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**Subscription department:**
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e-mail: sfmihajlova@fa.ru
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# Stakeholder Model of Corporate Governance: Methodology for Rapid Assessment of the Impact of Macroeconomic Challenges

**I.N. Tkachenko**[a], **M.A. Meteleva**[b]
[a] Ural State University of Economics, Yekaterinburg, Russia;
[b] ANO "Institute for Scientific Research of Management Problems", Kemerovo, Russia

## ABSTRACT

The global humanitarian and economic challenges facing Russian corporate structures today require not only a rethinking of the role of public institutions in the future fate of the national economy, but also unprecedented innovative development of mechanisms for making management decisions in conditions of limited time and information. Well-known and methodologically developed approaches need transformation and development in relation to new realities. Based on the competent opinion of Russian corporate management on the current situation in the business environment, voiced at the XII All-Russian Forum "Business Management: Adaptation to Challenges and Development," requirements for the transformation of the corporate governance model have been determined. The **purpose** of the study was to develop the methodology proposed earlier by the authors for assessing the stakeholder value of the corporate network of the ESG activities of the corporation in terms of the influence of macro-level factors on it, in particular, economic sanctions. The following methods were used as a methodological basis: network approach, methods of logical analysis, correlation and regression analysis, comparison, graphic visualization. The methodology presented in the article was tested on the example of PJSC Norilsk Nickel and the region of its presence — the Krasnoyarsk Territory, based on data from two periods — pre-crisis (2012–2018) and including the COVID-19 pandemic and strengthening of foreign trade sanctions (2012–2021). The results showed the sensitivity of the stakeholder value model to changes in macro conditions, which confirms the validity of the methodology for solving problems of operational management of corporate processes. The prospects for the research lie in the area of expanding the composition of stakeholder groups, developing methods for establishing operational connections between them and their assessment.

***Keywords:*** corporate governance; stakeholder value; corporate network; crisis; network connections; strength of connection; meso-environment; macro-environment

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## INTRODUCTION

The growing role of corporations in the socio-economic development of society and the influence of global conditions on the formation of their competitiveness have become a powerful impetus for the development of corporate governance strategies aimed at creating a positive image among a wide range of interested parties — corporate stakeholders. The concept of taking into account common interests is widely implemented in the practice of public administration within the framework of a public approach, declaring a strategic partnership of state authorities, local government, business and civil society in the process of making strategic decisions [1].

The main tools of the stakeholder management model are methods for assessing the stakeholder value of a corporation. However, an analysis of scientific publications revealed a lack of works devoted to the applied aspects of the implementation of this model in the practice of corporate management, especially studies related to methods for assessing the contributions and benefits of stakeholders [2].

Previously, the authors of the article proposed and tested a method for a quick assessment of the stakeholder value of a corporation's social activities in conditions of unpredictable changes in external conditions by using a network approach for processes occurring in the internal and external immediate environment (mesic environment) of the corporation [3].

The task of further development of the methodological basis for the implementation of the stakeholder model in the practice of corporate and public management encouraged us to turn to the study of the role of factors in the distant external corporate environment (macroenvironment).

Moreover, its radical transformation, caused by the COVID-19 pandemic and macroeconomic sanctions, has led to the formation of a completely new market landscape and a change in corporate values from the point of view of stakeholders. A sensitive indicator of crisis changes was the market capitalization of Russian corporations, showing a rate of decline of 14% from 2021 to 2022 and of 29% from 2022 to 2023.[1] Rapidly changing realities have made urgent the problem of finding relevant approaches to both the transformation of the stakeholder management model and the development of tools for its implementation in corporate governance processes. New conditions have become a testing ground for the development of existing management techniques, as well as an impetus for the creation of others, born in a crisis mode of immediate testing [4].

## TRANSFORMATION OF THE RUSSIAN STAKEHOLDER MODEL OF CORPORATE GOVERNANCE UNDER THE INFLUENCE OF MACROECONOMIC CHALLENGES

In order to find the basic points of transformation of the stakeholder value model, we will determine the macroeconomic restrictions that today have the greatest impact on the activities of Russian corporations.

Experts note that of all the sanctions imposed by foreign countries against the Russian Federation,[2] the most noticeable impact is those that limit access to capital and technology, export and import trade operations. Thus, as a result of the latter,

[1] Market capitalization. Moscow Stock Exchange (official website). URL: https://www.moex.com (accessed on 24.05.2023).

[2] Information about the imposed sanctions against the Russian Federation. Chamber of Commerce and Industry of the Russian Federation (official website) URL: https://uslugi.tpprf.ru/ru/services/ (accessed on 21.03.2023).

business ties are destroyed, corporations suffer large financial and reputational losses [5].

Let us look in more detail at the changes that have occurred in the corporate governance system and in the boards of directors. According to a study conducted by a Russian consulting company focused on improving the quality of governance in the corporate sector of Russia (CSR) with the support of the Moscow Exchange and the National Association of Corporate Secretaries (NACS),[3] in 2021 the share of foreigners on the boards of directors of domestic public companies was approximately 1/ 3, in companies with state participation — about 10%, in private companies — about 40%; according to the Association of Independent Directors (AID), most of them were citizens of the USA (more than 30 people), Great Britain (20) and Germany (15). Before the introduction of sanctions, the organizations with the largest number of foreigners on the board were TCS Group (10 directors), Polymetal (7), Globaltrans and Rosneft (8). In 2022 (after the introduction of sanctions), in 75% of companies the number of foreign directors decreased, and in half of them to zero. The share of foreign citizens on councils has more than halved: in 2021 — to 30%, in 2022 — to 14%. At the end of 2022, foreigners were present on less than 50% of company boards of directors. As a result of this process, 30% of organizations updated their board compositions by 50% (and some by 80%).

In 2022, the regulator (Bank of Russia) made a number of relaxations regarding boards of directors — in particular, companies subject to sanctions could temporarily not elect them. The Bank of Russia recommended that public joint-stock companies whose shares are admitted to organized trading take all possible measures aimed at ensuring the inclusion of independent directors on the board, namely, searching for candidates who meet the independence criteria.

As such, the regulator advises considering representatives of both Russian professional associations of directors and business communities of friendly foreign jurisdictions who have the competencies and experience.[4] necessary for a public society.

In 2022, a number of changes were made to the legislation regarding the formation and work of the board of directors: Federal Law No. 292-FL[5] was adopted, allowing sanctioned companies not to form this body, dividing powers between the board and the general meeting of shareholders, amendments to the Federal Law "On Joint-Stock Companies[6]" (up to 3 people on the board of directors, quorum — at least half), as well as the Federal Law allowing joint-stock companies in 2023 to elect a board of directors for a three-year term.

The role of the board of directors is increasing as a strategic management body, providing a breadth of vision and a multifaceted approach to solving problems. In this regard, the issue of forming a balanced board of directors remains relevant, primarily from the point of view of its professionalism and independence. The ability of its members

[3] Review of corporate governance practices. URL: https://nokc.org.ru/wp-content/uploads/2023/02/rezultaty-issledovaniya.pdf (accessed on 20.05.2023).

[4] Information letter of the Central Bank of the Russian Federation on the formation of boards of directors (supervisory boards) of public joint-stock companies dated 17.01.2023 № ИН-02–28/5. URL: https://www.cbr.ru/Crosscut/LawActs/File/6125 (accessed on 19.03.2023).

[5] Federal Law No. 292-FL of July 14, 2022 "On amending certain legislative acts of the Russian Federation, invalidating paragraph six of part one of Article 7 of the Law of the Russian Federation "On State Secrets", suspending the validity of certain provisions of legislative acts of the Russian Federation and establishing the specifics of regulating corporate relations in 2022 and 2023." URL: http://www.kremlin.ru/acts/bank/48125

[6] Federal Law dated December 26, 1995 No. 208-FL "On Joint-Stock Companies" (as amended on December 19, 2022 No. 519-FZ). URL: https://www.consultant.ru/document/cons_doc_LAW_8743/?ysclid=lor98dbd1h132996423

to make objective judgments, free from the influence of executive bodies, individual groups of shareholders, contributes to improving the quality and depth of elaboration of issues within the competence of the board of directors and relating to the divergent interests of society, individual groups of shareholders and other interested parties.

According to the above-mentioned study by CSR, Moscow Exchange and NACS,[7] 34% of board members have been working for less than a year; independent directors among those elected for the first time in 2022 accounted for 46%, with 9% fewer chairmen of boards of directors among them; The number of foreign directors decreased by 4%, but the number of women heading the board of directors increased by 2%. In this context, the role of the strategic planning committee within the board of directors is increasing, especially those of its members who are ready, carefully thinking through and relying on their professionalism and qualifications, to propose solutions that will be useful both for the effective operation of the organization and for its development.

During the COVID-19 pandemic, corporations, along with the state, have shown that they have significant potential to mitigate social shocks; in the current conditions, they are heading towards maintaining the concept of ESG[8] development. Companies that have entered the Eastern markets note that there is a demand for commitment to ESG principles. Many organizations continue to pursue sustainable development strategies due to the personal beliefs of owners and management.[9] At the same time, there are concerns that companies that actively interacted with foreign partners who left the Russian market may curtail the ESG agenda, which is the latter's requirement as part of social ethics. The ESG agenda is also weakened by the difficulties associated with the participation of corporations in international ESG ratings. Such restrictions negatively affect the investment image of companies, so the sustainable development strategy requires rethinking in terms of a shift towards the social aspect, communication with society to create an understanding among Russian consumers of the importance of the ESG concept for future generations, the development of domestic ESG reporting tools and ESG ratings [6]. The principles of social responsibility and sustainable development goals are adhered to by those organizations for which solving urgent global social and environmental problems is not a showcase, but an ethical need for business behavior [7, 8], which increases trust in them from stakeholders, especially in the financial sector [9].

During periods of crisis, non-financial corporations also pay considerable attention to the problems of increasing the efficiency of corporate governance and especially to risk management issues [10].

Participants of the XII All-Russian Forum on Corporate Governance noted that domestic companies demonstrate a desire to maintain large investment projects and an intention to make large investments in the following periods.[10]

[7] Review of corporate governance practices. URL: https://nokc.org.ru/wp-content/uploads/2023/02/rezultaty-issledovaniya.pdf (accessed on 20.05 2023).

