital platforms (SEDPs) within the context of public governance. The theoretical framework was grounded in scholarly works on the digital transformation of government and the platform economy. To systematize existing approaches and develop the fundamental principles underlying the architecture of SEDPs, a comparative analysis was applied. This made it possible to identify their distinctive features in comparison with other types of information systems (such as state information systems and private digital platforms) and to substantiate the author's definition of this concept. The principal tool for structuring the research findings and ensuring their clarity and coherence was structural-functional analysis. Its results enabled the identification of the key characteristics, advantages, challenges, and risks associated with the formation of SEDPs. Particular attention was devoted to those platforms developed in the format of public–private partnerships (PPPs), with their competitive advantages and systemic constraints being specifically highlighted.

The scientific novelty of the study lies in the selection of SEDPs as an object of analysis at the meso-level, which made it possible to overcome the limitations of traditional micro-level approaches. The proposed interaction architecture ensures a balance between the autonomy of participants and sector-wide coordination, while providing a methodological justification for the optimal number of SEDPs based on a systematic classification of types of economic activity. The theoretical significance of the research consists in the establishment of a new scholarly domain — the economics of industry industry ecosystem digital platforms — whereas its practical value lies in the development of analytical tools for government authorities to support the design of SEDPs and the assessment of their economic efficiency. This opens up opportunities for measuring the contribution of digital platforms to labour productivity growth.

DEFINITION AND CHARACTERISTICS OF AN INDUSTRY ECOSYSTEM OF DIGITAL PLATFORMS

The specific features of the legal and regulatory framework governing the digital economy have contributed to the rapid development of digital platforms (DPs), while simultaneously revealing systemic gaps in this domain. As noted in the UNCTAD Report (2019),[1] the dominance of DPs in markets is driven by network effects, exclu-

[1] World Investment Report URL: https://unctad.org/system/files/official-document/wir2019_overview_ru.pdf

sive access to user data, and the high degree of dependence of economic agents on platforms [4]. This configuration generates a complex set of challenges, including the need to develop specialized governance mechanisms, ensure a balance between the innovative potential of platforms and the protection of public interests, overcome resistance by DPs to regulatory interventions by states, and counteract violations of antitrust legislation. Particular relevance is attached to the typologization of DPs, which makes it possible to differentiate regulatory approaches in accordance with the architectural features of platforms and their monetization models.

An analysis of the current stage of the platformization of socio-economic activity allows for the identification of four basic types of information systems:

- state information systems (SIS);
- private digital platforms (e.g., Yandex Taxi, Avito, CIAN);
- industry ecosystems of digital platforms;
- the state automated system for strategic governance of economic sector development and regulation (GASSU).[2]

The predominance of a particular type of information system within the economy makes it possible to assess the effectiveness of state strategies in the field of platform-based governance, including at the international level.

Contemporary research on DPs demonstrates substantial variability in their definitions [5–8], which is driven by a set of interrelated factors, including architectural diversity [9], multifunctionality [10], sector-specific applications [11], differences in value creation mechanisms [12], the regulation of platform activities [13–15], their integration into public governance [16], and the study of multi-sided markets [17–18]. In this context, particular scholarly interest is directed toward the development of industry ecosystems of digital platforms (SEDPs) [19].

A SEDP may be defined as a dynamic, self-developing, complex, and integrated information and communication platform that brings together digital platforms and state information systems. It is characterized by unified standards and interaction protocols and ensures end-to-end digitalization and synchronization of business processes among participants within a specific sector. Furthermore, it facilitates the formation of digital profiles, automated real-time data collection and analysis, support for managerial decision-making based on big data analytics, as well as the automation of legal and regulatory processes, monitoring, and reporting in order to establish a unified digital environment.

SEDPs differ fundamentally from traditional information systems. Compared with private digital platforms, they incorporate built-in mechanisms for automated legal and regulatory governance, maintain a balance between commercial and public interests, and perform functions of public governance. In contrast to SIS, SEDPs are distinguished by their multidimensional interaction with sector participants, real-time data processing capabilities, and the potential for cross-platform integration with other information systems. A key feature of SEDPs is their hybrid model, which organically combines market-based self-regulation mechanisms with instruments of state governance. This configuration enables SEDPs to effectively integrate the advantages of platform technologies with regulatory functions within a unified ecosystem. Thus, SEDPs represent a new type of digital infrastructure that ensures synergy between technological capabilities and institutional mechanisms in support of sustainable indutry development.

FEATURES OF INDUSTRY ECOSYSTEMS OF DIGITAL PLATFORMS

The importance of developing digital platforms in the Russian Federation was emphasized by the President of the Russian Federation in the Address to the Federal Assembly: “We need to establish our own digital platforms, naturally compatible

[2] The analysis of SIS, private digital platforms and GASSU lies beyond the scope of the present study.

with the global information space. This will enable a new organization of production processes, financial services, and logistics, including through the use of distributed ledger technology, which is extremely important for financial transactions and for the registration of property rights[3]…" The necessity of the practical implementation of platform-based solutions has been formalized in the Presidential Decree "On the National Development Goals of the Russian Federation for the period up to 2030 and for the outlook to 2036." In particular, the target indicator for achieving the national goal "Digital transformation of public and municipal governance, the economy, and the social sphere" envisages "the automation of the majority of transactions within unified industry digital platforms and a data-driven governance model, taking into account the accelerated adoption of big data processing technologies, machine learning, and artificial intelligence.[4]" "In order to ensure effective coordination among federal executive authorities, the Bank of Russia, governmental bodies of the constituent entities of the Russian Federation, and other public institutions involved in implementing state policy in the development of digital economy ecosystems and digital platforms", an interagency working group on the advancement of digital economy ecosystems and digital platforms has been established.[5]

[3] Address of the President of the Russian Federation to the Federal Assembly, 1 March 2018. URL: https://www.consultant.ru/document/cons_doc_LAW_291976/

[4] Decree of the President of the Russian Federation No. 309, 7 May 2024, "On the National Development Goals of the Russian Federation for the period up to 2030 and for the outlook to 2036." URL: https://www.consultant.ru/document/cons_doc_LAW_475991/

[5] Order of the President of the Russian Federation No. 325-rp, 14 October 2024, "On the Interagency Working Group on the Development of Digital Economy Ecosystems and Digital Platforms". URL: https://www.consultant.ru/cons/cgi/online.cgi?req=doc&base=EXP&n=859527#vtjtysUCg0dDvnJO2

Table 1

Specifics of Industry Ecosystems of Digital Platforms

Criteria	Description	Result
Access to information	Instant online access to up-to-date data enables managers to make informed decisions within limited timeframes.	Significant acceleration of business processes and increased adaptability of economic agents to changing market conditions.
Functions of SEDPs	Establishment of a unified digital environment for interaction among market participants; automation of processes for identifying partners and investment opportunities; implementation of real-time monitoring and control functions; capacity for end-to-end governance of value-added chains; reduction of transaction costs in interindustrial interaction; development of transparent managerial reporting for public authorities.	Enhanced efficiency in monitoring business processes and the timely identification of opportunities aimed at optimizing interaction among economic agents.
Data analytics	Formation of comprehensive rankings of ecosystem participants based on multifactor analysis; assessment of workforce professional potential; identification of the economy's demand for qualified personnel.	Improved quality of human resource management and the targeted development of human capital.
SEDP metasystem	Optimization and automation of business processes; development of advanced taxation mechanisms; creation of innovative financial instruments; operation of a self-developing intelligent digital system with adaptive algorithms.	Stimulation of ecosystem participants toward more efficient interaction with counterparties.

Source: Compiled by the author.

The integration of multiple digital platforms and state information systems into a industry ecosystem of digital platforms (rather than a single "universal" platform) makes it possible to ensure more systematic and strategically grounded monitoring and governance of economic sectors. It also helps to minimize subjective assessments of their effectiveness and contribution to the achievement of the state's strategic development objectives (*Table 1*).

Under conditions of the digitalization of the economy, the need to establish SEDPs increases substantially. Unlike aggregated information published in statistical reports and SIS, platform-based data contain information on the history of their emergence. On this basis, it becomes possible to understand how transactions between platform participants were conducted, where difficulties arise, which forms of activity are rarely used, and which, conversely, operate on a large scale. This approach enables the fine-tuning of industry development and the effective governance of its evolution. SEDPs contain information on industrial value-added chains in which various economic actors are involved. Managing such chains — which is practically unattainable using Rosstat data and SIS — becomes a feasible task through the use of digital platforms [20]. Public officials thereby gain the ability to analyze these chains in real time, identifying specific areas that require particular attention.

Moreover, the transparency of platform-based interactions among participants facilitates monitoring and oversight functions exercised by government authorities. As an example, attention should be drawn to the Federal Tax Service of Russia's use of preventive oversight instead of punitive measures (for instance, through the automation of tax administration), which positively affects the agency's financial performance.[6] Thus, SEDPs represent a fundamentally new stage in the digital transformation of the economy and exert a significant influence on public governance.

The justification of the number of SEDPs should be based on a detailed classification of economic activities according to the All-Russian Classifica-

[6] Working Meeting between Vladimir Putin and the Head of the Federal Tax Service Daniil Egorov. URL: http://www.kremlin.ru/events/president/news/75610/

Table 2

Advantages and Drawbacks of Forming Industry Ecosystems of Digital Platforms

Advantages	Difficulties
Interaction among digital platform participants is conducted online in real time.	The need to transform the activities of platform participants into a digital format.
Reduced time required for managerial decision-making in real time due to the availability of relevant data.	The increasing importance of data quality and of infrastructure for data storage, transmission, and processing.
Growing demand for innovative solutions and their rapid implementation in practice, including at the intersection of sectors.	The need for increased investment in R&D and the accelerated commercialization of its results.
Use of automated algorithms for enforcing legal and regulatory acts in order to govern relations between parties.	The requirement to algorithmize and automate the state's legal and regulatory framework.
Release of system participants from the obligation to submit reporting to public authorities	The need to algorithmize state supervisory and enforcement activities.
Formation of dynamic rankings of system participants based on data analytics.	The challenge of working with large volumes of fragmented and heterogeneous data.
Identification of industrial workforce needs and the training of personnel on the basis of data analytics.	The necessity of integrating the education system into the digital governance framework.

Source: Compiled by the author.

tion of Types of Economic Activity (OKVED 2). As a structural foundation, it is proposed to employ the levels of subclasses (XX.X) and groups (XX.XX), comprising 272 and 623 units, respectively.[7] Given the possibility of consolidating adjacent groupings within a single SEDP, the relevant set of platforms may be estimated at a minimum of 272 units. Such extensive coverage of major segments of the economy creates prerequisites for integrating SEDPs into a unified metasystem.

The formation of this metasystem constitutes a necessary condition for addressing tasks that cannot be realized within the boundaries of individual sectors, in particular, the governance of cross-cutting processes (such as logistics and financing), the conduct of cross- industrial analysis, the development of unified data standards, and the coordination of state regulation. The implementation of this approach in the Russian Federation entails significant investments and requires a long-term planning horizon, which corresponds to the global trend toward building integrated digital ecosystems.

In this context, it is appropriate to highlight the advantages and challenges associated with the practical implementation of SEDPs. (*Table 2*).

The implementation of the proposed strategy will result in the establishment of an integrated governance system for economic processes, with an emphasis on real performance indicators. Its adoption will improve the planning and regulation of socio-economic development, expand the volume of data and information subject to analysis, and enhance the overall reliability of the system.

CONCEPTUAL APPROACHES TO THE DEVELOPMENT OF THE ARCHITECTURE OF INDUSTRY ECOSYSTEMS OF DIGITAL PLATFORMS

As noted above, the development and implementation of SEDPs require a comprehensive approach that encompasses organizational, technological, legal, and other changes in the governance system and presupposes a deep understanding of the needs of all stakeholders involved. The key advantage of such platforms lies in their capacity to facilitate the effective exchange of experience and technologies across different levels of government and sectors of the economy, provided that equal access to digital solutions is ensured.

It appears that the creation and development of SEDPs should involve the following measures:

- identifying the principal directions of interaction;
- ensuring the openness of the SEDP infrastructure to all participants;
- creating conditions for convenient entry into the ecosystem;
- conducting continuous monitoring and analysis of user behavior;
- adapting SEDPs to the specific needs of different segments of the economy.

Such an approach creates prerequisites for achieving significant socio-economic outcomes while ensuring the economic justification of investments in the digitalization of public governance. SEDPs may include marketplaces (for the provision and sale of services, equipment, and products, as well as for reporting purposes), digital platforms, and the necessary supplementary modules, services, and databases, including those adapted for mobile devices depending on the market segment. Integration through marketplaces enables economic actors to reduce transaction costs, enhance efficiency, and build trust by automating processes, standardizing oversight, and ensuring operational transparency. Platform-based solutions lower production costs while simultaneously improving quality, accelerate the diffusion of innovations, and increase capital turnover through the optimization of logistics and financial settlements. They contribute to the automatic compliance with regulatory requirements through embedded algorithms and smart contracts. Taken together, these mecha-

[7] OK 029–2014 (NACE Rev. 2). All-Russian Classification of Types of Economic Activity, approved by Order of Rosstandart No. 14-st of 31 January 2014 (as amended on 25 June 2025). URL: https://www.consultant.ru/document/cons_doc_LAW_163320/

nisms create conditions for sustainable industrial development based on technological, economic, and regulatory synergy [21]. They make it possible not only to synchronize supply and demand, but also to shift toward algorithmic coordination of regulatory governance and reporting procedures, transaction-based taxation [22], and the management of interdependent segments of the economy. The implementation of such digital platforms and cloud services implies the automation of business processes, cost reduction, and increased labour productivity.

The key objectives of SEDPs may be summarized as follows:

- the creation of a personal digital account for an economic entity to enable remote electronic interaction with public authorities;
- the implementation of an automated system for the electronic submission of reports by economic entities to government bodies;
- the use of an automated system for the collection and analysis of reporting data by public authorities in order to obtain information on the current state of the sector and trends in its development;
- ensuring the visualization of industrial data across economy;
- the formation of an up-to-date electronic register of economic entities;
- enabling real-time remote interaction among market participants;
- the provision of real-time electronic information on the production and sale of goods;
- the development of a reference system on government support measures and mechanisms for submitting applications for state support in electronic form.

Thus, the functioning of SEDPs is aimed at reducing the administrative burden on users in the processes of reporting, obtaining subsidies, and accessing other forms of state support, as well as at automating the product life cycle and internal quality control. This should lead to improved accessibility of services and a reduction in costs.

PUBLIC–PRIVATE PARTNERSHIP AS A TOOL FOR THE DEVELOPMENT OF INDUSTRY ECOSYSTEMS OF DIGITAL PLATFORMS

The foregoing analysis indicates that, at the present stage, there is an increasing need to expand the parameters of the governance model through the establishment and integration of SEDPs. As a key instrument for addressing this objective, the public–private partnership (PPP) model should be regarded as particularly relevant, as it enables the effective integration of the financial, administrative, and intellectual resources of business, public authorities, and the academic community. This approach is based on a clear allocation of functions among the participants in the process. Private operators, in cooperation with industrial and scientific associations, develop and implement the digital platform, relying on their own investment resources with potential support from development institutions. The state, in turn, provides the necessary conditions for platform integration, in particular through their connection to SIS, the adaptation of the regulatory framework, and the regulation of tariffs for socially significant services (by analogy with natural monopolies). Such a distribution of responsibilities contributes to the establishment of a sustainable interaction system: business gains the opportunity to realize its technological and managerial competencies; the state ensures the protection of public interests and systemic stability; and industrial and academic organizations promote the innovativeness of solutions. The result is a balanced model of digital transformation that combines the efficiency of market mechanisms with the social orientation of state regulation. This form of synergy makes it possible to minimize risks and maximize the beneficial outcomes for all stakeholders involved. The advantages and challenges of developing and establishing SEDPs in the format of PPP are presented below (*Table 3*).