[8] The RUIE and the APD (Association of professional directors) held the XII All-Russian Forum on Corporate Governance. Russian Union of Industrialists and Entrepreneurs (official website). URL: https://rspp.ru/events/news/rspp-i-and-proveli-tseremoniyu-nagrazhdeniya-pobediteley-xii-natsionalnoy-premii-direktor-goda-64006520b0b51/ (accessed on 20.03.2023).

[9] The XII All-Russian Forum on Corporate Governance was held in Moscow. Interfax. URL: https://www.interfax.ru/events/news/892307 (accessed on 23.03.2023).

[10] ibid.

At the same time, the investment finance landscape has transformed. The exchange changes the tools and rules of the game, fulfilling its main function of redistributing capital in the economy; corporations are reorienting towards domestic investors in the structure of stock transactions in conditions of declining capitalization. At the same time, it is noted that it is necessary to preserve both the rules of a civilized exchange game, which presupposes information openness of listed companies (despite their legal opportunity not to publish information due to sanctions risks), and the responsibility of boards of directors and management of organizations for trading strategies and maintaining respect for domestic and foreign investors. The "share vaccine" against stock market fluctuations caused by crises is the shares of companies adhering to ESG principles as the safest instrument for investing capital and diversifying an investor's portfolio, as well as an incentive to maintain commitment to the ESG development strategy [11].

During a period of numerous overlapping crises, the social contract between business, society and the state undergoes changes [12].

Foreign trade restrictions have become a powerful factor in compressing demand for domestic companies focused on foreign markets. The main option for leveling out the situation seems to be the restructuring of import logistics chains and the search for new channels for export.

The sanctions had a particularly noticeable impact on processes related to the digitalization of corporate activities due to the suspension of activities in Russia of leading IT industry entities (Microsoft, Oracle, Autodesk, Nokia, Intel, etc.), a sharp increase in the cost of imported software and hardware, and also the increase in risks when conducting virtual financial payments (cessation of the PayPal system), the complexity of implementing e-learning corporate education programs and the limitations of SMM marketing due to the closure of a number of leading social networks [13].

Sanctions have a significant impact on the efficiency of large resource corporations; in particular, a decrease in the profitability of the latter in the oil and gas industries has been identified, as well as a decrease in their investment activity [14].

When macroeconomic conditions change, it is natural to think about the formation of a corporate governance model that includes mechanisms of state support for companies that remain committed to environmental and social responsibility [6].

Thus, the economic downturn due to the COVID-19 pandemic prompted governments of all countries to initiate an unprecedented number of temporary lending and tax deferment programs for businesses [15]. The entry of corporations into the coverage area of government support and guarantee mechanisms is intensifying. A study conducted in Italy showed that in the absence of any government intervention during the pandemic, about 26% of Italian firms would have faced insolvency risks (with a standard rate of 11%) [16]. During the coronavirus pandemic, mechanisms have emerged in the form of a model of state dirigisme — the active influence of the state on social and corporate processes, its massive intervention in the life of business and the impact on the collective behavior of the population [17]. Global financial and economic crises of the 2000s formed a flexible instrumental base for state stabilization participation in maintaining corporate systems — from a large-scale injection of funds to restore reserve capital to the purchase of shares of departing shareholders with their subsequent sale to new private investors (in order to avoid the nationalization of corporate assets) [18].

By activating government support instruments, government bodies acquire the status of stakeholders in corporate relations and become interested in obtaining reliable information about the actual contribution of corporations to environmental, innovative and social projects.

## METHODOLOGICAL PROVISIONS FOR ASSESSING THE STAKEHOLDER VALUE OF A CORPORATION'S ACTIVITIES BASED ON THE NETWORK APPROACH

Based on an analysis of the existing experience in methodological developments and taking into account the requirements defined above, in order to solve the problem of developing methodological approaches to the operational assessment of the stakeholder value of corporations, it is proposed to be guided by the following methodological provisions [3].

Based on the competent opinion about the situation in the Russian business environment, transmitted by corporate management, we can conclude that most problems are solved by them independently. At the same time, the management task of developing methods for quickly collecting and processing information for decision-making under conditions of uncertainty and time pressure has become more urgent. The "calm 2000s" taught management to be slow — any significant decisions were made over the years: a SWOT analysis was carried out, focus groups were held, requests for marketing research were made, etc. "Nowadays, a decision must be made right now; in a week it will be useless" [19].

In the conditions of the information paradigm of the development of modern society, it is proposed to consider the corporation and its stakeholders as a network structure, the main actors of which are all parties pursuing corporate interests [20].

The composition of actors (stakeholders), their benefits and usefulness for the corporate network are examined in the context of the ESG concept of socially significant corporate policies aimed at supporting stakeholder groups and institutional entities.

In contrast to existing methods for assessing stakeholder value, which rely on tools that require a significant time resource and a number of assumptions when comparing heterogeneous indicators, the author's development is designed to ensure a prompt comparison of the contributions and benefits of corporation stakeholders thanks to the features of the network approach focused on assessing the characteristics of connections [21, 22].

Network connections are established between a set of factors influencing the activity of the network, which are represented by the *microenvironment* — internal elements and subsystems of the network, the *external near mesoenvironment* — regional and sectoral conditions and processes, and the *external distant macroenvironment*, containing national and global factors [23]. At the same time, the conditions of the macroenvironment have a positive or negative impact on stakeholder value, worsening or improving the conditions for its formation; there is no reverse impact on the macroenvironment.

Hypotheses about the presence of direct and reverse connections between the internal and external environments are put forward on the basis of recognized dependencies of economic theory, providing a condition for efficiency; hypotheses about the presence of network connections are assessed for consistency using correlation analysis. For connections whose influence on the stakeholder value of the network is determined to be significant, a regression coefficient is calculated, whose statistical essence allows it to be interpreted as an indicator of the intensity of participation of actors in the corporate network along a certain

vector of economic relations in the creation of stakeholder value.

The model for assessing the participation of each group of actors in creating stakeholder value has the following formula:

$$SV = B - C, \quad (1)$$

where $SV$ — Stakeholders Value; $B$ — weight of benefit connection); $C$ — weight of contribution connection).

$$Y_b = BX + a, \quad (2)$$

where $Y_b$ — dynamics of the internal environment indicator); $X$ — dynamics of the external environment indicator); $B$ — weight of benefit connection); $a$ — Y-intersection.

$$Y_c = CX + a, \quad (3)$$

where $Y_c$ — dynamics of the external environment indicator; $X$ — dynamics of the internal environment indicator; $C$ — weight of the contribution connection); $a$ — Y-intersection

All used indicators of the state of the internal and external environment are data from the official financial statements of the corporation for the microenvironment and official statistics for the constituent entity of the Russian Federation for the mesoenvironment. Indicators of macroenvironmental conditions are official open information from institutions at the level of the national economy, for example, ministries and departments.

## RESULTS AND INTERPRETATION

PJSC Norilsk Nickel was chosen as the object of study by the authors of the article since it is one of the most powerful "players" in the corporate market. Like other Russian companies, Norilsk Nickel had a hard time after February 2022, however, despite the new challenges of last year, the company remained resilient and even increased the volume of investment in key projects.[11] Resource and energy efficiency, circular economy, social and labor sphere, quality of corporate governance, environmental and social programs in the regions of presence remain the company's key priorities.[12] The proposed methodology for assessing the stakeholder value of a corporation's social activities using the example of PJSC Norilsk Nickel and the region of its presence (Krasnoyarsk Territory) for the internal micro- and meso-environment was tested by the authors earlier — their publication [3] describes in detail how the contributions of the corporation and the benefits of stakeholders influenced the cost of an enterprise network during the COVID-19 crisis.

To develop the methodology, we will analyze the reaction of the internal environment and the nearby external mesoenvironment to changes in macroeconomic conditions. To do this, we will build a model for the periods of 2012–2018 with insignificant influence of macroeconomic restrictions and of 2012–2021, when this influence became extensive.

This application of the methodology is intended to demonstrate its ability to identify the most significant restrictions imposed by the macro environment, for example, in the process of justifying and determining directions for providing government support to business.

In the course of an iterative logical selection of possible connections between

[11] "Sustainable vector": Norilsk Nickel's investment program has grown by more than 50%. URL: https://krasnoyarsk.dk.ru/news/237184446

[12] Norilsk Nickel presented its results in the field of sustainable development for 2022. URL: https://nornickel.ru/news-and-media/press-releases-and-news/nornikel-predstavil-rezultaty-v-oblasti-ustoychivogo-razvitiya-za-2022-god-/ (accessed on 10.07.2023).

*Table 1*

**Models of the foreign trade restrictions influence on the stakeholder value of the PJSC Norilsk Nickel network during implementing the ESG policy**

| ESG direction | Stakeholder group | External environment indicator | Internal environment indicator |
|---|---|---|---|
| Ecology | Ecology, environmental management (H1)* | Imports volume CN FEA "Computing machines and blocks" RF, US dollars, thousand, X | Research costs, thousand rubles |
| Social | Employees (population) (H2) | Imports volume CN FEA "Mining Machinery" in RF, US dollars, X | Annual labor productivity at the enterprise, rub./person, Y |
| Governance | Corporation (H3) | Imports volume CN FEA "Mining machines" in the Russian Federation, US dollars, X | Net profit of the enterprise, thousand rubles, Y |
| | Corporation (H4) | Exports volume CN FEA "Nickel ores and concentrates" and "Copper ores and concentrates" from the Russian Federation, US dollars, X | Net profit of the enterprise, thousand rubles, Y |
| | Investors / Stakeholders (H5) | Exports volume CN FEA "Nickel ores and concentrates" and "Copper ores and concentrates" from the Russian Federation, US dollars, X | Market capitalization of the corporation based on trading results in CJSC MICEX Stock Exchange at the end of the year, thousand rubles, Y |

*Source:* compiled by the authors.