Table 3

Advantages and Drawbacks of Developing and Establishing Industry Ecosystems of Digital Platforms in the Public-Private Partnership Format

Advantages of SEDPs in the PPP format	Difficulties in developing and establishing SEDPs in the PPP format
The possibility of digital regulation of economic sectors.	Weak competition from other market participants (or its absence), reducing platform efficiency.
Algorithmization of industrial governance systems.	High costs of platform development and establishment without the use of PPP mechanisms
Commitment to increasing public value	Prolonged development timelines in the absence of a clear division of responsibilities between the state and private business.
Absence of an orientation toward profit maximization at any cost.	Bureaucratic complexities in coordination and decision-making procedures.
The possibility of generating additional budget revenues through the provision of ancillary services not directly related to core activities.	The need for continuous staffing of platform operations by leading specialists given the rapid evolution of digital technologies.
Sector participants automatically become platform participants upon meeting state-established criteria.	Regulatory and legal constraints on the innovative and other activities of the platform.
No requirement for commercial promotion of the platform in the market.	High cost of errors during platform development and establishment.
Reduction of government expenditures on sector regulation in the medium and long term.	Limited speed of changes in the functional characteristics of the platform.
Reduction of transaction costs.	The necessity of maintaining a high share of expenditures on R&D.
Real-time digital assessment of the effectiveness of sector regulation.	Unpredictable economic consequences in the absence of regulatory mechanisms and appropriate legal regimes, taking into account industrial specificity.
Availability of comprehensive and well-structured industrial information.	High proportion of expenditures on hardware and software infrastructure.
Improved quality of interagency and cross–industrial interaction at federal and municipal levels.	-
Availability and analysis of participant profiles updated in real time within the digital ecosystem.	-
Increased competition among platform participants.	-
Reduction of government expenditures on the creation and maintenance of state information systems at federal and regional levels.	-

Source: Compiled by the author.

PROSPECTS FOR THE DEVELOPMENT OF SEDPS

Despite all the advantages of the proposed instruments of public governance, particular attention should be paid to the risks associated with the implementation of SEDPs in the socio-economic activities of states. These risks include, inter alia:

- inefficient allocation of budgetary resources due to the lack of alignment between the digital platforms and state information systems (SIS)

being developed and national development goals and strategic priorities;

- the risk of functional duplication and overspending resulting from the absence of interagency integration;
- the threat of incorrect data interpretation in managerial decision-making due to insufficient verification and validation of information;
- a decline in the quality of digital transformation projects caused by technological and architectural fragmentation between digital platforms and SIS, which hampers seamless system integration;
- difficulties in planning expenditures for the development of SEDPs due to high and non-transparent costs;
- the risk of violating non-discriminatory access to information within digital platforms and SIS, particularly when a significant number of them are operated by private companies;
- the danger of digital monopolization of markets.

In addition, it is recommended that governments develop unified standards for the interaction of digital platforms with SIS, introduce automated tools for data monitoring and analysis, and ensure an appropriate balance between regulation and the free development of digital technologies. Consequently, the use of monitoring and data analytics mechanisms can contribute to the establishment of a secure and sustainable digital environment that aligns with the interests of society and the economy.

In this regard, foreign experience is of particular interest. For instance, scholarly literature notes that the economy of the People's Republic of China functions as a complex of SEDPs, which accelerates operational cycles and enhances the quality of governance. Online access to information reduces the time required for managerial decision-making and facilitates interaction among economic agents, thereby increasing the flexibility of economic sectors. SEDPs form a digital environment both for identifying counterparties, technologies, and investments, and for automated managerial accounting and reporting for public authorities. This enables officials to monitor markets in real time, identifying opportunities for necessary optimization and potential growth areas. The next stage of SEDP integration involves the establishment of an SEDP metasystem, providing tools for the development of effective taxation and monetary systems. It operates as an advanced digital infrastructure with self-adjusting mechanisms that incentivize the most efficient participants. Multifactor dynamic rankings based on data analytics, in turn, help to assess workforce potential and formulate demand for the training of qualified specialists for the economy [19]. Such an approach is aimed at the formation of open, self-developing systems that ensure more effective socio-economic and scientific-technological development.

In conclusion, it should be noted that the development of SEDPs enables the state to move to the next stage of ensuring technological sovereignty. This stage involves the design and practical implementation of a unified state automated system of strategic governance, with the gradual connection of existing SEDPs, and is aimed at the step-by-step automation of public governance processes at all levels in order to ensure a consistent and progressive increase in its effectiveness.

CONCLUSION

In the context of the growing importance of network-based governance, SEDPs offer an alternative to traditional competition by replacing it with cooperation among market participants. Participation in such platforms enables organizations to expand production capacity, reduce costs, and improve product quality. At the same time, the acceleration of operational cycles within a platform ecosystem, necessary for adaptation to new economic realities, requires corresponding changes in state regulation. In this regard, one of the key vectors of development is the introduction of network-centric governance within the public sector, aimed at creating open, self-developing systems operating on the basis of SEDPs and utilizing high-precision forecasting and algorithmic execution of decisions in real time.

The analysis conducted in this study allows several conclusions to be drawn. First, contemporary challenges require the establishment of a flexible governance mechanism capable of rapid planning, timely identification of emerging threats and challenges of the digital era, and effective responses to them. Thus, there is a need for comprehensive adaptation of the institutional environment to new conditions, as well as for the implementation of advanced digital technologies and the construction of an effective system of interaction among the state, society, and business.

Second, platform-based solutions and digital ecosystems are forming a new paradigm of socio-economic development and offer modern governance models, expanding the capabilities of the state, citizens, and business, while simultaneously creating new challenges for the system of public governance. Participants in such activities gain access to an open digital infrastructure for cooperation and incentives for development. In this context, it should be noted that contemporary digital platforms are transforming from instruments of interaction among economic entities into systemic solutions for the strategic governance of the state, enabling a shift from reactive to predictive economic regulation.

Third, in the Russian Federation, in order to enhance the effectiveness of economic regulation, it is necessary to stimulate the digital platformization of sectors, aimed at the joint development and support of all economic actors.

These factors determine a shift in state development priorities toward the establishment of SEDPs and highlight the need to maintain a balance between public governance and the autonomy of participants within digital ecosystems. Consequently, under current conditions, the development and implementation of a national strategy for platform-based development becomes a key task for sovereign states. At the same time, the introduction of SEDPs generates the need for a well-considered approach to goal-setting in public governance and for taking into account multiple factors when selecting instruments for achieving strategic national development objectives.

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Key Causes of Workforce Shortages in the Russia's Public Sector and Human Resource Management

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ABSTRACT

The **purpose** of this study is to provide a comprehensive analysis of the personnel shortage problem in Russia's public sector. Based on statistical data from the Federal State Statistics Service (Rosstat) and materials from recent academic publications, the key causes and factors behind the imbalance of labor resources in the social sector of the national economy are identified. A detailed analysis of the dynamics of public sector wages in comparison with the national average has been conducted, as well as an examination of the main trends in employment numbers. Special attention is given to the issue of precarious employment in the public sector, manifested in unstable labor relations, excessive workload, and lack of social guarantees. A direct correlation is revealed between low wage levels, high workloads, and staff shortages. From a managerial perspective, practical recommendations are proposed to overcome the personnel imbalance in the public sector. These include improving the wage system, optimizing workloads, and developing human resource planning under current conditions. The **findings** of the study may be useful for the heads of public institutions and government authorities responsible for implementing personnel policy in the Russian Federation.

Keywords: workforce shortage; social sector; imbalance of labor resources; precarization; wages; workload; personnel policy; social workers; regional disparities

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INTRODUCTION

The relevance of this study is determined by the growing imbalance between society's demand for high-quality social services and the workforce capacity available to support this sector. Under contemporary demographic challenges, particularly those associated with population ageing, these issues acquire strategic significance.

The aim of the study was to identify and examine the key causes of staffing shortages in Russia's public sector. To achieve this aim, the following objectives were addressed:

- an analysis was conducted of labor resource imbalances in the public sector;
- the problems of labor precarization[1] among public sector employees were identified;
- the influence of wage levels and workload intensity on staffing shortages was examined.

The scientific novelty of the research lies in conducting a managerial analysis of the causes of staffing deficits in the public sector, focusing on quantitative imbalances, qualitative characteristics of labor, and the development of targeted human resource policy measures. Particular emphasis was placed on identifying the relationship between processes of precarization and the outflow of qualified specialists, which requires systemic managerial intervention at both federal and regional levels.

The methodological foundation of the study was a systems-based approach to examining the staffing deficit problem, incorporating statistical, comparative, structural-functional, and time-series analyses. The information base of the research consisted of data from the Federal State Statistics Service (Rosstat).

[1] Labour precarization refers to the shift from stable, secure employment relationships toward unstable forms of work, resulting in the near-complete erosion of employees' social and labour rights. This includes, inter alia, wage underpayment, the absence of paid leave and sick leave, and the loss of other social protections.

LABOR RESOURCE IMBALANCES IN THE PUBLIC SECTOR: SCALE AND TRENDS

The Current State of Workforce Provision in the Public Sector

Rosstat data indicate a stable trend toward a decline in the number of employees in Russia's public sector over the period from 2017 to 2022.[2] During this time, a systematic reduction in workforce capacity was observed across various categories of specialists (*Table 1*).

The analysis of the data presented in *Table 1* indicates that over the six-year period the most substantial reductions occurred among junior medical personnel (–35.2%), higher education faculty (–14.4%), social workers (–14.1%), and supplementary education teachers for children (–13.0%). By contrast, the numbers of preschool and general education teachers remained relatively stable, showing only slight increases of 1.4% and 0.1%, respectively, as did the number of physicians, which rose marginally by 0.5%.

These trends point both to the systemic nature of staffing challenges in the public sector and to the need for comprehensive measures to address the situation. It is also important to note that the decline in public sector employment is occurring against the background of improving overall labor market indicators and decreasing unemployment rates in the country, which suggests the presence of problems specific to the social sector.

Disparities in Workforce Provision in the Public Sector

An important aspect of labor resource imbalance in the public sector is the presence of substantial regional disparities, as confirmed through the analysis of statistical data.

The situation is particularly acute in rural areas and remote territories, where staffing shortages in the public sector become critical. The severity of the problem varies depending on the type of

[2] Federal State Statistic Service (Rosstat)URL: https://www.fedstat.ru

Table 1

Dynamics of the Average Number of Public Sector Employees on the Payroll in Russia, 2017–2022, people

Employee category	2017	2018	2019	2020	2021	2022	Change 2022/2017,%
Physicians and employees with higher medical education	566 015.8	560 172.0	565 162.3	571 152.2	573 514.6	568 993.9	0.5
Mid-level medical personnel	1 353 192.7	1 320 540.8	1 314 265.3	1 305 127.2	1 291 815.8	1 264 774.9	–6.5
Junior medical personnel	423 939.7	286 904.4	264 794.1	271 772.9	284 892.8	274 746.0	–35.2
Preschool education teachers	611 574.9	612 996.2	617 924.0	623 004.9	626 160.8	619 899.1	1.4
General education teachers	1 229 415.2	1 235 402.8	1 241 272.1	1 244 895.7	1 247 048.7	1 231 015.1	0.1
Teachers and instructors in secondary vocational education	154 647.7	153 629.9	154 027.6	155 072.4	155 421.5	154 069.5	–0.4
Higher education faculty	208 531.4	196 496.1	189 367.2	184 435.6	180 925.3	178 506.9	–14.4
Supplementary education teachers	242 470.3	227 861.0	219 035.8	214 797.2	212 801.1	210 879.6	–13.0
Cultural institution employees	529 346.4	497 754.5	493 678.7	492 162.6	489 989.6	489 358.7	–7.6
Research staff	77 437.2	71 036.4	72 207.7	72 108.4	71 543.1	71 199.6	–8.1
Social workers	127 243.4	120 764.5	118 295.2	115 699.7	112 697.4	109 358.9	–14.1

Source: Compiled by the author on the basis of Rosstat data, [1]. URL: https://www.fedstat.ru

settlement and the level of socio-economic development of the region, creating conditions for the intensification of territorial disparities in the accessibility and quality of social services.

An examination of the ratio of regional employment to the working-age population (*Table 2*) makes it possible to identify regional differences in labor resource availability.

According to the data presented in *Table 2*, the most favorable situation is observed in Moscow and Saint Petersburg, where the ratio of employed persons to the working-age population exceeds

Table 2

The Ratio of Employed Population to Working-age Population by Federal District, 2020–2024 (%)

Federal District	2020	2021	2022	2023	2024
Russian Federation	84.2	85.4	85.7	85.7	–
Central Federal District (FD)	92.8	93.0	92.6	92.2	92.3
Moscow	117.0	115.8	113.7	112.5	111.3
Northwestern FD	87.2	88.0	88.9	88.0	88.7
Saint Petersburg	98.7	99.5	100.3	100.5	101.4
Southern FD	79.5	81.7	82.6	83.4	84.7
North Caucasus FD	64.1	65.1	68.0	67.9	69.7
Volga FD	81.5	83.4	83.9	83.8	84.7
Ural FD	89.1	90.6	89.6	91.1	92.0
Siberian FD	79.6	81.5	81.9	81.7	83.0
Far Eastern FD	83.4	83.9	83.4	84.2	85.5

Source: Compiled by the author on the basis of Rosstat data, [1]. URL: https://www.fedstat.ru

100%, indicating the attraction of specialists from other regions. By contrast, in the North Caucasus Federal District this indicator amounted to only 69.7% in 2024, suggesting a significant shortage of jobs and a potential outflow of labor resources from the region.

Such disparities exacerbate the problem of staffing shortages in the public sector. This is particularly relevant for regions experiencing an overall shortage of qualified personnel, as under these conditions the social sector becomes less competitive than other branches of the economy, leading to the outflow of qualified workers.

Structural imbalances become especially evident when examining workforce provision across different areas of social services. A comparative analysis of salary data for specialists across various categories of the public sector (*Table 3*) reveals substantial differences in the attractiveness of particular fields for potential employees.

The data presented in *Table 3* indicate substantial differences in wage levels across various fields of social services. In healthcare and social service activities, as well as in the cultural sector, wages in 2022 approached the national average (93.9% and 94.9%, respectively); however, this does not apply to all categories of employees. Particularly low levels of remuneration are observed in services such as home-based assistance for persons with disabilities (54.8% of the national average in 2022) and residential nursing care (63.4%).