*Note:* * (H1–H5) — Hypothesis.

micro- and macro-environment indicators, models of the possible impact of foreign trade restrictions on the stakeholder value of the network in the process of implementing the ESG policy of the Norilsk Nickel PJSC corporation were identified. *Table 1* presents hypotheses about the connection among macroeconomic restrictions, internal and meso-processes of the corporation:

H1 — to test the possibility of the influence of macroeconomic restrictions on the import of products into the Russian Federation according to the commodity nomenclature of foreign economic activity (CN FEA) "Computing machines and units", a hypothesis has been put forward about the impact of these restrictions on the innovation activities of the corporation. It is proposed to test the hypothesis through an analysis of the relationship between the indicators "Volumes of imports into the Russian Federation of products according to the commodity nomenclature of foreign economic activity (CN FEA) "Computer machines and units" and "Volumes of corporation expenses on scientific research and development (R&D)." The process belongs to the ESG direction Ecology (from English — environmental management); main stakeholder groups are ecology and business environment;

*Table 2*

**Results of assessing of the macro-environment conditions impact due to foreign trade restrictions on the stakeholder value of the PJSC Norilsk Nickel ESG network for the period 2012–2018**

| ESG direction | Stakeholder group | Impact on network stakeholder value | | | |
|---|---|---|---|---|---|
| | | Communication model | Communication quality — Pearson's coefficient, r | Model quality — coefficient of determination, R2 | Bond strength — coefficient of regression |
| Ecology | Ecology, environmental management (H1) | IVCMB, X — CRD, X | –0,61 | 0,37 | –0,12 |
| Social | Employees (population) (H2) | IVMM, X — ALP, Y | –0,82 | 0,68 | –6E-05 |
| Governance | Corporation (H3) | IVMM, X — NP, Y | –0,73 | 0,54 | –0,46 |
| | Corporation (H4) | EVNOC, X — NP, Y | 0,73 | 0,53 | 2,44 |
| | Investors / Stakeholders (H5) | EVNOC, X — MCC, Y | 0,79 | 0,62 | 22,55 |

*Source:* compiled by the authors based on Rosstat data. URL: https://www.rosstat.gov.ru; Rosstat service for providing accounting reporting data upon user requests. URL: https://www.rosstat.gov.ru/; MOEX data. URL: https://www. moex.com; Customs Online portal. URL: https:/www. customsonline.ru

H2 — to test the possible impact of macroeconomic restrictions on the import of goods into the Russian Federation under the commodity nomenclature of foreign economic activity "Mining Machinery", a hypothesis has been put forward about the impact of these restrictions on the labor productivity of workers at the Norilsk Nickel resource mining enterprise. It is proposed to test the hypothesis through an analysis of the relationship between the indicators "Volumes of imports into the Russian Federation of products under CN FEA "Mining Machinery" and "Annual Labor Productivity" of PJSC Norilsk Nickel, which is defined as the ratio between production volumes and the average number of employees of the enterprise. The process belongs to the ESG direction Social (from English — social management), the main stakeholder groups are employees (population), and labor productivity is considered as a source of welfare of the stakeholder group;

H3 — processes occurring in the internal environment of the corporation, which create benefits for stakeholder groups, i.e. actively participate in the formation of stakeholder value. In addition, the interests of many holders of corporate values (managers, employees, etc.) lie in the area of internal corporate processes.

To test the possible impact of macroeconomic restrictions on the volume of imports into the Russian Federation of goods under CN FEA "Mining Machinery" on the general indicator of the corporation's performance, which characterizes the effectiveness of corporate management, a hypothesis has been put forward about the impact of these restrictions on the net profit

*Table 3*

**Results of assessing of the macro-environment conditions impact due to foreign trade restrictions on the stakeholder value of the PJSC Norilsk Nickel ESG network for the period 2012–2021**

| ESG direction | Stakeholder group | Impact on network stakeholder value | | | |
|---|---|---|---|---|---|
| | | Communication model | Communication quality — Pearson's coefficient, r | Model quality — coefficient of determination, R2 | Bond strength — coefficientof regression |
| Ecology | Ecology, environmental management (H1) | IVCMB, X — CRD, X | 0,14 | 0,02 | 0,02 |
| Social | Employees (population) (H2) | IVMM, X — ALP, Y | –0,70 | 0,48 | –1E-05 |
| Governance | Corporation (H3) | IVMM, X — NP, Y | –0,57 | 0,33 | –1,20 |
| | Corporation (H4) | EVNOC, X — NP, Y | 0,39 | 0,15 | 0,64 |
| | Investors / Stakeholders (H5) | EVNOC, X — MCC, Y | 0,66 | 0,44 | 7,58 |

*Source:* compiled by the authors based on Rosstat data. URL: https://www.rosstat.gov.ru; Rosstat service for providing accounting reporting data upon user requests. URL: https://www.rosstat.gov.ru/; MOEX data. URL: https://www. moex.com; Customs Online portal. URL: https:/www. customsonline.ru

of the enterprise. The process belongs to the ESG direction of Government (from English "corporate governance"), the main stakeholder groups are the owners and management of the corporation;

H4 — to test the possible impact of macroeconomic restrictions on the export of goods from the Russian Federation under CN FEA "Nickel ores and concentrates" and "Copper ores and concentrates" — the main products of Norilsk Nickel on the general indicator of the corporation's activities, a hypothesis was put forward about the impact of these restrictions on the net profit of the enterprise. It is proposed to test the hypothesis through an analysis of the relationship between the indicators of the volume of exports from the Russian Federation of goods under CN FEA "Nickel ores and concentrates" and "Copper ores and concentrates" and the indicator "Net profit of the enterprise". The process belongs to the ESG direction of Government, the main stakeholder groups are the owners and management of the corporation;

H5 — to test the possible impact of macroeconomic restrictions on the export of goods from the Russian Federation under CN FEA "Nickel Ores and Concentrates" and "Copper Ores and Concentrates" — the main products of the enterprise on the investment image of the corporation, a hypothesis was put forward about the impact of these restrictions on the market capitalization of the corporation PJSC Norilsk Nickel. It is proposed to test the hypothesis through an analysis

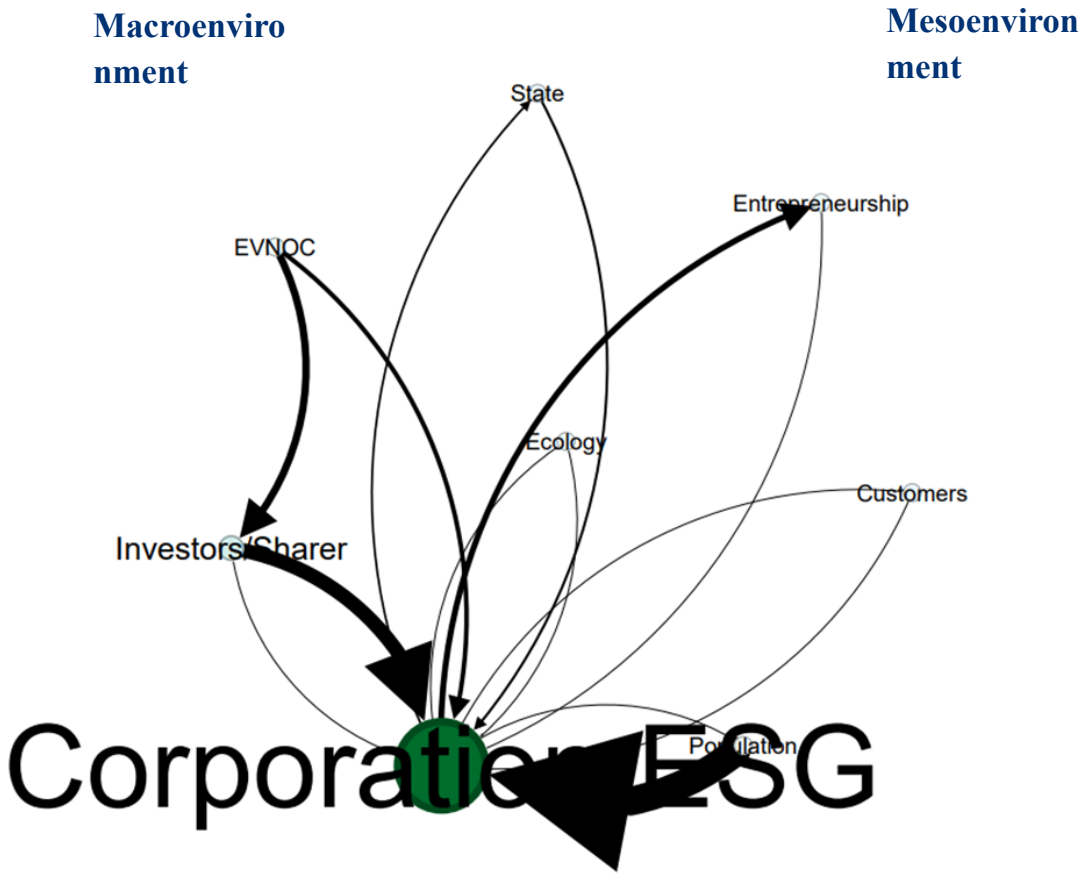


*Fig. 1.* **Network graph of the impact of foreign trade sanctions on the stakeholder value of the ESG policy of PJSC Norilsk Nickel for the period 2012–2018**

*Source:* developed by the authors.

*Note:* Corporation ESG — corporation implementing ESG policy; Ecology — natural environment; Entrepreneurship — business environment; Population — population/employees; State —state; Investors/Sharers —investors/ stockholders; Customers — suppliers/ buyers; EVNOC — volume of exports of the CN FEA "Nickel ores and concentrates" and "Copper ores and concentrates" from the Russian Federation.

of the relationship between the indicators of "volumes of exports from the Russian Federation of goods under CN FEA "Nickel ores and concentrates" and "Copper ores and concentrates" and "Market capitalization of PJSC Norilsk Nickel". The process belongs to the ESG direction of Government, the main stakeholder groups are investors and shareholders of the corporation.

Next, the validity of the hypotheses put forward is checked in relation to a specific corporation. The results of establishing significant connections between the actors of the macro-, meso- and microenvironment of PJSC Norilsk Nickel and assessing the strength of their influence on the stakeholder value of the ESG policy in the pre-sanction and sanctions periods are presented in *Table 2, 3*.

In the course of testing the hypotheses of the connections between the macroenvironment and the stakeholder value of the corporate network, the following conclusions were made.