LABOR PRECARIZATION IN THE PUBLIC SECTOR AS A FACTOR CONTRIBUTING TO STAFFING SHORTAGES

The Concept and Features of Precarization in the Public Sector

Precarization is understood as a process of increasing instability in employment relations, characterized by a reduction in social guaran-

Table 3

Average Monthly Nominal Accrued Wages of Public Sector Employees by Activity Type, 2017–2022 (rubles)

Field of Activity	2017	2018	2019	2020	2021	2022	Share of the National Average in 2022,%
Economy wide	34 421.6	39 016.68	42 263.2	46 674.06	49 516.3	55 717.0	100.0
Healthcare and social services activities	29 370.44	37 617.62	40 739.93	44 564.81	49 633.0	52 302.2	93.9
Cultural, sports, leisure and entertainment activities	31 671.59	41 338.96	43 959.12	46 737.42	46 696.5	52 862.0	94.9
Residential care activities with accommodation	–	–	–	39 785.5	39 106.3	42 248.9	75.8
Residential nursing care activities with accommodation	–	–	–	32 870.9	32 770.5	35 339.1	63.4
Home-care services for persons with disabilities	–	–	–	28 174.3	27 410.3	30 554.4	54.8
Residential care for the elderly and persons with disabilities with accommodation	–	–	–	38 282.7	34 588.8	37 855.7	67.9

Source: Compiled by the author on the basis of Rosstat data, [1]. URL: https://www.fedstat.ru

tees, growing uncertainty, and heightened vulnerability of workers [2–4]. Precarious forms of employment include temporary, daily, part-time, seasonal, contingent, informal employment, self-employment, and others. However, the features of this process may be observed in both standard and non-standard employment arrangements [5], manifesting in very low wages, irregular employment, extremely flexible working schedules, and harsh and exhausting working conditions [6]. The academic literature emphasizes that precarization in employment leads to precarization of life itself, namely a reduction in social activity due to regular overtime work and, consequently, a decrease in leisure time, loss of income, and limited access to social and cultural goods [7].

In the public sector, precarization manifests in the form of:

- instability of employment and labor relations;
- high workload combined with low remuneration;
- absence or insufficiency of social guarantees;
- informal employment and the use of civil-law contracts instead of labor contracts;
- psychological strain and a high risk of professional burnout.

The Impact of Precarization on Human Resource Capacity in the Public Sector

Precarization exerts a substantial negative influence on the human resource capacity of the public sector, manifesting in several ways:

1. Instability of employment relations, high workload, and low wages make the profession of social work unattractive for young specialists. A significant psycho-emotional burden combined with insufficient material incentives increases the risk of professional burnout. The problem is further aggravated by inadequate workforce planning, which leads not only to staffing shortages but also to serious imbalances across personnel categories.

2. Under conditions of excessive workload and insufficient motivation, the quality of social services inevitably declines. This shapes a negative public perception of the public sector and further reduces its attractiveness as a field of professional activity.

3. Employment instability and low remuneration levels contribute to the outflow of professionals from the public sector.

The managerial dimension of precarization is reflected in the fact that the spread of non-standard employment forms and the deterioration of working conditions often result not only from objective economic constraints but also from deliberate human resource policies aimed at reducing short-term institutional costs in the public sector [8]. However, such policies generate strategic risks, including the loss of key competencies, a decline in the quality of state and municipal services, and rising operational expenditures due to the continuous training of new personnel.

In the context of digital transformation, the phenomenon of "digital precarization" has emerged, affecting the public sector as well, particularly academic and teaching staff [9]. This phenomenon is expressed not only in unstable employment relations but also in the imposition of flexible working formats that blur the boundaries between working and personal time, thereby intensifying professional burnout without adequate compensation. The managerial task in this context is the development of regulatory and organizational mechanisms that prevent the erosion of labor rights in the digital environment.

LOW WAGES AND HIGH WORKLOAD AS KEY CAUSES OF STAFFING SHORTAGES

Analysis of Wage Dynamics in the Public Sector

Low levels of remuneration in the public sector represent one of the key causes of staffing shortages. Despite the implementation of the Presidential "May Decrees," aimed at increasing wages in this sector, pay levels remain significantly below the national average.

From a managerial perspective, this problem cannot be reduced solely to the volume of funding. Equally important are such aspects as the wage structure and the incentive system. In many public sector institutions, wages continue to be formed with a high proportion of variable (bonus-based) components, which reduces income stability and reinforces employees' sense of insecurity [3]. Improving managerial decisions in this area requires a transition toward transparent and predictable remuneration models that ensure an adequate guaranteed income.

For a more detailed analysis of the situation across different sub-sectors of the public sphere, let us examine the dynamics of employee numbers across institutions of various ownership forms (*Table 4*).

The data presented in *Table 4* indicate that the most substantial decline occurred among junior medical personnel both in federal (–26.1%) and regional institutions (–33.7%). A marked reduction was also observed in the number of social workers in institutions under municipal ownership (–21.0%) as well as those owned by constituent entities of the Russian Federation (–12.2%). In addition, the number of higher education faculty in federal institutions decreased considerably (–14.3%), as did the number of cultural institution employees at the municipal level (–12.4%).

Table 4

Dynamics of the Average Number of Public Sector Employees by Form of Ownership, 2017–2022 (people)

Form of ownership	Employee category	2017	2018	2019	2020	2021	2022	Change 2022/2017,%
Federal ownership	Physicians and employees with higher medical education	86 942.8	82 623.3	83 978.4	85 410.1	86 105.2	86 270.8	–0.8
Federal ownership	Mid-level medical personnel	145 201.8	140 048.3	138 803.0	138 357.9	136 383.2	134 641.9	–7.3
Federal ownership	Junior medical personnel	55 150.9	43 588.6	40 675.5	40 688.8	41 105.9	40 783.4	–26.1
Federal ownership	Higher education faculty	202 596.3	190 888.2	183 983.3	179 162.4	175 753.6	173 562.6	–14.3
Federal ownership	Cultural institution employees	49 649.3	47 909.3	48 913.5	50 684.9	51 552.9	51 591.2	3.9
Ownership of constituent entities of the RF	Physicians and employees with higher medical education	449 518.0	449 762.9	465 674.0	470 441.2	478 780.4	474 276.8	5.5
Ownership of constituent entities of the RF	Mid-level medical personnel	1 122 861.5	1 102 663.9	1 127 355.4	1 119 930.4	1 121 537.2	1 097 246.6	–2.3
Ownership of constituent entities of the RF	Junior medical personnel	347 090.6	229 939.3	219 837.1	226 619.4	239 718.2	230 230.5	–33.7
Ownership of constituent entities of the RF	General education teachers	224 592.3	227 257.3	232 295.9	237 114.9	239 309.0	238 121.3	6.0
Ownership of constituent entities of the RF	Cultural institution employees	166 388.8	160 996.1	162 420.9	162 697.9	162 508.7	163 403.8	–1.8
Ownership of constituent entities of the RF	Social workers	100 296.5	94 690.7	93 570.0	93 707.1	91 473.3	88 058.6	–12.2
Municipal ownership	Preschool education teachers	571 232.6	572 348.6	576 262.8	580 276.3	582 244.9	575 828.6	0.8
Municipal ownership	General education teachers	998 251.2	1 001 040.2	1 001 536.7	999 981.7	1 000 007.5	984 858.0	–1.3
Municipal ownership	Cultural institution employees	313 308.3	288 849.1	282 344.3	278 779.8	275 928.0	274 363.7	–12.4
Municipal ownership	Social workers	26 817.6	26 003.2	24 662.6	21 916.1	21 101.0	21 176.9	–21.0

Source: Compiled by the author on the basis of Rosstat data. URL: https://www.fedstat.ru

At the same time, positive dynamics were noted for physicians and employees with higher medical education, general education teachers, and cultural institution staff in organizations under federal ownership (+5.5%, +6.0%, and +3.9%, respectively).

These divergent trends reflect structural changes in workforce provision within the public sector. On the one hand, they may represent objective processes of staff optimization and increased institutional efficiency; on the other hand, they may indicate challenges in attracting and retaining personnel in specific sub-sectors of public services.

Of particular concern is the significant reduction in the number of social workers across all forms of ownership, which may negatively affect the accessibility of these services for the most vulnerable population groups, especially in the context of demographic trends such as population ageing and the increasing proportion of citizens in need of social support.

The identified imbalances require the development and implementation of comprehensive measures aimed at stabilizing the staffing situation in the public sector. These measures should include enhancing the attractiveness of professions, improving working conditions, developing systems of professional training and retraining, and improving mechanisms of financial incentives for employees.

The Problem of High Workload in the Public Sector

High workload represents the second key cause of specialist shortages in the public sector. Under conditions of declining numbers of social workers while the volume of services provided remains stable or increases, the workload borne by each worker inevitably grows.

E.A. Klimentova and A.A. Dubovitsky note that one of the major challenges of human resource policy in social public sector organizations is the mismatch between established staffing levels and the actual volume of work performed [10]. As a result, social workers are forced to operate under intensified conditions, leading to physical and emotional exhaustion.

The issue of excessive workload is particularly acute in rural areas and small towns, where staffing deficits are most pronounced. In such settings, a single social worker may be responsible for a number of clients that significantly exceeds established norms, adversely affecting both the quality of services delivered and the health of the specialists themselves, and becoming, in particular, a cause of professional burnout.

An analysis of the dynamics in the number of social workers (see *Table 1*) suggests that the reduction in public sector employment is occurring against the background of an overall decline in unemployment rates. This indicates an outflow of personnel from this sector into other branches of the economy.

The Relationship Between Wages, Workload, and Staffing Shortages

The initial cause of staffing shortages is often the low level of remuneration, which does not correspond to the complexity and responsibility of work in the public sector. This leads qualified specialists to move into other sectors and discourages young people from choosing this field as a professional career path.

A reduction in staff numbers while the volume of work is maintained or increased inevitably results in higher workload for remaining employees. Combined with low wages, this stimulates further personnel outflow and thereby aggravates the problem even more.

E.P. Kostenko, examining employers' expectations regarding the level of preparation of recent graduates, notes the existence of an imbalance between these expectations and the demands of young specialists concerning working conditions and wage levels [11]. This disparity is particularly evident in the public sector, where high qualification standards and personal requirements placed on employees coexist with low material compensation levels.

APPROACHES TO OVERCOMING STAFFING SHORTAGES IN THE PUBLIC SECTOR

Improving the Remuneration System in the Public Sector

To address staffing shortages in the public sector, it is first necessary to ensure a competitive level of remuneration that corresponds to the complexity and responsibility of the work performed. An analysis of wage data (see *Table 3*) indicates that substantial increases in pay are required in the public sector in order to achieve parity with the national average.

Particular attention should be given to the most problematic fields of social services, where wage levels are especially low, such as home-based assistance for persons with disabilities (the average earnings in this area in 2024 amounted to only 44.1% of the national average).

The managerial solution to this problem should be comprehensive and should include not only an overall increase in wage funds, but also a revision of grading and incentive systems in order to ensure fair wage differentiation depending on qualifications, performance outcomes, and working conditions [12].

Optimization of Workload and Improvement of Labor Standardization

Addressing the issue of high workload is possible only through a comprehensive approach that includes revising the following standards:

- staffing levels in the public sector, taking into account the actual volume of work and the complexity of the population served;
- workload norms, based on the specific characteristics of different areas of social work and the needs of the categories of citizens receiving support.

An important aspect of workload optimization is the introduction of modern technologies and working methods that make it possible to increase labor productivity without intensifying work. The digitalization of social services, the automation of routine operations, and the development of remote working formats can significantly reduce labor costs associated with performing administrative functions.

Enhancing the Prestige of Public Sector Professions

To overcome staffing shortages, it is necessary to increase the social prestige of public sector professions. This requires a set of measures aimed at shaping a positive image of social workers in public consciousness, promoting these professions among young people, and creating conditions for professional growth and self-realization of employees.

Improving Workforce Planning in the Public Sector

Staffing deficit challenges can be effectively addressed through the improvement of workforce planning systems based on a scientific approach and the consideration of long-term trends in societal development and the public sector.

Particular attention should be given to regional aspects of workforce planning. An analysis of the ratio of employment in the regional economy to the working-age population (see *Table 2*) indicates substantial regional differences in labor resource availability.

To address this issue, a differentiated approach is required. In regions with high employment levels and low unemployment rates (Moscow, Saint Petersburg), the primary emphasis should be placed on increasing the competitiveness of the public sector as an employer compared to other branches of the economy. In contrast, in territories characterized by a significant proportion of unemployed individuals (the North Caucasus Federal District), it is necessary to create new jobs while ensuring decent working conditions and adequate remuneration.

Development of Human Resource Capacity and Knowledge Management

Under conditions of high staff turnover and workforce ageing in the public sector, knowl-

edge management and the systematic development of human resource capacity become critically important. This requires institutional leadership to introduce mentoring programmes, continuous professional development initiatives, and the formation of internal personnel reserves. The development of corporate universities and partnerships with higher education institutions should be promoted in order to provide targeted training for specialists oriented toward employment in this sector [12].

Strengthening the Role of Trade Unions and Social Dialogue

Enhancing the role of trade unions and developing social partnership constitute important instruments for reducing precarization and strengthening human resource capacity. A managerial approach based on constructive dialogue with employee representatives enables the timely identification and resolution of systemic problems such as excessive workload, informal employment, and violations of labor rights [13, 14]. For public sector institution managers, it is important to perceive trade unions not as adversaries but as partners in addressing shared objectives related to workforce stabilization and the improvement of the quality of working life.

CONCLUSION

The conducted study leads to the conclusion that staffing shortages in Russia's public sector represent a systemic problem. An analysis of statistical data and academic publications shows that the key drivers of this phenomenon include labor resource imbalances, labor precarization, low wage levels, and high workload intensity.

Labor resource imbalance manifests in quantitative personnel shortages as well as regional and structural disparities. The most critical situation is observed in rural areas and remote regions, where the lack of specialists in the public sector becomes particularly acute.

Labor precarization in this economic sector is expressed in unstable employment relations, excessive workload combined with low remuneration, and the absence or insufficiency of social guarantees. This results in declining attractiveness of these professions, increased professional burnout, reduced quality of services provided, and the outflow of qualified personnel.

Low wages and high workload create a self-reinforcing cycle of challenges. An analysis of wage dynamics and growth rates indicates that these indicators remain substantially below national averages in the public sector.

From a managerial perspective, resolving the issue of specialist shortages is impossible without revising existing approaches to human resource policy at all levels. The proposed recommendations—including improving remuneration systems, optimizing workload, developing workforce planning, and strengthening social dialogue—are comprehensive in nature and require coordinated efforts from government authorities, institutional leadership, and professional communities.

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Approaches to Measuring Labor Productivity in Healthcare: An Analysis of Russian and International Practices

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ABSTRACT

In recent years, successful practices from the industrial sector have increasingly been adopted within the service sector. This trend is reflected in the 2025 expansion of the list of industries included in the federal project "Labor Productivity", which now encompasses healthcare. The **purpose** of this study is to analyze domestic and international methodologies, as well as theoretical and legal approaches, to measuring labor productivity in the healthcare sector. The author identifies, for the first time, both the shared features and the specific characteristics of this process. It is established that the assessment of healthcare labor productivity (LP) largely relies on traditional approaches based on output calculations using monetary and quantitative indicators. The study also reveals a methodological convergence in the measurement of LP in Russian healthcare, which is closely linked to the management tasks specific to each administrative level of the sector. To achieve the research objectives, **methods** of analysis and synthesis were employed. The **findings** may be of practical use to administrators of healthcare institutions, as well as to policymakers at both regional and federal levels.
Keywords: labor productivity; healthcare effectiveness; international experience; integrated approach; measurement methodology

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INTRODUCTION

The relevance of the present study is determined by the need to enhance the performance of healthcare institutions, with labor productivity (LP) occupying a central role in this regard. It is not by chance that Nobel Prize laureate P. Krugman argues that productivity "is not everything, but in the long run it is almost everything…" [1, p. 229]. For a long time, this indicator remained outside the focus of healthcare managers, largely due to the absence of a standardized benchmark for its measurement, as well as the perception of the healthcare sector as a largely non-market domain with significant externalities, where productivity assessment requires the use of specific metrics that take into account indirect and external effects of its functioning.[1] This may explain why healthcare has not been included in the list of economic activities for which the productivity index is regularly assessed across the Russian Federation.[2] Given the existing debate regarding the appropriateness of applying labor productivity indicators to institutions within the social sector [2–5], the author's attention to the issue of implementing this measure in healthcare represents a highly topical and timely theoretical and applied problem.

Current approaches to the assessment of labor productivity in both Russian and global healthcare systems are often fragmented and highly variable, suggesting the necessity of synthesizing existing economic research and practical methodologies in this field. At present, no such integrative studies are available in the publications of either Russian or international scholars. In this context, the view that "new concepts of efficiency and productivity have yet to be developed and learned to be measured" [6, p. 6] appears particularly relevant.

The significance of this study is further determined by the current stage of socio-economic development in Russia, marked by the launch of new national (NP) and federal projects (FP), which are increasingly associated with improving the effectiveness of public administration [7]. Among these, long-term development of the healthcare sector is directly supported by projects such as "Prolonged and Active Life,[3]" "Health Technologies,[4]" and "Family,[5]" which continue the earlier national projects "Health[6]" and "Demography[7]" implemented between 2019 and 2024. However, the strategic development indicators of the healthcare sector are not limited to the target benchmarks (TB) of these initiatives. Thus, beginning in 2025, the federal project "Labor Productivity,[8]" implemented within the framework of the national project "Efficient and Competitive Economy,[9]" includes a set of target indicators related to social sectors (including healthcare). In particular, indicators such as the "increase in cases of preventive follow-up monitoring per one employed position of a primary healthcare physician in outpatient settings,%" and the "increase in bed turnover rate,%" serve as monitoring measures reflecting changes in the studied indicator.[10]

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[1] On labour productivity in Russia's economic sectors in comparison with other countries URL: https://clck.ru/3JbL6P

[2] Order of the Federal State Statistics Service of 28 April 2018 № 274 approving the methodology for calculating the "Labour Productivity Index" indicator URL: https://docs.cntd.ru/document/557348428

[3] NP "Prolonged and Active Life". URL: https://национальныепроекты.рф/new-projects/prodolzhitelnaya-i-aktivnaya-zhizn/

[4] NP "Health Technologies. URL https://национальныепроекты.рф/new-projects/tekhnologii-zdorovya/

[5] NP "Family". URL: https://национальныепроекты.рф/new-projects/semya/

[6] NP "Health". URL https://национальныепроекты.рф/projects/

[7] NP "Demography".URL https://национальныепроекты.рф/projects/

[8] FP "Labour Productivity". URL: https://национальныепроекты.рф/new-projects/effektivnaya konkurentnaya-ekonomika/proizvoditelnost-truda/

[9] NP "Efficient and Competitive Economy" URL: https://национальныепроекты.рф/new-projects/effektivnaya-i-konkurentnaya-ekonomika/

[10] The Unified Plan for Achieving the National Development Goals of the Russian Federation up to 2024 and for the Planning Period up to 2030 (approved by the Order of the Government of the Russian Federation of 1 October 2021 № 2765-r). URL: https://www.consultant.ru/document/cons_doc_LAW_398015/

RESEARCH METHODOLOGY

In the course of the study, relevant literature sources on the research topic were examined, including the bibliographic databases PubMed and e-LIBRARY.RU, as well as regulatory and legal documentation. The latter was accessed through the reference legal systems Garant and ConsultantPlus, and the official legal information portal "Laws, Codes and Regulatory Legal Acts of the Russian Federation."

RESEARCH RESULTS

Theory and Practice of Measuring Labor Productivity in Russian Healthcare

The limited number of examples of labor productivity measurement in Russian healthcare institutions demonstrates a wide variety of approaches to defining this indicator. The theoretical foundations of these practices are based on classical methods of productivity assessment, namely the consideration of labor intensity and output. Output is calculated on the basis of the number of services provided per unit of working time or per average employee. Structurally, output is represented through both monetary and physical metrics [8], such as the number of patient visits; the number of patients treated by a single physician; the number of procedures performed per member of mid-level medical staff; and the volume of healthcare provision (medical services) per healthcare worker [9]. Monetary valuation involves various approaches to determining labor productivity. These are formalized in the provisions of the OECD Manual on Measuring Productivity Growth at the Industry Level and at the Aggregate Level[11] and are calculated in

[11] The OECD Manual on Measuring Productivity Growth at the Industry Level and at the Aggregate Level. URL: http://www.oecd.org/std/research

Table 1

Generalized Analysis of Selected Practices for Measuring Labor Productivity in Russian Healthcare

Name of the research object	Measurement method	Measurement method, characteristic
Regional level		
Omsk Region	Monetary	OECD methodology
Tomsk Region	Monetary	OECD methodology
Kemerovo Region	Physical (quantitative)	Number of patient visits per physician
Republic of Crimea	Monetary	OECD methodology
Healthcare institution level		
Kursk City Polyclinic No. 5 (OBUZ)	Physical (quantitative)	Number of patient visits per physician
Kuzbass Clinical Cardiology Dispensary named after Academician L.S. Barbarash (GBUZ)	Physical (quantitative)	Number of patient visits per physician
City Polyclinic No. 191, Moscow Department of Health	Physical (quantitative)	Number of medical reports prepared by one physician per unit of time
Regional Clinical Hospital No. 3, Chelyabinsk (GAUZ)	Monetary	Total value of services provided / total time spent delivering services

Source: Developed by the author based on data from [13–22].

financial terms as the ratio of output (gross domestic or regional product, or profit), recorded on the basis of value added, to labor inputs (hours worked, number of employees, or number of jobs) [10].

Generalized and systematized practices for measuring the labor productivity of medical personnel in the domestic healthcare system are presented in *Table 1*.

Based on the data presented in *Table 1*, value-based (monetary) methods of measuring the indicator under study prevail at the regional level. This situation is associated with the fact that one of the key objectives of the healthcare system at the level of a constituent entity of the Russian Federation is to ensure the financial sustainability of the sector [11].

The focus of healthcare organization managers is primarily directed toward optimizing workforce management processes and assessing the quantitative and qualitative characteristics of personnel [12]. At this level, issues of employment, labor intensity, and work performance come to the forefront, with labor productivity serving as one of the key indicators of efficiency. Therefore, at the institutional (local) level, physical (quantitative) methods of labor productivity measurement predominate.

Let us consider the regions and healthcare organizations listed in *Table 1* in greater detail. In the Omsk Region, labor productivity is regarded as one of the factors contributing to the competitiveness of healthcare institutions within the sector [13]. In the Tomsk Region, labor productivity in healthcare demonstrated an upward trend during the period 2006–2012 [14]. An analysis conducted in the Republic of Crimea revealed that "against the background of a steady increase in profit accompanied by a simultaneous decline in the average number of medical personnel, labor productivity rose up to 2021, with a slight decrease by 2023 to the level observed in 2020" [15, p. 75]. In a previously published study, the author highlighted the heterogeneous dynamics of labor productivity in the healthcare sector of the Kemerovo Region over the period 2011–2021, measured using a physical (quantitative) approach [16].

In calculating the labor productivity of employees at Kursk City Polyclinic No. 5 (OBUZ), it was found that the number of patient visits per physician increased by 2.87 units between 2016 and 2018 [17].

At the Kuzbass Clinical Cardiology Dispensary named after Academician L. S. Barbarash (GBUZ), physicians' labor productivity increased in 2019 and declined markedly in 2020 [18]. This measurement practice was applied not only in clinical but also in paraclinical departments. Thus, a physical (quantitative) method was employed at City Polyclinic No. 191 of the Moscow Department of Health [19], whereas a monetary method was used in the functional diagnostics department of Regional Clinical Hospital No. 3 in Chelyabinsk (GAUZ) [20].

In cases where labor productivity in Russian healthcare institutions was measured on a one-time basis using value-based assessment and OECD methodologies [21, 22], conclusions were drawn regarding the relatively low level of this indicator compared with countries such as Germany, Japan, and the United States.

Theory and Practice of Measuring Labor Productivity in International Healthcare

In analyzing international practices of labor productivity calculation, the present study draws on data from a number of countries that are members of the Organisation for Economic Co-operation and Development (OECD). Labor productivity is assessed with consideration of several factors, namely labor, capital, and investments in the provision of healthcare services. Thus, physicians' labor input (Z_t) is treated as one of the resources incorporated into a multifactor model and is measured by multiplying the average number of medical personnel (H_t), expressed in full-time equivalent terms, by the average wage level (N_t).

Table 2

Approaches to Measuring the Volume of Medical Services in Selected OECD Countries

Measurement method	Characteristic	Countries
Monetary	Number of services weighted by their cost	Austria, Australia, Germany, Sweden, Japan
	Total number of services weighted by the Consumer Price Index (CPI)	United States, Norway, France, Finland
Physical	Number of services delivered (consultations, examinations, etc.)	Portugal, Hungary, Italy, Belgium

Source: Developed by the author based on OESD data. URL: https://www.oecd.org/en/publications/towards-measuring-the-volume-output-of-education-and-health services_5kmd34g1zk9x-en.htmlpoм

Note: CPI — consumer price index

In turn, the baseline output index of the sector (X_t) may be calculated either using a monetary (value-based) approach — by multiplying quantitative indicators of activity x_j (e.g., the number of procedures performed, consultations provided, prescriptions issued, etc.) by their respective costs (c_t) — or using a physical (quantitative) approach based on the volume of services delivered.

Changes in labor productivity (ΔLP) are determined by comparing the annual growth of output and inputs using the Laspeyres formula (1) [1]:

$$\Delta LP = \frac{x_t / z_t}{x_0 / z_0} - 1 = \frac{x_t / x_0}{z_t / z_0} - 1, \quad (1)$$

$$Z_t = H_t \cdot N_{t,} \quad (2)$$

$$X_t = \sum X_j \cdot C_{t,} \quad (3)$$

where Z_t denotes the quantitative measure of labor inputs in the reporting period and in the base period (Z_0); while X_t represents the volume of healthcare services provided in the reporting period and in the base period (X_0).

Approaches to calculating the output indicator X_t across different countries (*Table 2*) exhibit both common and country-specific features.

According to the data presented in *Table 2*, in assessing physicians' labor productivity, the volume of services delivered may be defined using either physical (quantitative) or monetary (value-based) approaches. The latter is more widely applied in countries where the market serves as the primary regulator and mechanism for satisfying demand for healthcare services [23], and where service prices reflect producers' marginal costs and consumers' maximum utility.[12] This approach is predominantly associated with the United States, where a market-based healthcare system is implemented, as well as with France, Norway, and Finland, which exhibit a stronger orientation toward market principles despite operating within a social insurance model of sectoral governance. By contrast, the physical (quantitative) approach is mainly characteristic of countries with state-based and social insurance models of national healthcare systems, in which public institutions play the central role in ensuring access to medical services (Belgium, Hungary, Italy, Portugal, among others).

Unlike the emerging Russian practice of labor productivity measurement in this sector, some countries (e.g., the United Kingdom, Australia, and Germany) have a long-established history of developing this indicator. In these systems, clinical outcomes and certain aspects of healthcare service quality are incorporated as weighting co-

[12] Schreyer P. Towards measuring the volume output of education and health services: a handbook. https://www.oecd.org/en/publications/towards-measuring-the-volume-output-of-education-and-health services_5kmd34g1zk9x-en.htmlpoм based on (date of access: 01.06.2025).

Table 3

Examples of Qualitative Indicators Used in UK Healthcare System to Assess Productivity

Types of medical care	Indicators of the quality measurement of services rendered			
	Improving health indicators	Survival in the short term	Medical waiting time	National survey of patients
Inpatient care	+	+	+	+
Outpatient (ambulatory) care	–	–	–	+
Emergency medical care	–	–	–	+

Source: Developed by the author based on ONS data Office for National Statistics. URL: https://www.ons.gov.uk/economy/economicoutputandproductivity/publicservicesproductivity/methodologies/sourcesandmethodsforpublicserviceproductivityestimates /

Table 4

Characteristics of Output Measurement methods in Non-market Sectors

The name of the method	Industry	Brief characteristic of the method
Pseudo-price index method for output measurement	Culture, education, and other public sector industries	Calculated on the basis of data on output price indices for comparable products.
Output volume method	Education, healthcare	Measures the actual volume of services delivered, taking into account both their quantitative and qualitative characteristics.
Input (cost) method	Defense	Applied when it is not possible to assess qualitative characteristics, by summing all incurred costs.

Source: Compiled by the author based on the System of National Accounts — 2008 URL: https://unstats.un.org/unsd/nationalaccount/docs/sna2008russianwc.pdf

efficients. For example, in Australia, healthcare quality is assessed using the QALY unit (Quality-Adjusted Life Year), which conventionally represents one year lived in a stable state of health and reflects the contribution of the healthcare system to increasing both the length and quality of patients' lives. Data sources for such evaluations include sociological survey results, such as the national Household, Income and Labour Dynamics in Australia (HILDA) study, as well as findings from regular statistical analyses. Another method of adjusting service volumes according to quality involves accounting for health indicators (morbidity and mortality) per unit of healthcare provision. Under this approach, labor productivity measurement should focus not only on the number of services delivered but also on outcomes that hold value for the patient.[13]

Within the United Kingdom's healthcare system, when determining quantitative indicators of medical staff activity, it is customary — where

[13] Health workforce strategy. URL: https://www.pc.gov.au/inquiries/completed/health-workforce/report/healthworkforce.pdf

Table 5

Characteristics of Methods for Measuring the Volume of Healthcare Services

Description of the method	Characteristic	Category
Deflation of final service output	A procedure that converts economic indicators calculated at current prices into comparable constant prices.	A
Output volume method	Quantitative measurement of services delivered, adjusted using a quality coefficient.	A
	Quantitative measurement of services delivered without accounting for qualitative or monetary components.	C
Output volume method based on the International Classification of Diseases, 10th Revision (ICD-10)	A method for the quantitative assessment of treatment cases in which ICD-10 is used for classification.	B
Note: ICD-10 refers to the International Classification of Diseases, 10th Revision		

Source: Compiled by the author based on Guidelines for measuring prices and volumes in national accounts. URL: https://www.unescap.org/sites/default/files/1.Handbook_on_volume_measures_RUS.pdf

possible —to apply qualitative criteria aimed both at assessing the degree of clinical effectiveness achieved and at analyzing levels of patient satisfaction (*Table 3*). The information presented in *Table 3* illustrates the differentiated nature of quality parameter approaches depending on the type of healthcare service provided. Thus, output adjustment is employed to reflect the impact and effect of the services delivered.