For the tested corporate network, hypothesis H1 is not accepted, since there is no logic of connection between the selected indicators due to the established inversely proportional relationship between them. That

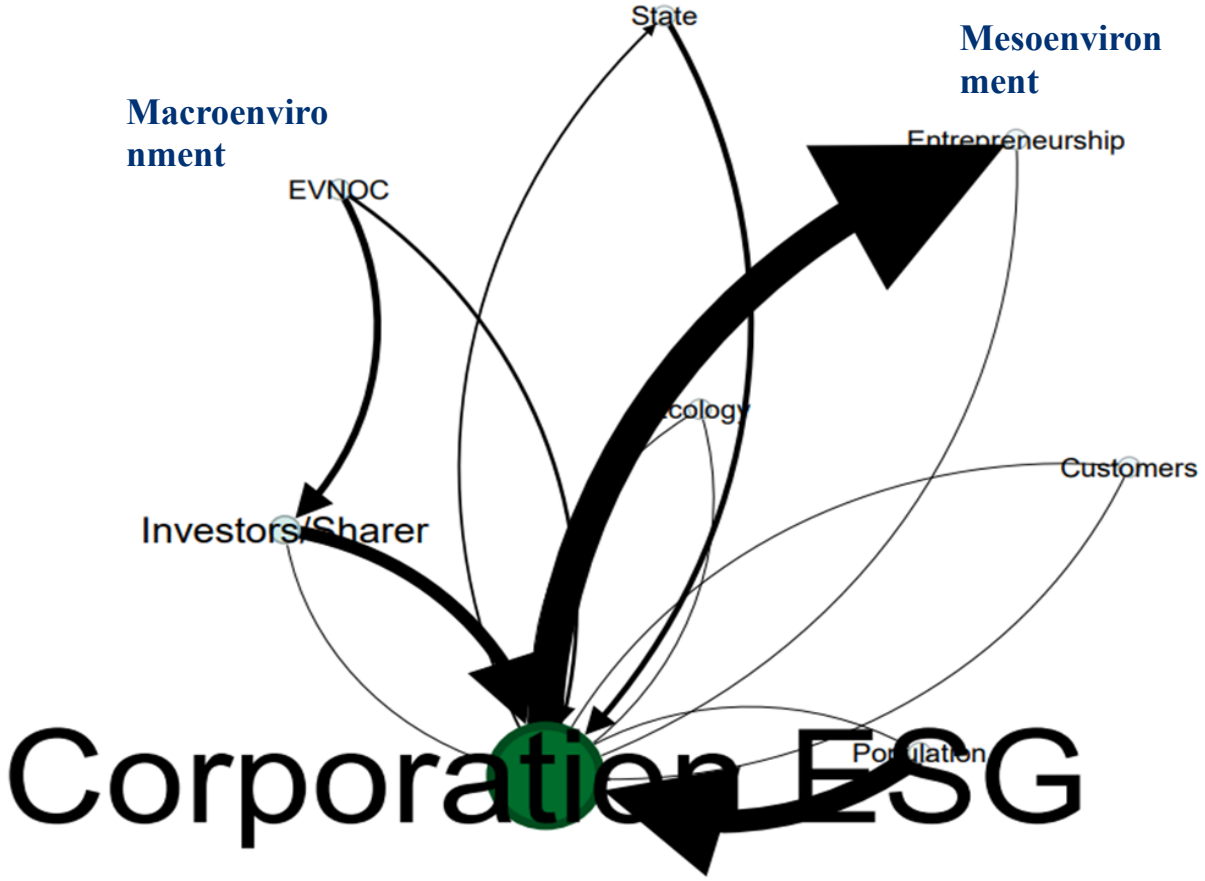


*Fig. 2.* **Network graph of the impact of foreign trade sanctions on the stakeholder value of the ESG policy of PJSC Norilsk Nickel for the period 2012–2021**

*Source:* developed by the authors.

*Note:* Corporation ESG — corporation implementing ESG policy; Ecology — natural environment; Entrepreneurship — business environment; Population — population/employees; State —state; Investors/Sharers —investors/ stockholders; Customers — suppliers/ buyers; EVNOC — volume of exports of the CN FEA "Nickel ores and concentrates" and "Copper ores and concentrates" from the Russian Federation.

is, changes in import volumes by product group do not affect the entrepreneurial and environmental activity of Norilsk Nickel PJSC. The behavior of the hypothesis in the case of other enterprises may differ.

For the tested corporate network, hypothesis H2 is not accepted, since the inversely proportional nature of the relationship between the volume of imports into the country of products according to the CN FEA group "Coal and rock mining machines" and labor productivity at a resource mining enterprise seems illogical. Consequently, there is no expected connection between the indicators, and restrictions on the import of mining machinery do not affect the productivity of employees of this organization.

For the tested corporate network, hypothesis H3 is not accepted, since there is no direct economic relationship between the volume of imports into the country of products according to the Commodity Nomenclature of

Foreign Economic Activity group "Machinery for the extraction of coal and rocks" and the net profit of the enterprise, which is confirmed by the values of the correlation coefficients: –0.73 and –0.57. The greater the volume of imports of special vehicles into the country, the lower the financial result of the corporation's activities — there is no logic of connection.

Hypothesis H4 is accepted. According to it, exports from the Russian Federation of goods under the CN FEA "Nickel ores and concentrates" and "Copper ores and concentrates" (the main products of PJSC Norilsk Nickel) before the strengthening of foreign trade restrictions in the period 2012–2018. had a significant impact on the amount of net profit (correlation coefficient 0.73). After strengthening foreign trade restrictions, the strength of the relationship between export operations in the country and the profitability of Norilsk Nickel PJSC noticeably decreased (correlation coefficient 0.39) and the model ceased to be indicative (R 2 = 0.1509). The company lost a significant share of profits from export operations. This is confirmed by verification of the results: corporate profit before tax in 2022 decreased by 40% compared to 2021, and inventories increased by 54%.[13]. As a result of foreign trade sanctions, the contribution of the export group to the stakeholder value of the corporate network has lost significance.

Hypothesis H5 is accepted. According to it, export activities had a strong impact on the investment image of the corporation in the pre-crisis period, assessed through the stock market capitalization indicator of the corporation (correlation coefficient 0.79). A decrease in its influence on the stakeholder value of the corporation due to the introduction of foreign trade restrictions (correlation coefficient 0.66) leads to image losses in the capital market.

The methodological approaches presented above are focused on automating the process of collecting and processing information. All data can be obtained from open official sources publicly available on the Internet through web scraping (parsing). For the end user — owners, management, state, other stakeholders of the corporation, the result or user tool of the methodology is a dashboard *(Fig. 1.2),* made using the Gephi 10.1 software tool, which shows the change in the corporation's contribution to the formation of stakeholder values and the return of stakeholder groups to the corporation, which has come to the "money box" of stakeholder values.

The managerial value of network models lies in the ability to quickly monitor their changes in terms of contributions and benefits in the context of the network potential (usefulness and attractiveness for each stakeholder [24]), represented by direct and "response" reactions (both the network and the stakeholders themselves), measured intensity of direct and reverse dual connections. Regression models, strictly speaking, represent the value of the dependent indicator Y at the value of the explanatory indicator X = 1, which gives stakeholders a quick idea of the corporation's real attention to ESG policy areas and about groups of stakeholders with the greatest networking potential in this area. Here, the weight of each connection (graph arc), representing the strength/intensity of the dual interaction of each pair of actors, is graphically displayed by the thickness of the lines, which is rational when the numerical results are represented by 8–9 orders of magnitude.

Let us analyze the results of the impact of crisis changes in macroenvironmental

[13] For Investors and shareholders. Financial statements. Norilsk Nickel (official website). URL: https://www. nornickel.ru/

conditions on the stakeholder value of the network (formed at the micro- and meso-levels).

From the "pre-crisis" network diagram it follows that of all the hypotheses, the macro-indicator of the volume of exports from the Russian Federation of the main types of products of the corporation — EVNOC — has a significant positive impact on the stakeholder value of the corporation. These macroenvironmental conditions influence the value created in the internal environment by the Corporation group and in the mesoenvironment by investors and shareholders (Investors/Shareers).

From the "crisis" graph it is clear that as a result of foreign trade restrictions, the positive impact of EVNOC macro conditions on the stakeholder value of the network is reduced and is a signal for increased managerial attention to this area of network value creation.

## CONCLUSION

As a result of the development of a methodology for quickly assessing the stakeholder value of a corporation's social activities under time pressure and uncertainty in the external environment, current requirements for the corporate governance model have been identified; Methodological provisions are proposed for assessing the influence of macroenvironmental factors on the stakeholder value of a corporation using a network approach and correlation-regression analysis.

In the process of testing the methodology using the example of PJSC Norilsk Nickel, it was established that in the pre-crisis period, a significant positive impact on the stakeholder value of the corporate network was exerted by the macro-indicator of the volume of exports from the Russian Federation of its main types of products for the stakeholders "Corporation" and "Investors/Shareholders".

During the period including the crisis associated with COVID-19 and foreign economic sanctions, the positive impact on the stakeholder value of the network of macro conditions associated with export volumes is reduced as a result of foreign trade restrictions, which is a signal for increased managerial attention to this area of network value creation.

Changes in the volume of imports into the Russian Federation for the product group "Computing machines and units" do not affect the entrepreneurial and environmental activity of the corporation. Also, restrictions on imports into the Russian Federation of products under the Commodity Nomenclature of Foreign Economic Activity group "Machinery for the extraction of coal and rocks" do not affect the productivity of the enterprise's employees.

The results obtained correspond to the real situation in the corporation's business environment, which indicates the validity of the methodology for the task of quickly assessing the impact of macroenvironmental conditions on stakeholder value. This technique can become a tool for making management decisions, in demand both by company management to identify particularly vulnerable areas of corporate relations, and by government authorities to justify and determine directions for providing government support to businesses in times of crisis.

The principle of using data from open official sources underlying the methodology creates the basis for automating the process of assessing stakeholder value, ensuring the requirement for the efficiency of generating information in a rapidly changing external environment.