In the absence of a benchmark unified at the level of the global scientific community, each country may independently determine the necessity and adequacy of adjustment coefficients for the volume of services delivered, taking into account relevant requirements, patient complexity, levels of patient satisfaction, and other indicators that correspond to the challenges of modern patient-centered and value-based healthcare. At the same time, international experience indicates the importance of consistently developing labor productivity measurement methodology, beginning with direct output-based indicators and gradually moving toward an integrated approach that incorporates the quality of medical care and the degree of patient satisfaction. A possible modification of the traditional physical (quantitative) method of labor productivity calculation was demonstrated in the author's previously published work [24]. The present study analyzes a number of documents that establish the legal foundations for its measurement within the framework of a regulatory approach to healthcare governance in Russia.

Review of the Regulatory and Methodological Foundations for Determining Labor Productivity in International Practice and Russian Healthcare

The focus of the present analysis is on regulatory legal acts that have made a significant contribution to understanding approaches to labor productivity assessment. The System of National Accounts 2008 (SNA 2008) guidelines state that the category under consideration should be understood as "the volume of output per hour worked (or per employed person).[14]" The provisions of this document apply to both market and non-market sectors, including education, healthcare, defense, and others. A distinctive feature of non-market

[14] "The system of National Accounts — 2008" URL: https://unstats.un.org/unsd/nationalaccount/docs/sna2008russianwc.pdf

sectors lies in the complexity of assessing both the quality of services rendered and labor productivity. In addition to the information presented in *Table 1*, it is important to clarify the approaches to the quantitative evaluation of healthcare service output indicators. According to SNA 2008, several methods exist for measuring output, and their application depends on the characteristics of the specific sector. As shown in *Table 4*, for healthcare the preferred approach is the one based on the quantitative assessment of output volume while taking into account its qualitative characteristics.

Subsequent documents largely develop the ideas of SNA 2008 by further specifying the content and approaches to labor productivity calculation. Thus, the European Commission's Handbook on Price and Volume Measures in National Accounts defines the volume of healthcare output as the medical care received by patients, adjusted for the quality of services provided for each type of care. At the same time, it is noted that quantitative indicators should be applied in conjunction with data on healthcare costs or prices.[15] The document also presents a classification of methods for assessing output volume, indicating the feasibility and appropriateness of their application (*Table 5*):

- *Category A methods* — the most appropriate approaches for measuring output volume.
- *Category B methods* — acceptable when Category A methods cannot be applied.
- *Category C methods* — methods that cannot be applied in practice.

The information presented in *Table 5* reflects the priority of applying quantitative methods incorporating quality adjustment coefficients or cost deflation when assessing output indicators for the measurement of labor productivity in the healthcare sector.

The documents discussed above represent examples of the development of *international-level* regulatory foundations for labor productivity governance in healthcare. An illustration of a successful *national-level* methodological framework for labor productivity measurement is provided by the Atkinson Review (United Kingdom), which formulates key principles for defining labor productivity in non-market sectors and serves as an important reference point for practical healthcare management. Among the most significant principles are the following: the greatest possible standardization of approaches to measuring the volume of services delivered in both market and non-market sectors; the necessity of adjusting quantitative analyses of public services to account for their quality; and the requirement to establish criteria for the quantitative assessment of direct output.[16]

In contrast to certain foreign countries, the healthcare sector in Russia, as noted above, is not included in the list of industries for which labor productivity is routinely calculated. At the same time, a retrospective analysis of sectoral legislation has identified a limited number of references to measurement approaches, illustrating the institutional integration of labor productivity considerations within the industry. In the Soviet Union, this indicator was examined in the context of the economic justification for establishing labor standards and was defined on the basis of actual output, measured by the number of patients seen by a physician in an outpatient clinic and the amount of time spent on this activity.[17] Other documents from both the Soviet and Russian periods contain references to factors influencing labor productivity

[15] Handbook on Price and Volume Measures in National Accounts URL: https://www.unescap.org/sites/default/files/1.Handbook_on_volume_measures_RUS.pdf

[16] Atkinson A. B. The Atkinson review: final report. Measurement of government output and productivity for the national accounts. URL: https://clck.ru/3MhKwr

[17] Letter of the Ministry of Health of the USSR dated 2 October 1987 No. 02–14/82–14 "On the Procedure for Expanding Autonomy and Increasing the Accountability of Heads of Healthcare Authorities in the Application of the Order of the Ministry of Health of the USSR dated 13 August 1987 No. 955" (together with the "Methodological Guidelines on Labor Standardization for Medical Personnel"). URL: https://www.consultant.ru/cons/cgi/online.cgi?req=doc&base=ESU&n=11641#BOkLKuT4a7wXQ2ll

in healthcare, in connection with the scientific organization of labor[18] and lean production,[19] as well as the application of this evaluation tool within the functional responsibilities of administrative and managerial staff in clinical department.[20]

CONCLUSION

The conducted analysis allows the following conclusions to be drawn:

1. Existing practices of labor productivity measurement in Russian healthcare are methodologically comparable to approaches applied in foreign countries and are based on both monetary (value-based) and physical (quantitative) methods of calculation.

2. The choice of methods for determining output indicators of healthcare service provision, as well as the approaches to labor productivity measurement, is largely shaped by the structure of the national healthcare system.

3. Distinctive features of this process in international practice are associated with the development of labor productivity assessment methods that incorporate service quality requirements and the implementation of a patient-centered approach.

4. In contrast to international experience, Russian healthcare currently lacks scientifically grounded methodologies for measuring this indicator.

5. At present, the sector is at an initial stage of actively applying the concept of labor productivity to evaluate institutional performance, driven by the implementation of the national project "Labor Productivity." Further accumulation of empirical data may provide a basis for developing evidence-based methodologies to improve measurement approaches.

6. Prospects for further research lie in providing a scientific rationale for the directions of methodological development in measuring labor productivity in the Russian healthcare sector. This may be achieved through the synthesis of domestic and international practices, taking into account contemporary priorities in healthcare development, which are associated with improving the quality and safety of medical services, ensuring sectoral sustainability, and adopting integrated, systemic, and human-centered approaches.

[18] Scientific Organization of Labor in Clinical Diagnostic Laboratories of Healthcare Institutions (Methodological Guidelines) (approved by the Ministry of Health of the USSR on 5 May 1975).URL: https://www.consultant.ru/cons/cgi/online.cgi?req=doc&base=ESU&n=10768#1wiMKuT7vUG9WKZT)

[19] Federal Project "Lean Polyclinic." Methodological Guidelines for the Application of Lean Production Methods in Medical Organizations. URL: https://ovmf2.consultant.ru/cgi/online.cgi?req=doc&base=LAW&n=371095&cacheid=87658DFC 727AE 43B 4806C 94845D 16792&mode=splus&rnd=hvR 0mg#KbWf B 1Vg1fdDRivq

[20] Order of the Ministry of Health and Medical Industry of the Russian Federation dated 29 November 1994 No. 256 (as amended on 29 September 1997) "On the Organization of Emergency Narcological Care Units (Wards)." URL: https://recipe.ru/nd/medical-and-pharmaceutical-workers/prikaz-minzdravmedproma-rf-ot-29–11–1994-n-256-red-ot-29–09–1997-ob-organizatsii-otdelenij-palat-neotlozhnoj-narkologicheskoj-pomoshhi-prikaz-komiteta-farmatsii-g-moskvy-ot-22–09–1997-n-129-ob-organ/

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Managing Organizational Risks in Russia's Oil and Gas Enterprises Based on Expert Assessment

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ABSTRACT

The Comprehensive Security System (CSS) is designed to prevent the emergence and development of risks — technical, organizational-technical, and purely organizational — at enterprises within Russia's oil and gas sector. This study focuses on reducing losses by assessing and managing organizational risks that arise from insufficient actions or shortcomings on the part of personnel responsible for ensuring the effective operation of the CSS. The aim of the research is to identify an approach that makes it possible to convert qualitative indicators of organizational risks into quantitative terms (a measurable negative impact). In the course of the study, the author substantiates the use of an expert-based method (priority ranking) to evaluate risks associated with inadequate actions by management bodies that oversee subordinate personnel. This method has advantages and introduces elements of novelty compared with current solutions used in practice. When applied together with the functionality of the Gaussian probability distribution, it allows experts to determine specific safety areas in which organizational risks arise due to insufficient control measures. In real organizational systems, having reliable information with weighted values for all identified risks makes it possible to construct a ranked list, determine priorities, and develop a set of preventive measures. The article provides an example illustrating how personnel in various safety areas influence the overall state of the CSS, and it justifies the feasibility of applying the *priority-ranking method* in practice to obtain quantitative results for organizational risks.

Keywords: integrated security system; organizational risks; prioritization method; Gauss probability distribution; expert decision; insufficient actions

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INTRODUCTION

Knowledge concerning the implementation of a risk-oriented approach aimed at reducing damage from hazardous events at enterprises of the Russian oil and gas sector is continuously expanding through new analytical findings on technical, engineering-organizational, and organizational risks [1]. For the overall component across all risk groups, the presence of a substantial share (approximately 75%) associated with the human factor has been confirmed [2].

Approaches to the study of the first two types of risks are comprehensively presented in the works of the A.A. Blagonravov Institute of Machine Science of the Russian Academy of Sciences (risk analysis and safety of hazardous production facilities) [3]; the Scientific and Technical Center for Industrial Safety Research (safety justification of hazardous production facilities, as well as risk analysis, safety substantiation, and safety declaration provided as commercial services upon request from legal entities) [4–6]; the All-Russian Research Institute for Fire Protection of EMERCOM of Russia (organizational and methodological support for activities related to independent fire risk assessment carried out on a fee-for-service basis upon request from legal entities) [7–9]; and the All-Russian Research Institute for Civil Defense and Emergency Situations of EMERCOM of Russia (improvement of emergency risk management methods in response to national security challenges and threats in the development of regulatory legal acts and normative documents) [10; 11].

As regards the assessment of organizational risks, further research is required to enhance technosphere safety at protected facilities of oil and gas enterprises in Russia [1]. The author identifies a problem situation consisting in the need to manage organizational risks manifested as hazardous events (accidents and fires), proposes an expert-based method for their assessment, and substantiates its advantages.

RESEARCH METHOLOGY

The activities of oil and gas enterprises in Russia aimed at preventing the emergence and manifestation of organizational risks are schematically presented *in Fig. 1*.

The developed sequence of actions makes it possible to account for the dynamics of damage reduction U_{OC} resulting from the manifestation of organizational risk R_O in hazardous events (accidents and fires), once the indicators of negative impact become known in quantitative terms (measure):

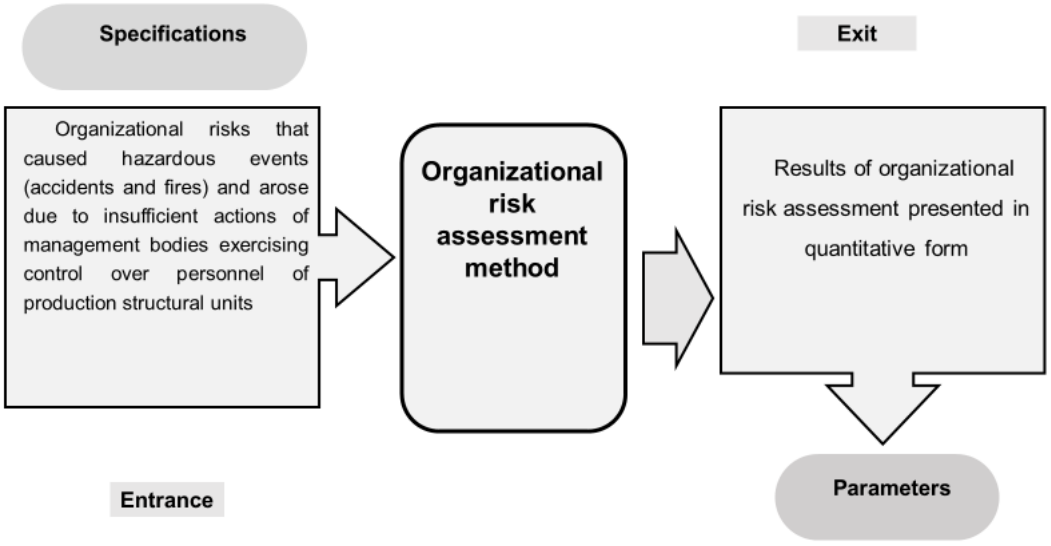


Fig. 1. **The Sequence of Transformation of Organizational Risks from Characteristics to Parameters**

Source: Compiled by the author.

$$U_{\text{ос}} = F_{U_{\text{ос}}}\{R_0, P\} = \sum_i \left[F_{U_i}(R_{0_i}, P_i\right] =$$
$$= \int C(R_0) P\left(R_0\right) dR_0 = \int C\left(P\right) R_0\left(P\right) dP, \quad (1)$$

where

P — probability of occurrence of hazardous events (accidents and fires);

i— groups of adverse factors influencing the outcome in the form of hazardous events (accidents and fires);

C— weighting functions accounting for the interdependence of risks.

Since the objective of the study was to substantiate the selection of an expert method capable of transforming qualitative characteristics of organizational risks into quantitative ones, the parameter (M) — representing the weight of the negative impact of organizational risk — should be employed within the range $M_{\min}$= 0,001; $BM_{\max}$= 0,999. Then

$$R_{\text{O}} = \int_{M\min}^{M\max} f\left(M\right) \cdot P\left(M\right) dM, \quad (2)$$

where $f\left(M\right)$ denotes the distribution density of organizational risk groups, taking into account the frequency of their manifestation in hazardous events; $P\left(M\right)$ — denotes the probability of manifestation of organizational risks in hazardous events, determined using the functional framework of Bayesian belief networks [2, 12, 13].

The shortcomings of existing risk assessment methodologies are presented in *Table 1*.

At present, various methods are used for risk assessment, for example FMEA1 (Failure Mode and Effects Analysis) [1] and Bayesian analysis (or Bayesian networks2) [2]. The advantage of the former lies in identifying potential failures of production equipment and their impact on the functioning of facilities or processes, the environment, and personnel. This makes it possible to increase equipment reliability, reduce negative environmental impact, lower operating costs, and ultimately enhance the company's business reputation. The FMEA method has gained wide recognition and is applied primarily in the assessment of *technical risks*. Bayesian analysis and Bayesian networks may be useful in developing a probabilistic Poisson model for events such as accidents, enabling the identification of causal relationships among variables (represented as a Bayesian network). However, in practice they are used infrequently due to the complexity of representing all interactions within a technical system, as conditional probabilities become excessively extensive. The above methods have the following limitations:

- obtaining results requires the input of empirical data expressed in quantitative form;
- meaningful results are obtained only in domains where probabilistic laws play a decisive role.

A distinguishing feature of selecting an expert-based method for assessing organizational risks is the identification of the deviation magnitude of the baseline vector from the chosen direction, that is, the capacity of the governing body to adjust the trajectory toward achieving the objective. As noted earlier, a key problem is that initial risk data are presented as qualitative descriptions rather than formalized information. This circumstance confirms the feasibility of transforming them into quantitative form.