## REFERENCES


1. Tkachenko I. N., Meteleva M. A. The process of public governance of investment activities' infrastructure at meso level. *Izvestiya Ural'skogo gosudarstvennogo ekonomicheskogo universiteta = Journal of the Ural State University of Economics*. 2018;19(2):5–23. (In Russ.). DOI: 10.29141/2073–1019–2018–19–2–1
2. Tkachenko I. **N**. Rethinking the stakeholder approach to corporate governance in the coronavirus crisis: From commitment declaration to applied models. *Upravlenets = The Manager*. 2021;12(2):2–16. (In Russ.). DOI: 10.29141/2218–5003–2021–12–2–1
3. Tkachenko I. N., Meteleva M. A. Modelling a corporate network's stakeholder value created amid CSR policy implementation. *Upravlenets = The Manager*. 2023;14(3):44–58. (In Russ.). DOI: 10.29141/2218–5003–2023–14–3–4
4. Gkeredakis M., Lifshitz-Assaf H., Barrett M. Crisis as opportunity, disruption and exposure: Exploring emergent responses to crisis through digital technology. *Information and Organization*. 2021;31(1):100344. DOI: 10.1016/j.infoandorg.2021.100344
5. Odintsova T. M. Troublesome matters of regional sustainable development strategies in the situation of sanctions and restrictions. *Vestnik Vitebskogo gosudarstvennogo tekhnologicheskogo universiteta = Vestnik of Vitebsk State Technological University*. 2021;(1):232–245. (In Russ.). DOI: 10.24412/2079–7958–2021–1–232–245
6. Izmailova M. A. Implementation of ESG strategies of Russian companies under sanctions restrictions. *MIR (Modernizatsiya. Innovatsii. Razvitie) = MIR (Modernization. Innovation. Research)*. 2022;13(2):185–201. (In Russ.). DOI: 10.18184/2079–4665.2022.13.2.185–201
7. Garel A., Petit-Romec A. Investor rewards to environmental responsibility: Evidence from the COVID-19 crisis. *Journal of Corporate Finance*. 2021;68:101948. DOI: 10.1016/j.jcorpfin.2021.101948
8. He H., Harris L. The impact of Covid-19 pandemic on corporate social responsibility and marketing philosophy. *Journal of Business Research*. 2020;116:176–182. DOI: 10.1016/j.jbusres.2020.05.030
9. Trinh V. Q., Cao N. D., Li T., Elnahass M. Social capital, trust, and bank tail risk: The value of ESG rating and the effects of crisis shocks. *Journal of International Financial Markets, Institutions and Money*. 2023;83:101740. DOI: 10.1016/j.intfin.2023.101740
10. Huang J., Kombate B., Li Y., Kouadio K. R., Xie P. Effective risk management in the shadow of COVID-19 pandemic: The evidence of Indonesian listed corporations. *Heliyon*. 2023;9(5): e15744. DOI: 10.1016/j.heliyon.2023.e15744
11. Dai Yu. Is ESG investing an 'equity vaccine' in times of crisis? Evidence from the 2020 Wuhan lockdown and the 2022 Shanghai lockdown. *Borsa Istanbul Review*. 2022;22(5):992–1004. DOI: 10.1016/j.bir.2022.07.003
12. Hampton S., Blundel R., Eadson W. et al. Crisis and opportunity: Transforming climate governance for SMEs. *Global Environmental Change*. 2023;82:102707. DOI: 10.1016/j.gloenvcha.2023.102707
13. Stepanova O. A. Impact of the 2022 sanctions on the processes of digitalization of organizations' activities of the Russian economy. *Kazanskii ekonomicheskii vestnik = Kazan Economic Bulletin*. 2022;(2):16–20. (In Russ.).
14. Nikolaeva E. V., Lymar E. N. The impact of external economic sanctions on the economic efficiency of Russian oil and gas corporations. *Vestnik Chelyabinskogo gosudarstvennogo universiteta = Bulletin of Chelyabinsk State University*. 2021;(6):162–170. (In Russ.). DOI: 10.47475/1994–2796–2021–10618
15. Brown J. R., Martinsson G., Thomann C. Government lending in a crisis. *Journal of Corporate Finance*. 2021; 71:102116. DOI: 10.1016/j.jcorpfin.2021.102116
16. Buchetti B., Parbonetti A., Pugliese A. Covid-19, corporate survival and public policy: The role of accounting information and regulation in the wake of a systemic crisis. *Journal of Accounting and Public Policy*. 2022;41(1):106919. DOI: 10.1016/j.jaccpubpol.2021.106919

17. Mirkin Ya. M. Transforming the economic and financial structures of the world: The impact of growing shocks of catastrophes. *Kontury global'nykh transformatsii: politika, ekonomika, pravo = Outlines of Global Transformations: Politics, Economics, Law*. 2020;13(4):97–116. (In Russ.). DOI: 10.23932/2542–0240–2020–13–4–5
18. Honohan P. Irish banking policy during and after the crisis. YPFS Resource Library Documents. 2009;(9694). URL: https://elischolar.library.yale.edu/cgi/viewcontent.cgi?article=10742&context=ypfs-documents
19. Valetskii M. "The decision needs to be made right now; in a week it will be useless". Sber Pro. URL: https://sber.pro/publication/maksim-valeczkij-reshenie-nuzhno-prinimat-pryamo-sejchas-cherez-nedelyu-ono-uzhe-bespolezno (In Russ.).
20. Castells M. The rise of the network society. Malden, MA; Oxford: Blackwell Publishing; 1996. 656 p. (The information age: Economy, society, and culture. Vol. 1). (Russ. ed.: Castells M. Informatsionnaya epokha: ekonomika, obshchestvo i kul'tura. Moscow: SU HSE; 2000. 608 p.).
21. Burt R. S. Models of network structure. *Annual Review of Sociology*. 1980;6:79–141. DOI: 10.1146/annurev.so.06.080180.000455
22. Newman M. E. J. The structure and function of complex networks. *SIAM Review*. 2003;45(2):167–256. DOI: 10.1137/S 003614450342480
23. Asaul A. N. Patterns and trends in the development of modern entrepreneurship. St. Petersburg: Institute for Problems of Economic Revival; 2008. 280 p. (In Russ.).
24. Meteleva M. A. Design of entrepreneurial networks: Evaluation of the network potential in Russian Arctic. *Sever i rynok: formirovanie ekonomicheskogo poryadka*. 2020;(3):56–71. (In Russ.). DOI: 10.37614/2220–802X.2.2020.69.004

## ABOUT THE AUTHORS

***Irina N. Tkachenko*** — Dr. Sci. (Econ.), Professor, Head of the Department of Corporate Economics and Business Management, Ural State University of Economics, Yekaterinburg, Russia
https://orcid.org/0000-0003-0996-0684
*Corresponding author:*
Tkachenko@usue.ru

***Marina A. Meteleva*** — Cand. Sci. (Econ.), Director of the ANO "Institute for Scientific Research of Management Problems", Kemerovo, Russia
https://orcid.org/0000-0002-5785-8409
IMR 42meteleva@gmail.com

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# Mathematical Model for Searching for an Optimal Solution to the Problem of Forming Supply Chains for Raw Materials of Forestry Enterprises under Conditions of Uncertainty

**R.S. Rogulin**
Vladivostok State University of Economics and Service, Vladivostok, Russia

## ABSTRACT

This paper examines important aspects related to the problems of forming supply chains and production volumes at forest processing enterprises. The main emphasis is on assessing the optimality of decisions made. The study focuses on enterprises that do not have their own sources of raw materials and that are seeking to find the most appropriate solution based on the planning horizon based on data on transactions carried out on the commodity exchange. The **purpose** of the study is to create a mathematical model that allows us to establish the optimal volume of production of goods based on the formed supply chains of raw materials from the commodity exchange, considering the share of its useful volume, the time the lots are in transit and the uncertainty associated with supply and logistics. The following research methods were proposed: mathematical modeling, theory and optimization methods. Testing the model using data from the St. Petersburg Stock Exchange and enterprises of the Primorsky Territory made it possible to determine the optimal trajectories of profit, production volume and other important indicators. The work also raises issues of planning supply chains and production volumes, analyzes regions — sources of raw materials and presents the advantages and disadvantages of the presented mathematical model. The **results** obtained are of interest to the top management of forestry enterprises seeking to improve the efficiency of their activities and can be the basis for assessing the rationality of commodity transactions on the Russian Commodity and Raw Materials Exchange.

***Keywords:*** formation of supply chains; production volumes; timber processing enterprises; optimality of decisions; mathematical model; commodity and raw material exchange; share of useful volume of raw materials; time of lots in transit; rational raw material transactions; efficiency improvement

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## INTRODUCTION

In today's global economy and rapidly changing business environment, the effective development of raw material supply chains (SC) is becoming a strategically important factor in the success of forestry companies. The management of supply chains directly affects the competitiveness and profitability of enterprises, since the raw material base is an integral component of the production process.

However, the procedure for creating optimal SCs currently faces a number of difficulties. Factors such as fluctuations in demand, changes in the volume and quality of raw materials, transport restrictions and geographical features cause risks and uncertainty. In such a situation, it is necessary to develop a mathematical model that would take into account the above circumstances and allow one to find optimal solutions.

The relevance of this study is due not only to the rapid changes taking place in the business environment, but also to the existing need to reduce costs, increase production efficiency, optimize the use of resources and improve the competitiveness of companies as a whole. The mathematical model proposed in this article can become a valuable tool for organizing the process of managing the formation of raw material supply chains, taking into account the problems that enterprises face in their activities.

## GOALS, OBJECTIVES AND RESEARCH HYPOTHESIS

This work takes into account two stages of the activities of companies in the timber industry: the purchase of raw materials on the exchange (and their delivery), as well as the production of a certain volume of products based on the existing timber stock. It is necessary to explain what is the algorithm for the receipt of raw materials on the stock exchange. It, as an organizer of auctions, enters into contracts with plot tenants from various regions, allowing them to use its site. After completing a transaction between the enterprise (customer) and the seller (plot) for processing raw materials, the latter in the amount specified in the contract is sent to the customer. Typically, businesses receive orders from customers well in advance and (as one might assume) plan their activities for the long term.

It should be noted that the demand for forest products is seasonal, which complicates the work of companies. During the study, a mathematical model was formed, with the help of which it was suggested to estimate the maximum profit of the enterprise over the entire planning horizon.

To achieve the goal of the work, the author set the following tasks:

• to review scientific literature on the research topic.

• to create an economic and mathematical model for the formation of SC and calculate the optimal volume of production of goods in the timber industry, taking into account events that have already occurred, namely:

- distribution of orders over time;
- delivery of consignments of goods to the enterprise warehouse.

• to analyze the model's testing results.

## LITERATURE REVIEW

Existing academic works related to the field of raw material supply chain management in uncertain environment is often driven by the use of empirical methods and heuristic approaches, which limits its accuracy and applicability.

The author has analyzed a significant number of works that are relevant to the problems discussed in the article. So, A.A. Tsai and N. Agrawal assessed a supply chain consisting of one supplier and two competing retailers, focusing on service and price

competition; their findings showed that, under certain scenarios, retailers favored increased competition [1]. The same authors studied the symbiosis of cooperation and competition in a supply chain that includes retail and direct channels [2].

F. Bernstein and A. Federgruen described the development of a general stochastic equilibrium inventory structure including service and price competition as key factors [3]. D.K. Yao, S. Yue and J. Liu focused on the impact of information sharing on optimal strategies for a retailer [4]. T. Xiao and D. Yang compared the impact of retail risk sensitivity on channel members' strategies in two different supply chains, showing that retailers with higher risk sensitivity have optimal service levels and lower prices, and also presented a competitive price and service framework, based on demand uncertainty [5].

D. Wu considered service and pricing in different channels, where service levels can be adjusted by both parties (both sellers and merchants) either sequentially or simultaneously [6]. C.H. Wu studied two-level SC, examined the impact of service and price competition between established manufacturers and those introducing new products, and showed that the degree of this competition determines the costs of processing and investment in services (especially for manufacturers introducing new products) [7].

S. Rezapour and R.Z. Farahani presented a two-tier supply chain model that takes into account price competition and service level of retailers [8]. The authors of the study [9] analyzed an SC model subject to demand disruptions, and Z. Pi, W. Fang and B. Zhang, when estimating a two-channel model, applied game theory approaches to achieve a Stackelberg-Nash equilibrium, since two competing retailers and a supplier supplied the product through a direct online channel [10].

The authors of [11] examined the distribution of a single product by a single manufacturer to multiple retailers within an SC, focusing on replenishment and pricing policies based on Bertrand and Cournot competition; Further, scientists expanded their research to include retailers' behavior in relation to competition and cooperation [12].

K. Chen and T. Xiao developed a supply chain model based on demand uncertainty, with a decentralized structure involving one supplier and several competing retailers, and a form of contracts that allows SCs to exhibit centralized behavior [13]. G.P. Cachon found an approximate solution to the inventory problem in a two-tier SC model with one manufacturer and several retailers, where the latter could compete or cooperate [14]. A team of scholars in [15] analyzed decentralized and centralized supply chain models and presented a model that considers a single supplier and multiple differentiated retailers, emphasizing that the former seeks to maximize the quantity of the latter [16].

Numerous studies are devoted to inventory management issues [17–36]. Their authors evaluate the coordination and sharing of inventory among retailers in SC with independent determination of order quantities and joint inventory allocation [22]; build supply chain models with both a decentralized structure (one monopolist manufacturer and several dependent retailers) [32] and one manufacturer and two retailers [33].

From the above one can conclude that the problems of supply chain management in the context of commodity exchanges are relevant and described in detail in a large number of scientific works. However, it is important to note such features of the studies as the relatively little attention paid to the conditions of uncertainty and risks that arise, in particular,

on commodity stock exchanges. Typically, commodity transactions occur in B 2B format (directly between sellers and buyers). However, in the timber industry, especially in Russia, many companies continue to operate outside the official system and evade taxes. As a result, the process of connecting buyers and sellers can be time-consuming, limiting the potential number of customers and affecting commodity prices, as well as creating losses for the national budget, which does not receive sufficient tax revenue. The use of commodity exchange tools will contribute to the transparency of transactions and increase the number of potential clients for sellers, since even foreign companies in need of raw materials will be able to contact the latter without the need to seek direct contact. This will ultimately lead to competitive prices and more efficient sales of raw materials.

The literature typically examines issues relevant to supply chain management. These works describe mathematical models that help to effectively form SC taking into account the characteristics of the industry, and also explore management problems associated with organizing production and creating supply chains. Basic approaches are often used, such as Lean Logistics,[1] Six Sigma,[2] etc. However, scientific sources have little coverage of the issue of analyzing possible profits in a situation of uncertainty, although this task is useful for assessing the effectiveness of IT solutions and the quality of management. A feature of the timber industry is the reduction in the volume of wood during transportation, and this property of raw materials must be taken into account when developing a production plan and supply chains to the enterprise warehouse.

## DEVELOPMENT OF A MATHEMATICAL MODEL

Any production, be it timber industry or otherwise, cannot function without the necessary supply of raw materials. The work uses data on its sale provided by the St. Petersburg International Commodity and Raw Materials Exchange[3] (hereinafter referred to as the exchange), which is publicly available. Every day, information on the number of transactions, prices and volume of raw materials sold is published on the exchange website. It provides services for the delivery of raw materials to the consumer (which are included in the cost of raw materials) from many regions, so that the buyer has a choice. According to the rules of the exchange, you can only purchase the entire lot of raw materials. Timber production is organized as follows: raw materials are delivered to a warehouse, then they are processed into dust and pressed into OSB[4] boards, i.e. into finished products. Each type of raw material corresponds to certain OSB. Transportation of boards is carried out by rail (including along the Trans-Siberian Railway) at the expense of the sender, who includes all costs for delivery of the lot in the price of the product.

Before moving on to the description of the model, we introduce the following notation for parameters and variables.

*Parameters:*

$p_{km}$ — is price for goods of type $k$ on day $m$;

$c_{ilrm}$ — is the price of lot $i$ with raw material type $l$ from region $r$, which appeared on the exchange on day $m$;

[1] Lean logistics is a pull system that includes all organizations in the value stream for the end customer, when inventory is replenished according to the needs of internal and external consumers in small quantities.

[2] Six Sigma is a methodology for setting up business processes to reduce all types of defects, losses and costs.

[3] St. Petersburg International Commodity and Raw Materials Exchange (SPICRME) (official website). URL: https://spimex.com/markets/wood/trades/results/

[4] Oriented strand board (OSB) is a multilayer (3–4 or more layers) sheet consisting of wood chips (thin chips).

$A_{lk}$ — is the rate of consumption of raw materials of type $l$ for the production of a unit of goods of type $k$;

$\gamma_{\tilde{m}m}$ — is coefficient of spoilage of raw materials purchased on day $\tilde{m}$ to day $m$ ($m \geq \tilde{m}$);

$V_{ilrm}$ — is volume of raw materials in lot $i$ with raw material type $l$ from region $r$, which appeared on the exchange on day $m$;

$H_{km}$ — is the maximum production volume of goods of type $k$ on day $m$;

$\underline{b}$ — is the emergency level of raw material reserves;

$\overline{b}$ — is maximum storage capacity;

$B_0$ — is initial budget;

$FC$ — are fixed costs;

$M$ — is planning horizon;

$T_{r\tilde{m}}$ — is the time it takes for a lot purchased on day $\tilde{m}$ from region $r$ to reach the warehouse;

$L_r$ — is distance from the warehouse to region $r$;

$S_m$ — is distance traveled by the application on day $m$;

$\beta$ — is a constant;

$\varepsilon^{(1)}$ — is noise;

*left* and *right* — are the minimum and maximum values of a random variable distributed according to a uniform law;

$LN(a_m, \delta_m)$ — is lognormal distribution of a random variable with parameters $(a_m, \delta_m)$ respectively;

$E$ — is the number of different sets of input parameters $\{V_{ilrm}(e), c_{ilrm}(e), T_{r\tilde{m}}(e)\}$.

*Variables:*

$x_{km}$ — is the volume of production of goods of type $k$ on day $m$;

$\lambda_{ilrm}$ — is decision to purchase lot $i$ with raw material type $l$ from region $r$, which appeared on the exchange on day $m$;

$b_{lm}$ — is the stock level of raw materials of type $l$ in the warehouse on day $m$.

Let us denote the problem to be solved for each set of parameters $e$ (the list of parameters is given above) as $F^{(1,1)}(e)$. The model will look:

$$\sum_{k,m} p_{km} x_{km} - \sum_{i,l,r,m} c_{imrl} \lambda_{imrl} \to \max, \quad (1)$$

$$b_{lm} = b_{lm-1} - \sum_{k} A_{lk} x_{km} + \gamma_{\tilde{m}m} \sum_{i,r} V_{i\tilde{m}rl} \lambda_{i\tilde{m}rl}, \quad (2)$$

where the condition $\tilde{m} = m - T_{r\tilde{m}}$ is satisfied.

$$x_{km} \in N, \quad (3)$$

$$\lambda_{imrl} = \{0;1\}, \quad (4)$$

$$0 \leq \sum_{l} b_{lm} \leq \overline{b}, \quad (5)$$

$$0 < \underline{b} \leq b_{lm}, \quad (6)$$

$$B_0 + \sum_{m=1}^{\underline{m}} \left( \sum_{k} p_{km} x_{km} - \sum_{i,l,r} c_{i\tilde{m}rl} \lambda_{i\tilde{m}rl} - FC \right) \geq 0, \underline{m} = 1 : M, \quad (7),$$

where $\tilde{m} = m - T_{r\tilde{m}}$.

$$T_{r\tilde{m}} = m^* : \begin{cases} \left| L_r - \sum_{m=\tilde{m}}^{m^*} S_m \right| \to \min \\ L_r - \sum_{m=\tilde{m}}^{m^*} S_m \leq 0, \end{cases} \quad (8)$$

$$S_m \sim LN(a_m, \delta_m), \quad (9)$$

$$\gamma_{\tilde{m}m} = \min\left(1; \max\left[0; 1 - \frac{2}{\pi} arctg\left(\beta(m - \tilde{m})\right) + \varepsilon^{(1)}\right]\right), \quad (10)$$

$$\varepsilon^{(1)} \sim U(left, right), \quad (11)$$

$$0 \leq x_{km} \leq H_{km}. \quad (12)$$

Let us explain that in expressions (2) and (7) the values $V_{ilr(m-T_{r\tilde{m}})}$ are written into the system of restrictions if and only if the condition $\tilde{m} = m - T_{r\tilde{m}}$ is satisfied.

Problem $F^{(1,1)}(e)$ is solved for all $e = 1 : E$.

Let's consider expressions (1–12) in more detail. Objective function (1) is aimed at obtaining the maximum profit value on the last

day of the planning horizon. The level of raw material stock on day $m$ is calculated according to formula (2), based on the volume of raw materials spent on production $\sum_k A_{lk} x_{km}$, the stock of raw materials at the end of the previous day $b_{lm-1}$, as well as the amount of raw materials received at the warehouse on the current day day adjusted for travel time $\tilde{m}$ and, accordingly, for the share of the useful volume of raw materials $\gamma_{\tilde{m}m}$.

Production volume (3) has only integer and non-negative values. The fact of making a decision on the purchase of a lot is given by relation (4). The volume of raw materials in the warehouse is limited by the maximum warehouse capacity (5) at the top and (6) at the bottom, since this value cannot have a negative value. Any enterprise has a certain budget, beyond which it cannot go (7). The travel time of each request is calculated from relations (8–9). In formula (9), the assumption was introduced that the random variable of the distance traveled by the lot on day $m$ has a lognormal distribution. This is due to the seasonality of rail transportation, through which products are delivered to the buyer's warehouse. These data can be found in detail in [25, 27, 29].