Activities of industrial enterprises aimed at reducing the risks of damage caused by hazardous events should be carried out not only in the domain of managing technical and engineering-organizational risks. The field of assessment and management of organizational risks also requires particular attention [14], since this group of risks:

- arises in the process of managerial influence exerted by the governing body on personnel of production structural units;

[1] GOST R 27.303–2021 (IEC 60812:2018).Dependability in engineering. Failure Mode and Effects Analysis (FMEA) URL: https://meganorm.ru/Data/758/75897.pdf

[2] GOST R IEC 31010–2021. Dependability in engineering. Risk assessment techniques. URL: https://docs.cntd.ru/document/1200180987

Table 1

Disadvantages of Existing Risk Assessment Methods

Rostechnadzor Order No. 387 dated 03.11.2022	Order of the Ministry of Emergency Situations of Russia dated 26.06.2024 No. 533	Order of the Ministry of Labor of Russia dated December 28, 2021 No. 926	Disadvantages
Qualitative Description of Risks			
Risk prioritization: 1, 2, 3 (based on accident hazard categorization)	–	+	The nature of interrelations is not taken into account when one safety domain affects another and when they interact. No risk result is presented in the form of a weighted quantitative value; therefore, it is impossible to determine risk priority when forming a unified ranked list.
Risk grading: A, B, C, D (from lowest to highest).		+	
Risk significance: high, medium, low.		+	
Quantitative Representation of Risks			
Numerical expression of pipeline depressurization risk: 10^{-n}/year, where *n* is the exponent value.	Quantities characterizing risks in determining calculated evacuation time (minutes)	–	Sensitivity to measurement errors (significant uncertainty). Alternative relationships with the influence of external factors are not considered.
Probabilistic relation to risk realization (1–100%), with representation of probability values 10^{-n}/year, where *n* denotes the risk magnitude exponent.		–	

Источник / Source: составлено автором / Compiled by the author.

• is identified and prevented through continuous monitoring conducted by industrial and fire safety departments and occupational safety units. These subdivisions oversee compliance with regulatory legal acts and normative documents approved in the areas of industrial safety (Rostekhnadzor), emergency protection (EMERCOM of Russia), and occupational safety (Ministry of Labor). The reports produced do not contain information on deficiencies within a specific safety domain in which such risk arose and manifested itself in the form of a hazardous event. All changes occurring in organizational management systems can be represented as a trajectory of the development (emergence, manifestation, realization) of organizational risk processes R_O in the state space of the system, with zonal boundary delineation (*Fig. 2*).

Let us consider *Fig. 2*:

1. In the zone highlighted in green (lower part), all production processes in the technical system are carried out without disruptions — this corresponds to state S_0.

2. The area marked in yellow (middle part) relates to the zone where organizational risks R_{NDD} and R_{ND}, emerge; under favorable conditions they may manifest as hazardous events (accidents or fires) — this corresponds to state S_n;

3. The section highlighted in red (upper part), where organizational risks R_{NDD} and R_{ND} have become causes of hazardous events (accidents or fires), represents the zone in which various damage-development scenarios unfold; this corresponds to state S_i. If, within the *organizational* system in which the initiating event (IE) occurs (i.e., organizational risks R_{NDD} and R_{ND} arise),

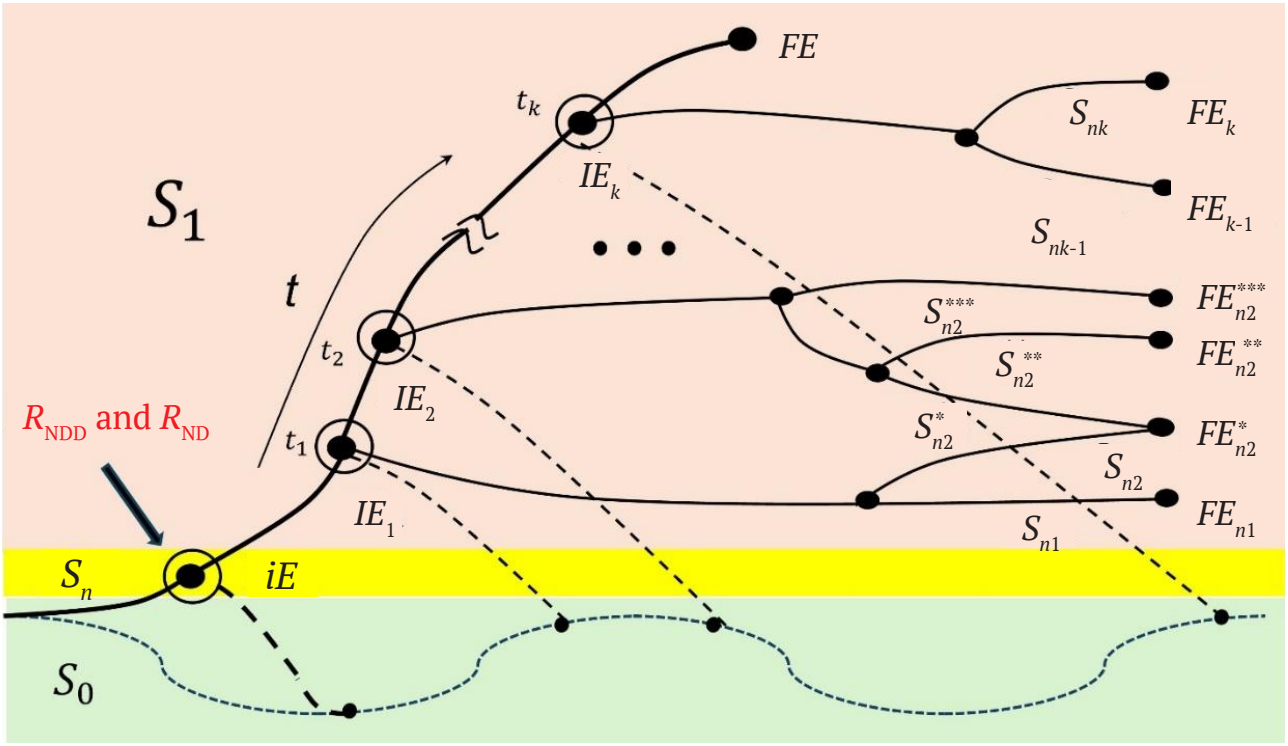


Fig. 2. **Trajectory with the Process of the Emergence and Manifestation of Organizational Risks in Dangerous Events**

Source: Compiled by the author.

conditions are created that lead to deviation toward the zone associated with state S_1, then numerous damage scenarios S_{ij}. may be realized in the *technical* system. The final state (*FS*) for each scenario differs (see *Fig. 2*):

$$FS_{ij} \neq FS^{*}_{ij} \neq FS^{**}_{ij} \neq FS^{***}_{ij}. \quad (3)$$

If, during an incident (failure), the *technical* system is capable of returning from S_1 to S_0 within the shortest time interval, then in approximately 20% of accidents fires occur that cause maximum damage and disable elements of the technical system for an extended period. In this context, there is an opportunity to prevent the emergence of organizational risks in the zone corresponding to state $S_{\text{П}}$, and when they transition into the zone associated with state S_1 (points (t_1, t_2, t_k), to implement a set of protective measures.

Risk will be understood as a consciously recognized danger (threat) of the occurrence of a negative event in any system, with consequences[3] determined in time and space [1]. A consciously recognized danger (threat) may appropriately be defined as the conditions under which risk manifests (or escalates), ultimately transitioning into a final phase involving damage caused by hazardous factors (accidents or fires). Given the specifics of assessing organizational risks, it is recommended to consider them as:

- insufficient actions of personnel responsible for safety assurance and exercising control over the staff of production structural units — R_{NDD};
- deficiencies in personnel performance when complying with regulatory legal acts and normative documents — R_{ND}.

The overall indicator of organizational risks R_0 for a selected period may be calculated using the following expression:

[3] Glossary of Terms and Definitions of EMERCOM of Russia. URL: https://mchs.gov.ru/ministerstvo/o-ministerstve/terminy-mchs-rossii/term/3579.(date of access: 13.07.2025).

$$R_0(t) = \frac{\sum_{i=1}^{j}(R_{NDD}) + \sum_{i=1}^{j}(R_{ND})}{n\cdot(R_{NDD}) + n\cdot(R_{ND})}(t), \quad (4)$$

where $n\cdot(R_{NDD})$ and $n\cdot(R_{ND})$ denote the number of accident reports included in the sample (units); t —the period under consideration (month, quarter, year).

To identify organizational risks, it is advisable to employ both individual and group expert assessment methods.

Furthermore, explanatory guidance should be provided to experts regarding the following components:

- evaluation of the priority of qualitative risk characteristics and the type of scale applied;
- sequence of procedures or operations aimed at forming judgments;
- order of actions intended to solve the task of processing expert The author proposes the use of an ***expert-calculation method***, specifically the *priority-ranking method* [15], which belongs to a new class of approaches and enables the transformation of qualitative expert assessment results into quantitative form (i.e., determining the magnitude of negative impact).

Application of this method makes it possible to:

- enable a group of experts to select the functional domain (industrial safety; fire safety; occupational safety; production structural units) in which an organizational risk emerged due to insufficient control-related actions and manifested itself as a hazardous event. In this case, experts are able to determine the degree of personnel involvement in its occurrence: direct (*absolute attribution*), mediated (*priority attribution*), or indirect (*relative attribution*);
- obtain for each organizational risk an individual numerical value M (weight of negative impact of organizational risk) within the range диапазоне M_{min}= 0,001; M_{max}= 0,999.

THEORETICAL BASIS FOR THE STUDY

Expert methods applied in practice are generally reduced to solving problems through priority ranking based on the collective judgment of experts [16]. Such a decision is formed by comparing the current state space of the system with the existing risks $M_R(t)$ and by developing a set of organizational and technical measures — $M_M(t)$ aimed at preventing them, expressed as

$$M_R(t) = \begin{pmatrix} n_{11}, & n_{12}, \cdots & , n_{1,k_1} \\ n_{21}, & n_{22}, \cdots & , n_{1,k_1} \\ & \cdots & \\ n_{75,1}, & n_{75,2}, \cdots & , n_{75,k_{75}} \end{pmatrix},$$

$$M_M(t) = \begin{pmatrix} n'_{11}, & n'_{12}, \cdots & , n'_{1,k_1} \\ n_{21}, & n_{22}, \cdots & , n'_{1,k_2} \\ & \cdots & \\ n'_{75,1}, & n'_{75,2}, \cdots & , n'_{75,k_{75}} \end{pmatrix}, \quad (5)$$

where n_{ij} and n'_{ij} are parameters of the compared values of elements included in the respective arrays, taking into account the discrete deterministic functional relationship between them. Accordingly, on the coordinate plane, the interaction of such data arrays $M_R(t)$ and $M_M(t)$ may be represented as an area bounded by vec-

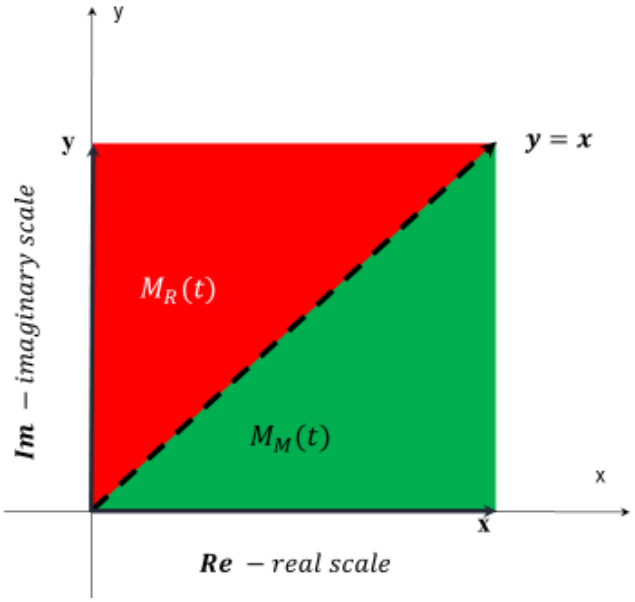


Fig. 3. **The Basic Directional Vector *y=x*, Separating the Areas of the Data Arrays $M_R(t)$ and $M_M(t)$**

Source: Compiled by the author.

tors (y) and (x) of the corresponding dimensionality. As abstract objects, two right isosceles triangles colored red and green are proposed for consideration *(Fig. 3)*.

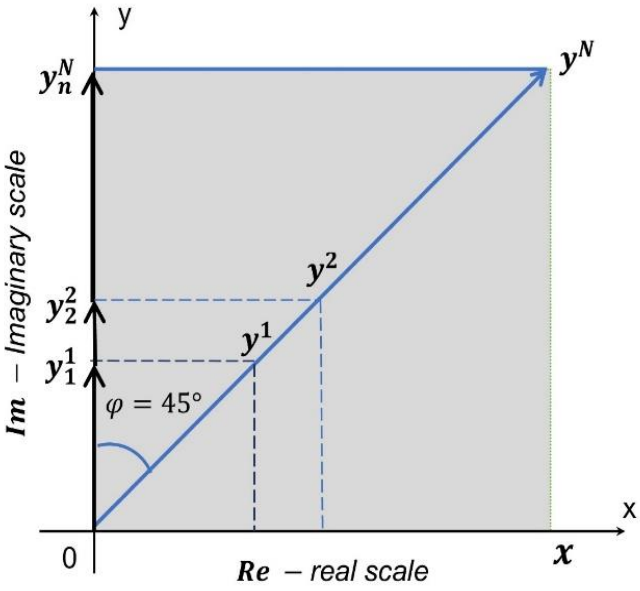


Fig. 4. **The Vector *x*, as a Square Value Plotted on a Real Scale**

Source: Compiled by the author.

In accordance with the concept of integrated safety, the compared arrays (see *Fig. 3*) are balanced by the *baseline directional vector* ($y = x$); in this case, some elements from the array $M_R(t)$ are transformed to determine the elements n_{ij} of the array$M_M(t)$. Such a condition makes it possible to focus on identifying new organizational risks R_0 and, consequently, to obtain the outcome of the influence of the implemented measures expressed by the relation ($y < x$). This enables the decision-maker to represent changes in the impact indicators of the array $M_M(t)$ on $M_M(t)$ based on variation in the orthogonal orientation of the resultant vector. The importance of applying a balancing *baseline directional vector* lies in the fact that the magnitude (x,y) may be interpreted as the square of the length of a vector plotted on the *Re* scale of real numbers (the x-axis) (*Fig. 4*).