The coefficient of useful volume of raw materials is given by formulas (10)–(11). Let us assume that $\varepsilon^{(1)}$ has a uniform distribution, since there are no estimates of how exactly the working volume of raw materials changes over time. The number of goods produced (12) is also limited from above for physical reasons.

As follows from the description of the model $F^{(1,1)}(e)$, it is a problem of nonlinear and stochastic programming. To solve it, it is necessary to consider an algorithm, namely:

Play values (8)–(9) and $\gamma_{\tilde{m}m}$ taking into account (11).

Solve mixed-integer programming problem (1)–(7), (12) for each data set $e$.

## CALIBRATION

The model was tested on the basis of data, on the one hand, obtained at the LLC DNS-Les enterprise,[5] located in Spassk-Dalny, Primorsky Territory, and on the other hand, generated by the authors.

Let's look at how data related to the distribution of lots over time was generated. For this purpose, information from the exchange website was used for 120 days starting from 02/01/2021. Every 30 days, the mathematical expectation and dispersion of the number of applications, the volume of raw materials in each of them and the average price per 1 m3 were calculated. Next, according to the normal law, $E$ sets of data were generated with the calculated characteristics. The remaining values of the parameters of logistics and production processes $\left(\overline{b}, \underline{b}, B_0, FC, a_m, \delta_m, \beta, L_r\right)$ were obtained at the above-mentioned enterprise in accordance with its estimates.

To be specific, we will use the following parameters: $K = 4$ (types of goods); $M = 100$ days (length of the planning horizon); $L = 2$ (types of raw materials); $R = 4$ (number of regions); $0 \le I \le 6$ (number of lots every day in the range); $E = 400$ (number of different sets of input parameters).

The exchange is represented by four regions: Irkutsk region ($R$ = 1), Perm region ($R$ = 2), Republic of Buryatia ($R$ = 3), Moscow region ($R$ = 4). The planning horizon lies between February 1, 2021 and mid-May 2021. The main input data characterizing the enterprise are presented in *Tables 1, 2*.

To carry out the calculations, we will use the high-level programming language Matlab and the built-in Intlinprog[6] function to find solutions to mixed-integer linear optimization problems. This function uses the branch and bound algorithm.

[5] LLC DNS-Les (official web-site). URL: http://dns-les.ru/

[6] Website MathWorks. URL: https://www.mathworks.com/help/optim/ug/intlinprog.html

*Table 1*

**Main input parameters of the enterprise**

| Option | Value |
|---|---|
| $\forall m > 0 : p_{km}, k = 1 : K$, RUB. | $(1,1.49,1.61,1.71)*10^4$ |
| $\overline{b}$, m³ | 3000 |
| $\underline{b}$, m³ | 21 |
| $B_0$, rub. | 3,01*106 |
| $left(m)$, c.u. | $-\frac{100}{m*10^5}$ |
| $right(m)$, | $\frac{100}{m*10^5}$ |
| $\forall m, k > 0 : H_{km}$ | 4 |
| $L_r, r = 1 : R$, KM | $(3741,7561,3251,9021)$ |

*Source:* compiled by the author based on LLC "DNS-Les" data. URL: http://dns-les.ru/; SPIMEX. URL: https://spimex.com/markets/wood/trades/results

*Table 2*

**Cost of raw materials for the production of a unit of good, m³**

| $A_{lk}$ | $k = 1$ | $k = 2$ | $k = 3$ | $k = 4$ |
|---|---|---|---|---|
| $l = 1$ | 2 | 3 | 4 | 3 |
| $l = 2$ | 1 | 3 | 3 | 5 |

*Source:* compiled by the author based on LLC "DNS-Les" data. URL: http://dns-les.ru/

## INTERPRETATION

Let's look at *Fig. 1*. It shows the volume of goods produced each day (from the 1st to the 100th day). Gray color indicates the production volumes of each individual data set e, black color indicates the average value. Despite the higher price for goods 3 and 4, the calculation results show that the most frequently produced goods are types 1 and 2. However, as can be seen from the averages, all goods are almost always produced.

*Figure 2* shows the profit indicators $\pi_m(e)$, received every day (from the 1st to the 100th day). Gray color indicates the profit volumes for each individual data set *e*, black color indicates their average value.

As follows from *Fig. 2*, the most financially difficult period (from the point of view of the

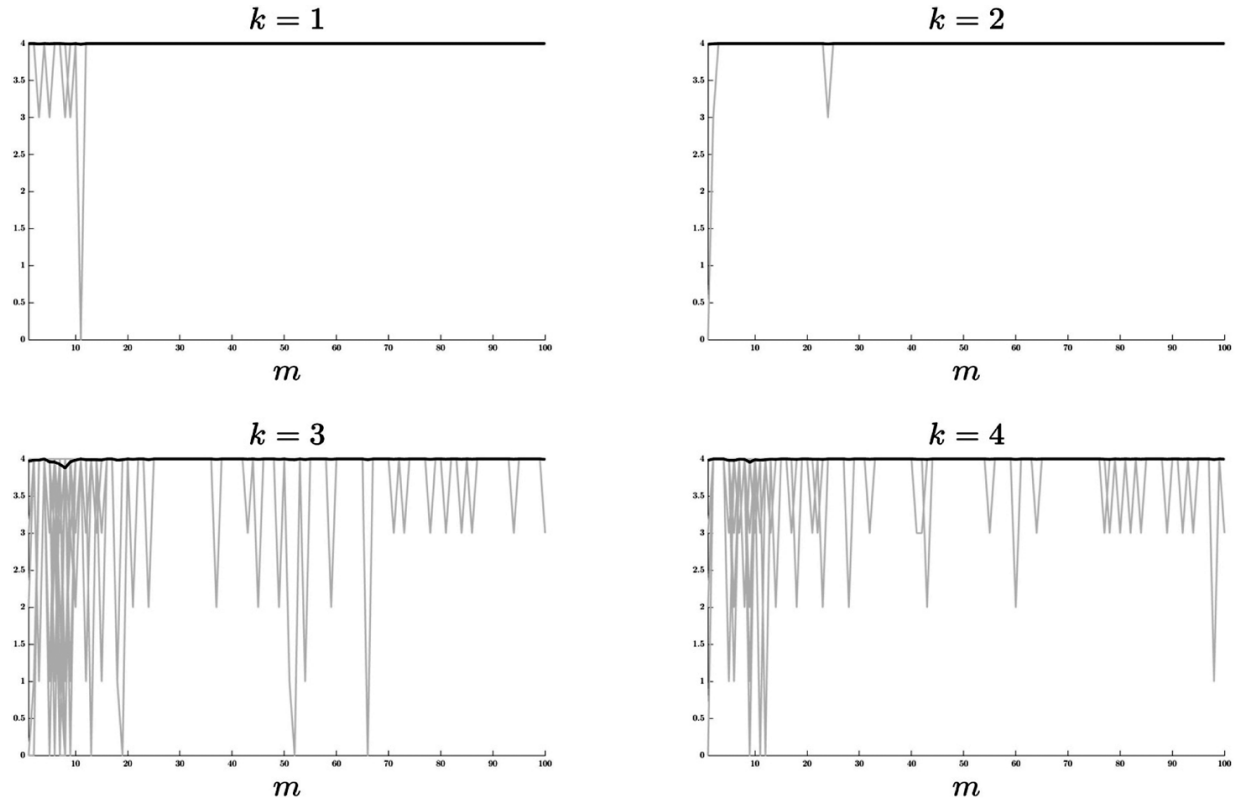


*Fig. 1.* **Visualization of production volumes**

*Source:* developed by the authors.

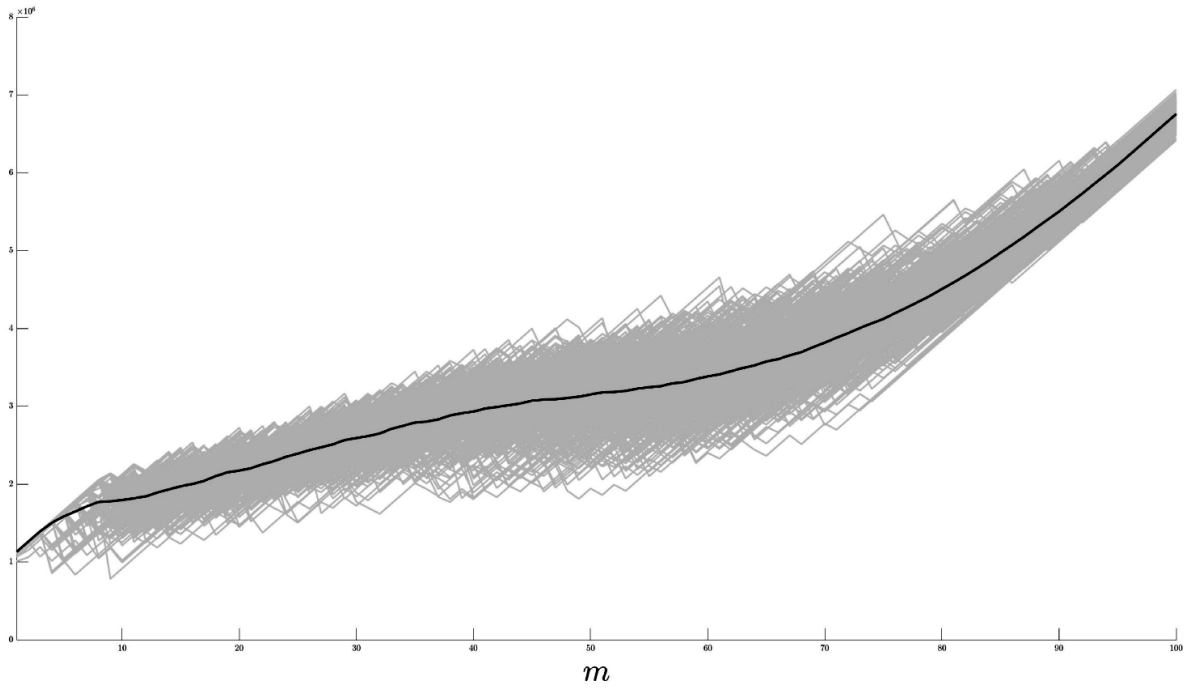


*Fig. 2.* **Visualization of profit values**

*Source:* developed by the authors.

management approach) falls on the interval from the 40th to the 60th day of planning — this can be said based on the almost stabilized and unchanged value of the profit indicator with the *optimal solution*.