If the causes of organizational risks are considered as the area of a square representing the entire set of risks under study, it becomes possible to identify a region (designated by a directional vector) represented by the area of a rectangle corresponding to new (previously unexamined) organizational risks. Over time, it

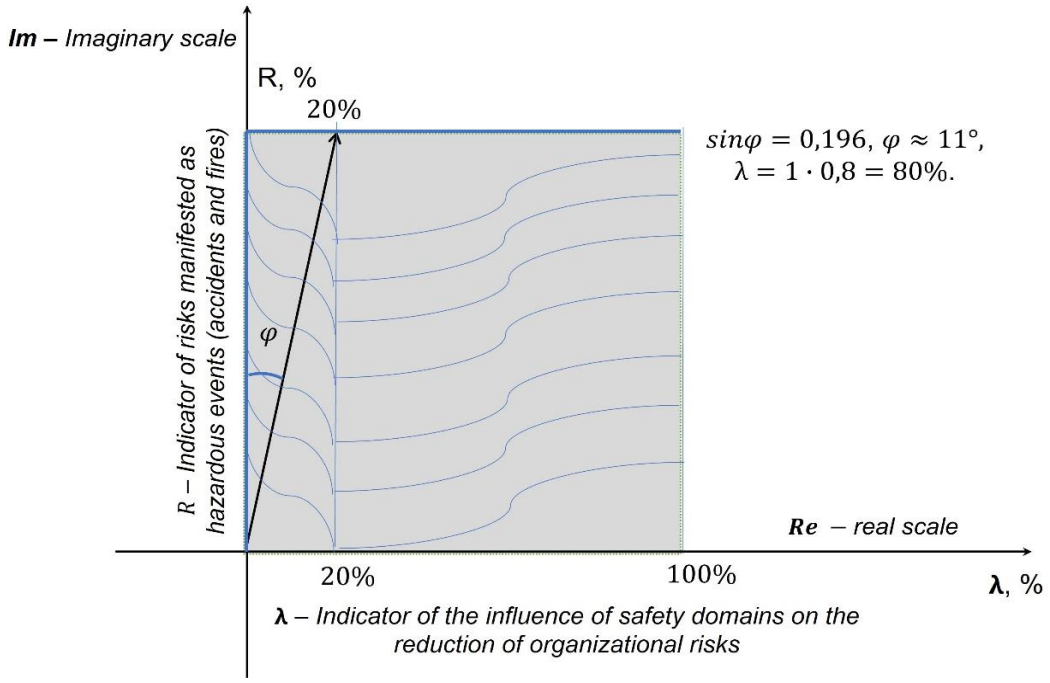


Fig. 5. **The Allocated Share with the Risks Manifested in Dangerous Events (Accidents and Fires)**

Source: Compiled by the author.

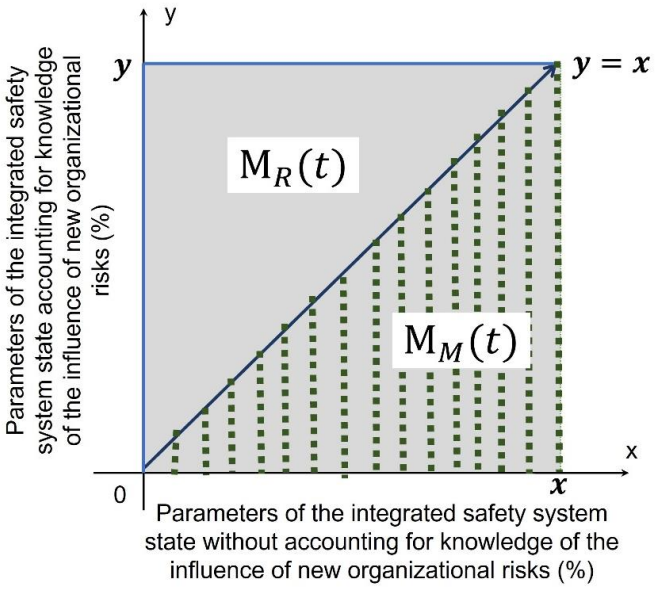


Fig. 6. **A Dedicated Area for Displaying New Organizational Risks Manifested in Dangerous Events (Accidents and Fires)**

Source: Compiled by the author.

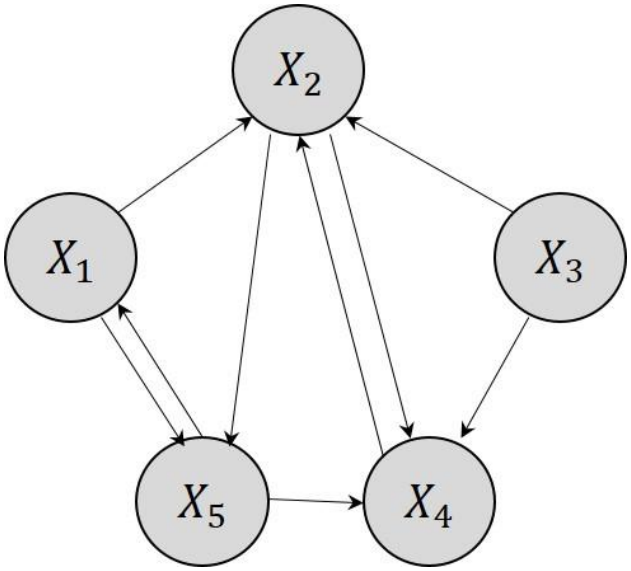


Fig. 7. **Graph of the *n*-object evaluation result**

Source: Compiled by the author.

becomes necessary to reduce this area through the development and implementation of a specific set of actions addressing such unexplored risks as R_{NDD} and R_{ND} (*Fig. 5*).

Since the article addresses the quality of the influence exerted by personnel of higher professional education units at enterprises in preventing organizational risks R_0, the dynamics of effectiveness of the measures included in the array $M_M(t)$ will be positive when the area of the isosceles triangle belonging to the array $M_R(t)$, changes, and negative under analogous changes in the triangle belonging to the array — $M_M(t)$ (*Fig. 6*).

When applying the proposed approach in practice, it becomes possible:

- on the one hand, to use the *baseline directional vector* as the reference scale on which emerging risks exert no influence, i.e., the influence indicator $\lambda_{inf} = 0$;
- on the other hand, the impact of efforts aimed at preventing the emergence of organizational risks makes it possible to bring the system state at oil and gas enterprises in Russia to a normalized condition, that is

$$\lambda_{inf}\{IS;FS;OS;PSU\} \Rightarrow 1.$$

JUSTIFICATION FOR THE PREFERENTIAL SELECTION OF THE PRIORITY-RANKING METHOD FOR ASSESSING ORGANIZATIONAL RISKS

Each of the *n*–objects (X_1, X_2,...., X_n) (*Fig. 7*) corresponds to a vertex of a graph reflecting the result of comparison between two evaluated objects. The task is to determine the maximum of functions of several variables that are related to one another through rank dependence.

Если рассматривать любую расчетную модель с точки зрения ее упрощения, то (согласно условиям предпочтительности) целесообразно применять квадратичную форму

$$A = \begin{vmatrix} a_{11} & a_{12}\dots & a_{1j}\dots & a_{1N} \\ a_{21} & a_{23}\dots & a_{2j}\dots & a_{2N} \\ \dots & \dots\dots & \dots\dots & \dots \\ a_{i1} & a_{i2}\dots & a_{ij}\dots & a_{iN} \\ \dots & \dots\dots & \dots\dots & \dots \\ a_{n1} & a_{n2}\dots & a_{nj}\dots & a_{nN} \end{vmatrix},$$

If any computational model is considered from the standpoint of simplification, then

(according to preference conditions) it is appropriate to apply a quadratic form, where a_{ij}— risk indicators obtained through pairwise comparisons;

N— matrix rank;

$a_{n1}, a_{n2}, ..., a_{nj}, a_{nN}$— risk indicators included in the j-th row of matrix A;

$a_{1N}, a_{2N}, ..., a_{jN}, a_{nN}$ — j-risk indicators located in the j-th column of matrix (A).

In this case,

$$a_{ij} = \begin{cases} 1, if\ X_i > X_j \\ 0,5, if\ X_i = X_j \\ 0, if\ X_i < X_j \end{cases},$$

where $i = j \to \{1,2,\ldots,n\}; a_{ij} = 0,5.$

$X_i > X_j$ indicates the priority of one evaluated object relative to another, while $X_i = X_j$ indicates equal importance of the evaluated objects.

The use of a qualitative ratio scale makes it possible:

- on the one hand, to determine organizational risks R_0 as a result of identified deviations (insufficient actions of functional domains [industrial safety; fire safety; occupational safety; personnel of production structural units] when implementing control measures with respect to staff), represented by the coefficient of negative impact K_{NI} (associated with domain X_i;
- on the other hand, to establish the nature of damage caused by each hazardous event (accident or fire).

The justification presented above largely corresponds to the *priority-ranking method* (PRM) [15]. This method has certain advantages over other expert assessment techniques, as it enables:

- identification of interrelations among elements comprising the system state space;
- representation, where possible, of quantitative assessments (subjective, expert-based) [16];
- formulation and transformation of the problem into a logically structured form;
- expansion of analytical capabilities through the application of mathematical modeling tools and optimal decision selection [17], as well as other methods used in practice, including statistical distributions (*Tables 2* and *3*).

In scientific studies [18, 19], when sampling data constrained by dependent indicators of qualitative characteristics (3–4 units), it is considered preferable to use an average indicator reflecting the typical level of a feature formed under the influence of dominant non-random factors. In this context, the normal distribution is appropriate. The use of mean values makes it possible to characterize a specific attribute of a population by a single number, despite variations in its values across individual units. Taking into account the presence of uncertainty when calculating estimates of the studied parameters using a verbal scale, a compromise approach was adopted to select the most preferable weighting value by employing point estimates derived from the law of normal distribution. This approach accounts for the limited number of organizational risks (3–4 units) identified in the reports "Lessons Learned from Accidents" (subsection addressing organizational causes) at Russian oil and gas enterprises. Within this framework:

- on the one hand, point estimates should be applied cautiously when selecting the preferred decision, given the uncertainty in estimating factors and their weights;
- on the other hand, it becomes possible to employ a *ratio scale* constructed on the basis of the functional application of established probabilistic laws. For example, the Gaussian distribution, characterized by the manifestation of specific values of an organizational risk indicator across the *total area* = 100%, and within intervals bounded by $\bar{x} \pm \sigma = 68{,}2\%$, $\bar{x} \pm 2\sigma = 95{,}4\%$, $\bar{x} \pm 3\sigma = 99{,}6\%$. This makes it possible to confirm the reliability of expert judgments when processing questionnaire data at the ***second stage*** of the study (primary processing of survey results), that is, to test them for sensitivity. Since the assessed organizational risks arise and manifest as hazardous events across different safety

Table 2

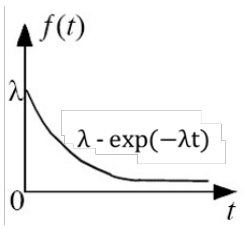
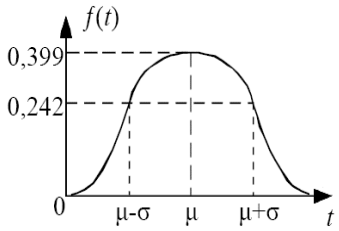
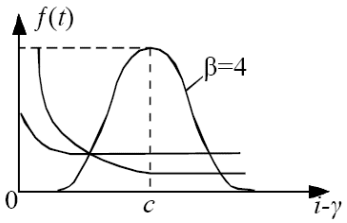
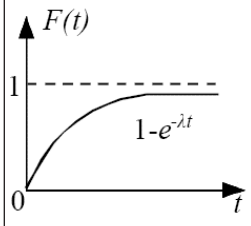
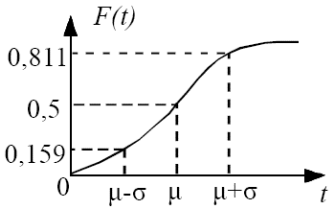
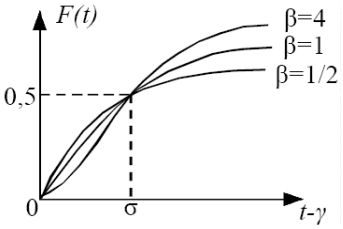
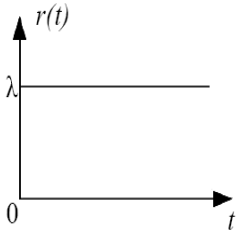
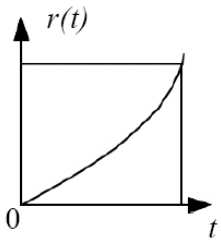
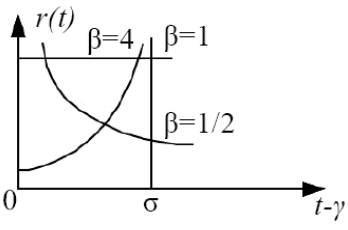
Statistical Distributions Used in Practice (Presented in the Form of Calculation Formulas)

Parameter	Exponential	Normal (Gauss)	Weibull
Probability Density $f(t)$	$\lambda e^{-\lambda t}$	$\frac{1}{\sigma\sqrt{2\pi}} e\left[-\frac{1}{2}\left(\frac{t-\mu}{\sigma}\right)^2\right]$	$\frac{\beta(t-\gamma)^{\beta-1}}{\sigma^{\beta}} e\left[\left(-\frac{t-\gamma}{\sigma}\right)^{\beta}\right]$
Distribution Function $F(t)$	$1-e^{-\lambda t}$	$\frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{t} e^{-\frac{1}{2}\left(\frac{t-\mu}{\sigma}\right)^2} dx,$ $(-\infty < t < \infty)$	$1-e\left[-\left(\frac{t-\gamma}{\sigma}\right)^{\beta}\right]$
Magnitude of Variation Limit.	λ	$\frac{f(t)}{1-F(t)}$	$\frac{\beta(t-\gamma)^{\beta-1}}{\sigma^{t}}$

Source: Compiled by the author.

Table 3

Statistical Distributions Used in Practice (Presented in the Form of Graphs

Parameter	Exponential	Normal (Gauss)	Weibull
Probability Density $f(t)$			
Distribution Function $F(t)$			
Magnitude of Variation Limit.			

Source: Compiled by the author.

Table 4

Results with Negative Impact Indicators for Organizational Risks

Security directions, attitude								Sign of the relationship of organizational risk to the direction of safety	Negative impact indicator
IS		FS		OS		PSU		*Direct relationship (DR)*	0.682
								Mediated relationship (MR)	0.272
								Indirect relationship (IR)	0.042

Source: Compiled by the author.

domains (industrial safety, fire safety, occupational safety, and production structural units), they may be treated as independent; therefore, in accordance with formal mathematical reasoning, the author considered it appropriate to assign a specific numerical value to each alternative (*Table 4*).

Such an approach makes it possible to associate specific numerical values with the following qualitative characteristics:

those having a *direct* relationship (*absolute attribution*) to the emergence and escalation of conditions leading to damage from accidents and fires. In proportional terms, the value amounts to approximately 68.2% (≈ 0.682), and this indicator is assigned to one of the domains (industrial safety; fire safety; occupational safety; production structural units);

- those having a *mediated* relationship (*priority attribution*) — approximately 27.2% (≈ 0.272); this indicator is assigned to one of the domains (industrial safety; fire safety; occupational safety; production structural units), even if it had previously been characterized as having a *direct* relationship;
- those having an *indirect* relationship *(relative attribution*) — approximately 4.6% (≈ 0.046); this indicator is assigned to one of the domains (industrial safety; fire safety; occupational safety; production structural units);
- those having *no relationship* (i.e., ≈ 0), corresponding to the domain to which none of the above indicators was assigned[4].

JUSTIFICATION OF THE QUALITY OF EXPERT ASSESSMENT AND VALIDATION OF THE STUDY RESULTS

To summarize the risk assessment with consideration of the influence of personnel from specific safety domains (occupational safety; industrial safety; fire safety) and production structural units on the overall state of the integrated safety system, an expert group was formed comprising specialists from PJSC Mosenergo responsible for analyzing:

- accidents (experts in industrial safety);
- fires (experts in fire safety);
- occupational injuries (experts in occupational safety).

The size of the expert group was calculated using the formula

$$n_T = \frac{c\overline{a}_n - b}{\overline{a}_n (1-c)}, \quad (6)$$

[4] Gvozdev E.V., Sadovsky B.S., Gvozdeva E.D. Certificate of State Registration of Computer Software No. 2024680621 (Russian Federation). Calculator for assessing the influence of subsystem personnel on the state of the integrated safety system of explosion- and fire-hazardous enterprises. No. 2024665338, dated 30 Aug 2024.

where n_r — required number of experts; $\overline{a}_n$ — arithmetic mean of the assessments provided by n experts; b — assessment obtained from an additional (n +1)-th expert; c — measure of the influence of a single expert judgment on the group assessment:

$$c = \frac{\overline{a}_{n+1}}{\overline{a}_n}. \quad (7)$$

In this case: c = 1 when $\overline{a}_n = b$; c >1 when $\overline{a}_n < b$; c < 1 when $\overline{a}_n > b$.

Expressing $\overline{a}_{(n+1)}$ through $\overline{a}_n$ and b, the formula takes the form:

$$\overline{a}_{n+1} = \frac{n\overline{a}_n + b}{n+1}. \quad (8)$$

Then the final value is represented as

$$c = \frac{n\overline{a}_n + b}{(n+1)\overline{a}_n}. \quad (9)$$

Each expert was required to solve the task using documentary materials from the commission investigating the accident at PJSC Nizhnekamskneftekhim (Russian oil and gas sector) in 2016. Organizational risks are listed in *Table 5*, and their normalized assessments (obtained by experts through application of the Gaussian probability distribution) are presented in *Table 6*.

The maximum indicator (*Table 6*) corresponds to the assessment of Expert 4 (b = 0.728). The final calculated value is $\overline{a}_n$ =0,47, but $\overline{a}_{n+1}$ =0,51, obtained using formula (8). The measure of influence of an individual expert's judgment on the group assessment was found to be (c = 1.08) in accordance with formula (9). The calculation results confirmed the need to expand the expert group to seven members, as determined by formula (9).

$$n_r = \frac{1,08 \cdot 0,47 - 0,728}{0,47(1-1,08)} \approx 7.$$

Thus, the minimum composition of specialists capable of ensuring the required influence of an individual expert's judgment on the group assessment was established [20; 21].

When processing expert data from each analyzed accident report, indicators (coefficients)

Table 5

List of Organizational Risks Formed During the Analysis of Accidents

№	Organizational risks
1	Insufficient tightness of fittings in the installed pipeline section in the lower part of the tank
2	Presence of ignition sources within the tank farm area (failure to shut down the welding station), leading to ignition of a flammable medium.
3	Unsatisfactory organization of acceptance procedures for completed work after equipment installation
4	Violation of procedures for the safe commissioning of the tank after installation
5	Ineffectiveness of production control

Source: Compiled by the author.

Table 6

Results of Expert Risk Assessments in Standardized Form

Experts	1	2	3	4	5
Expert appraisal	0.318	0.318	0.682	0.728	0.318

Source: Compiled by the author.

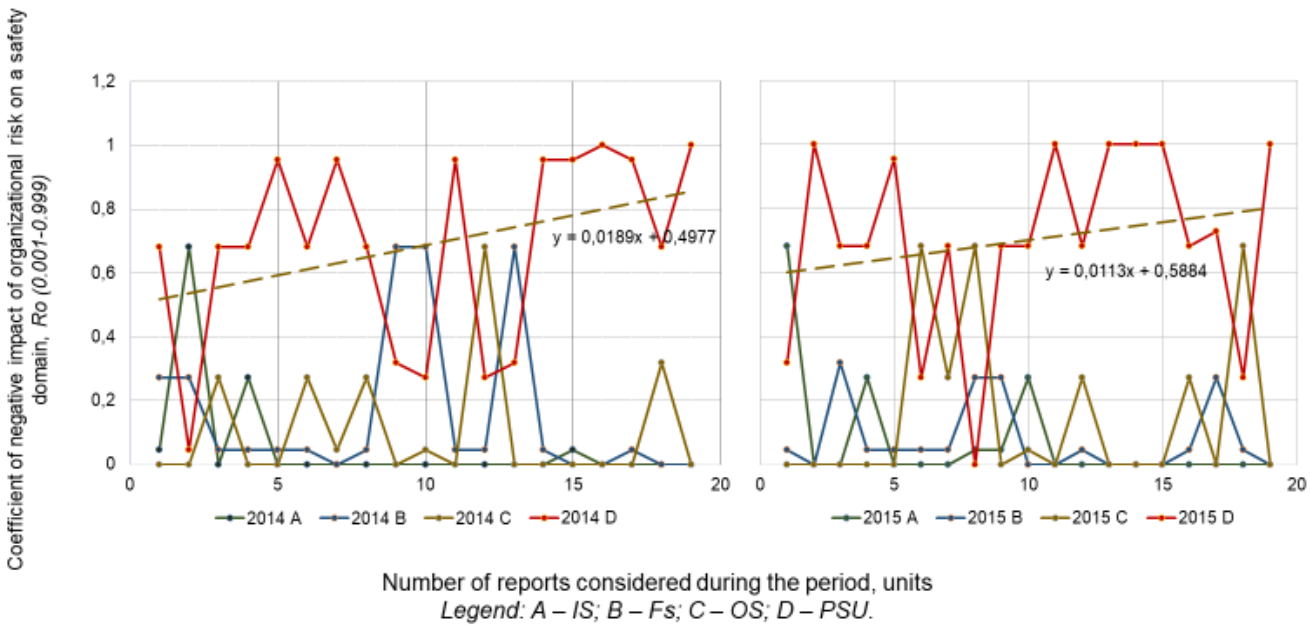


Fig. 8. **Indicators of the negative impact of security trends in 2014–2015**

Source: Compiled by the author.

of the negative impact of organizational risks R_0 are formed for the safety domains (industrial safety; fire safety; occupational safety; production structural units):

$$R_O\{IS;FS;OS;PSU\} \approx$$
$$\approx \lambda_{inf\{1;2;3;4\}} \in \{IS;FS;OS;PSU\}, (10)$$

where $\lambda_{inf1} = 0{,}682$; $\lambda_{inf2} = 0{,}272$; $\lambda_{inf3} = 0{,}046$; $\lambda_{inf4} \approx 0$

The results of calculations based on accident reports from oil and gas enterprises in Russia for 2014–2015 are presented in *Fig. 8*.

The value of the efficiency indicators reflecting the influence of each safety domain $\lambda_{inf} S_{\{IS;FS;OS;PSU\}}$ is determined as the difference between the ratios of risk magnitudes: the organizational risk manifested in a hazardous event taken as 100% impact, and the value obtained from expert decisions regarding the domain having a *direct, mediated, or indirect* relationship. Accordingly, the influence efficiency indicators are calculated as

$$\lambda_{inf} S_{(IS)} = 1 - \varphi_{(S1)}; \lambda_{inf} S_{(FS)} = 1 - \varphi_{(S2)};$$

$$\lambda_{inf} S_{(OS)} = 1 - \varphi_{(S3)}; \lambda_{inf} S_{(PSU)} = 1 - \varphi_{(S4)}, (11)$$

where $\varphi_{\{S1;S2;S3;S4\}}$ are indicators of the negative impact of personnel in each safety domain (industrial safety, fire safety, occupational safety, production structural units) that worsen the overall state of the integrated safety system.

The graphs (*Fig. 8*) allow focus on organizational risks arising within the production structural units domain, which demonstrate a high negative impact indicator - $\varphi_{(S4)}$. The efficiency indicators λ_{inf} calculated using formula (11) for accident reports from 2014–2015 are presented in *Fig. 9*.

To confirm the reliability of expert evaluations, it was necessary to determine the true numerical ratios associated with safety domains according to

$$\overline{w} = \frac{\sum_i^n w_i}{n}, \quad (12)$$

where $\overline{w}$ is the overall weighted-average indicator; n is the number of reports in the sample.

To assess the consistency of expert opinions, the consistency-quality model K_s was applied, defined as the difference between the additive

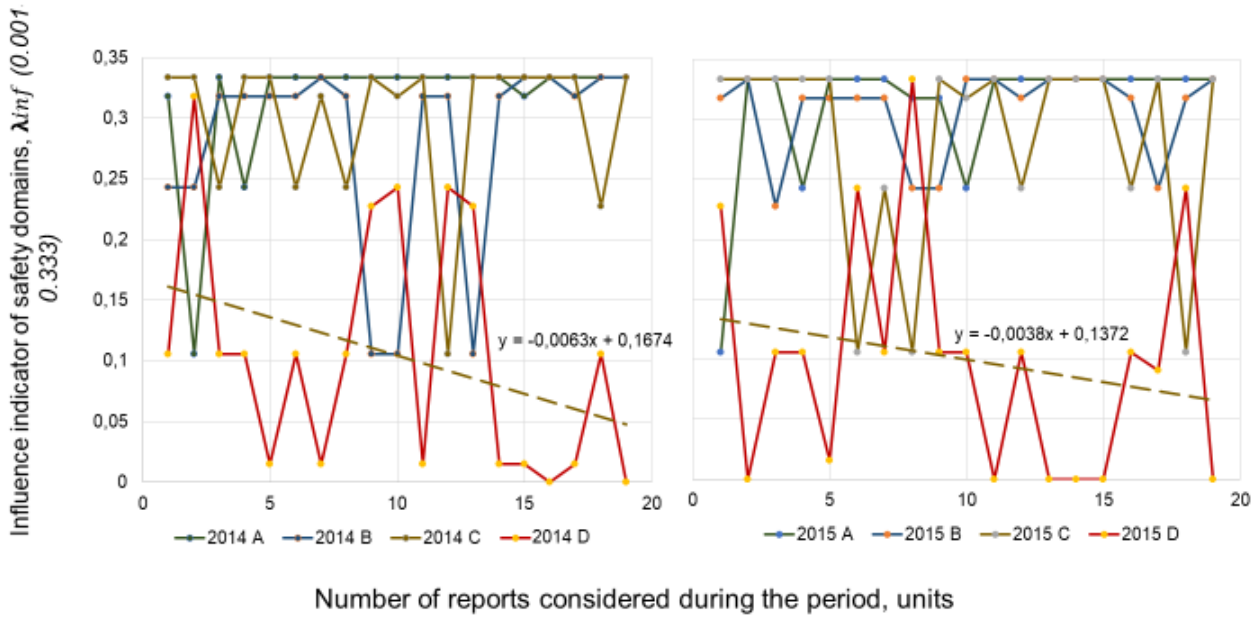


Fig 9. **Indicators of the Effectiveness of the Impact of Security Trends in 2014–2015**

Source: cCompiled by the author.

Table 7

The Results of the Quality Control of the Experts' Consistency

Belongingness factor		Overall results of individual expert assessments with the relationship of the organizational risk indicator to the security area (NO; OO; KO)							E_s	E_I
		1 expert	2 expert	3 expert	4 expert	5 expert	6 expert	7 expert		
IS	DR	0	0	0	0	0	0	0	0.06	0.02
	MR	0.03	0.08	0.08	0.09	0.05	0.06	0.06		
	IR	0.03	0.05	0.09	0.04	0.07	0.05	0.06		
FS	DR	0.09	0.21	0.16	0.12	0.17	0.14	0.11	0.14	0.04
	MR	0.14	0.11	0.09	0.21	0.16	0.12	0.17		
	IR	0.17	0.14	0.11	0.09	0.21	0.16	0.12		
OS	DR	0.08	0.2	0.15	0.11	0.16	0.13	0.1	0.13	0.04
	MR	0.13	0.1	0.08	0.2	0.15	0.11	0.16		
	IR	0.16	0.13	0.1	0.08	0.2	0.15	0.11		
PSU	DR	0.83	0.59	0.69	0.77	0.67	0.73	0.79	0.66	0.06
	MR	0.70	0.71	0.75	0.50	0.64	0.71	0.61		
	IR	0.64	0.68	0.70	0.79	0.52	0.64	0.71		

Источник / Source: составлено автором / Compiled by the author.

weighted average of expert evaluations and the weighted average of their deviations:

$$K_S = E_I, \quad (13)$$

$$E_I = E_S - \sum_{j=1}^{n} w_j, \quad (14)$$

$$E_I = \sum_{i=1}^{n} w_i = 1,0. \quad (15)$$

Here E_S — denotes the result of the weighted averaging of expert evaluations; E_I — denotes the weighted average adjusted for deviations from E_S, w_i and w_j — represent indicators of both evaluations and their deviations.

The data in *Table 7* confirm the quality of agreement among expert assessments, since the final calculated indicator satisfies the condition for solving expert-evaluation problems. $E_I \le 0,1$.

The validity of the calculations is supported by the correct application of the improved priority-ranking method enhanced by the functionality of the Gaussian probability distribution. Sensitivity is ensured through the use of parametric approaches involving determination of the mean value and its standard deviation expressed as a variance indicator for the sample dataset *(Table 8)*.

CONCLUSION

The study analyzed retrospective, current, and expert information concerning the safe operation of enterprises in the Russian oil and gas sector.

The practical applicability of the improved priority-ranking method for assessing organizational risks arising from insufficient actions of personnel responsible for supervising employees of production structural units has been substantiated.

An example demonstrating the validity of applying this method at oil and gas enterprises in Russia has been presented.

To reduce the risks of damage from hazardous events (accidents and fires) and mitigate their consequences, it is advisable for oil and gas production facilities to develop integrated safety systems — new systems capable of diagnosing problem situations and promptly generating control actions intended for decision-makers and aimed at preventing organizational risks.

Table 8

Mathematical Apparatus That Substantiates the Reliability and Sensitivity of Data Processing

Reliability		
Priority –ranking method	$\frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{t} e^{-\frac{1}{2}\left(\frac{t-\mu}{\sigma}\right)^2} dx \; (-\infty < t < \infty)$	$\sigma_1 = 0,682$ $\sigma_2 = 0,272$ $\sigma_3 = 0,046$ $\sigma_4 \approx 0$
Sensitivity analysis		
$\overline{x}_a = \frac{\sum_{S=1}^{S=n} x_S m_S}{\sum_{S=1}^{S=n} m_S}$	$\sigma^2 = \frac{\sum_{S=1}^{S=n} \left(x_S - \overline{x}_a\right)^2 \cdot m_S}{\sum_{S=1}^{S=n} m_S}$	

Source: Compiled by the author.

Note: μ — mathematical expectation; (σ_1; σ_2; σ_3; σ_4) — indicators taking into account the standard deviation; $\overline{x}_a$ — the mean value indicator for a data sample; x_S —risk indicator in the middle of the intervals (S) of the interval series; m_S is the indicator of the probability of risk manifestation (frequency, repeatability) of a set of features for an interval series; n — list of risks for the sample object; σ^2 — dispersion measure for a data sample/

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