Let's consider the positive and negative aspects of the designed model.

*Negative aspects:*

1. In real production during the planning stage, it is hardly possible to imagine a situation where managers responsible for making decisions can know the practical distribution of lots over time with all their characteristics. Therefore it is important:

a) collect data related to the task at hand over a large period of time; however, firstly, information is available on the exchange website only starting from the 2010s, and secondly, the exchange website is protected by anti-bot technology to reduce the load on the site in case the data is read using bots, which makes the process extremely complicated generating a sufficient sample size for analysis. It is worth noting that over time this problem becomes less relevant, as the volume of reports on completed transactions grows.

b) build complex mathematical models for the most accurate forecast of the distribution of requests over time. However, it has long been known that predicting situations on stock exchanges is not an easy task, since as private investors (in the context of the current task — small enterprises) are admitted to them, the influence of sentiment increases, and the latter are very difficult to predict. Based on this circumstance, the relevance of developing methods for forecasting situations not only on securities exchanges, but also on commodity exchanges sharply increases.

2. A rapidly growing number of limitations due to the linearity of the model [24].

3. For each day, it is necessary to know the parameters $a_m, \delta_m$, which can change over time.

4. There is no clear explanation for the validity of using a lognormal distribution for the distance traveled by a lot.

5. The parameter β should also change over time, because in summer the useful volume of raw materials decreases faster under the influence of temperature, moisture and the mechanical impact of insects [29].

6. In real conditions, constraint (12) should include the value $\min(H_{km}, Q_{km})$, as an upper estimate, where $Q_{km}$ — is the demand for goods of type $k$ on day $m$, which will significantly specify the solution to the problem.

7. The model does not imply a choice of risk tolerance, which is extremely important when determining the strategy for forming a "commodity portfolio" in modern conditions.

8. Enterprises in the timber industry do not always use only the exchange as a source of raw materials; direct B 2B agreements are often concluded, which mitigate risks. This feature is not provided in the model.

*Positive aspects:*

1. For an upper estimate of the profitability of production (even of such a scale as the largest company in the timber industry sector of the Russian Federation — PJSC Segezha[7]) with sufficiently large values of the number of raw materials, lots and regions on the stock exchange, this model can be effective with a planning horizon of 1 year, the most common at enterprises in this industry [23–26].

2. Conceptual simplicity of the model.

3. It contains the possibility of recording the time of the lot in transit.

4. Availability of a coefficient of useful volume of raw materials for production.

5. The presence of well-known optimization methods for linear programming problems [29].

[7] PJSC Segezha Group (official website). URL: https://segezha-group.com/about/

## CONCLUSION

The developed model determines the upper limit of the profit of an enterprise in the timber industry and takes into account the time of lots in transit and their useful volume; it allows to create supply chains for raw materials and production volumes using the enterprise budget and just-in-time policy. The structure of the model covers production, budget status, supply chains and inventory levels — it is useful for top management of forestry enterprises and complements the economic and mathematical theory of decision making.

Testing the model at a timber processing enterprise made it possible to formulate recommendations for cooperation with the commodity exchange. The analysis showed that purchasing raw materials in the Moscow region and Perm region may be advisable, despite the proximity of other regions. However, it is recommended to purchase raw materials from the Irkutsk region and the Republic of Buryatia only under certain conditions. Calculations confirm the possibility of rational commodity transactions on the Russian stock exchange.

## REFERENCES


1. Tsay A.A., Agrawal N. Channel dynamics under price and service competition. *Manufacturing & Service Operations Management*. 2000;2(4):372–391. DOI: 10.1287/msom.2.4.372.12342
2. Tsay A.A., Agrawal N. Channel conflict and coordination in the e-commerce age. *Production and Operations Management*. 2004;13(1):93–110. DOI: 10.1111/j.1937–5956.2004.tb00147.x
3. Bernstein F., Federgruen A. A general equilibrium model for industries with price and service competition. *Operations Research*. 2004;52(6):868–886. DOI: 10.1287/opre.1040.0149
4. Yao D.-Q., Yue X., Liu J. Vertical cost information sharing in a supply chain with value-adding retailers. *Omega*. 2008;36(5):838–851. DOI: 10.1016/j.omega.2006.04.003
5. Xiao T., Yang D. Price and service competition of supply chains with risk-averse retailers under demand uncertainty. *International Journal of Production Economics*. 2008;114(1):187–200. DOI: 10.1016/j.ijpe.2008.01.006
6. Wu D. Joint pricing-servicing decision and channel strategies in the supply chain. *Central European Journal of Operations Research*. 2011;19(1):99–137. DOI: 10.1007/s10100–009–0133-z
7. Wu C.-H. Price and service competition between new and remanufactured products in a two-echelon supply chain. *International Journal of Production Economics*. 2012;140(1):496–507. DOI: 10.1016/j.ijpe.2012.06.034
8. Rezapour S., Farahani R.Z. Supply chain network design under oligopolistic price and service level competition with foresight. *Computers & Industrial Engineering*. 2014;72:129–142. DOI: 10.1016/j.cie.2014.03.005
9. Ali S.M., Rahman M.H., Tumpa T.J., Rifat A.A.M., Paul S.K. Examining price and service competition among retailers in a supply chain under potential demand disruption. *Journal of Retailing and Consumer Services*. 2018;40:40–47. DOI: 10.1016/j.jretconser.2017.08.025
10. Pi Z., Fang W., Zhang B. Service and pricing strategies with competition and cooperation in a dual-channel supply chain with demand disruption. *Computers & Industrial Engineering*. 2019;138:106130. DOI: 10.1016/j.cie.2019.106130
11. Bernstein F., Federgruen A. Pricing and replenishment strategies in a distribution system with competing retailers. *Operations Research*. 2003;51(3):409–426. DOI: 10.1287/opre.51.3.409.14957
12. Bernstein F., Federgruen A. Decentralized supply chains with competing retailers under demand uncertainty. *Management Science*. 2005;51(1):18–29. DOI: 10.1287/mnsc.1040.0218

13. Chen K., Xiao T. Pricing and replenishment policies in a supply chain with competing retailers under different retail behaviors. *Computers & Industrial Engineering*. 2017;103:145–157. DOI: 10.1016/j.cie.2016.11.018
14. Cachon G. P. Stock wars: Inventory competition in a two-echelon supply chain with multiple retailers. *Operations Research*. 2001;49(5):658–674. DOI: 10.1287/opre.49.5.658.10611
15. Anderson E. J., Bao Y. Price competition with integrated and decentralized supply chains. *European Journal of Operational Research*. 2010;200(1):227–234. DOI: 10.1016/j.ejor.2008.11.049
16. David A., Adida E. Competition and coordination in a two-channel supply chain. *Production and Operations Management*. 2015;24(8):1358–1370. DOI: 10.1111/poms.12327
17. Adida E., DeMiguel V. Supply chain competition with multiple manufacturers and retailers. *Operations Research*. 2011;59(1):156–172. DOI: 10.1287/opre.1100.0863
18. Konur D., Geunes J. Supplier wholesale pricing for a retail chain: implications of centralized vs. decentralized retailing and procurement under quantity competition. *Omega*. 2016;65:98–110. DOI: 10.1016/j.omega.2016.01.002
19. Shenoy P. P. Competitive inventory models. *RAIRO — Operations Research*. 1987;21(1):1–19. URL: http://www.numdam.org/article/RO_1987__21_1_1_0.pdf
20. Yang S.-L., Zhou Y.-W. Two-echelon supply chain models: Considering duopolistic retailers' different competitive behaviors. *International Journal of Production Economics*. 2006;103(1):104–116. DOI: 10.1016/j.ijpe.2005.06.001
21. Zhang P., He Y., Shi C. V. Transshipment and coordination in a two-echelon supply chain. *RAIRO — Operations Research*. 2017;51(3):729–747. DOI: 10.1051/ro/2016052
22. Yan X., Zhao H. Inventory sharing and coordination among *n* independent retailers. *European Journal of Operational Research*. 2015;243(2):576–587. DOI: 10.1016/j.ejor.2014.12.033
23. Rogulin R. S., Mazelis L. S. Algorithm and mathematical model of supply chain management for raw wood from the regions in Russia: Comparison and analysis. *Vestnik Permskogo universiteta. Seriya: Ekonomika = Perm University Herald. Economy.* 2020;15(3):385–404. (In Russ.). DOI: 10.17072/1994–9960–2020–3–385–404
24. Rogulin R. S. Modeling of promising interaction between a timber industry enterprise and a commodity exchange in Russia. *Journal of Applied Economic Research*. 2020;19(4):489–511. (In Russ.). DOI: 10.15826/vestnik.2020.19.4.023
25. Rogulin R. S. A model for optimizing plans for procurement of raw materials from regions of Russia in a timber-processing enterprise. *Business Informatics.* 2020;14(4):19–35. DOI: 10.17323/2587–814X.2020.4.19.35 (In Russ.: *Biznes-informatika.* 2020;14(4):19–35. DOI: 10.17323/2587–814X.2020.4.19.35).
26. Rogulin R. S. The place of ICT and entrepreneurship in forming sustainable supply chains. *Ekonomicheskaya politika = Economic Policy.* 2021;16(4):84–103. (In Russ.). DOI: 10.18288/1994–5124–2021–4–84–103
27. Rogulin R. S. A mathematical model for the formation of the pricing policy and the plan of the production and transport system in a timber-processing enterprise. *Business Informatics.* 2021;15(3):60–77. (In Russ.: *Biznes-informatika.* 2021;15(3):60–77. DOI: 10.17323/2587–814X.2021.3.60.77).
28. Rogulin R. S. The role of ICT and entrepreneurship in forming sustainable supply chains: Before and after the COVID-19 pandemic. *Journal of Applied Economic Research*. 2021;20(3):461–488. (In Russ.). DOI: 10.15826/vestnik.2021.20.3.019
29. Mazelis L., Rogulin R. Devising a method for the formation of sustainable chains of supply of raw materials from mercantile exchange to a timber processing enterprise considering uncertainties and risks. *Eastern-European Journal of Enterprise Technologies*. 2021;5(3–113):6–18. DOI: 10.15587/1729–4061.2021.242960
30. Tarasov V. B. From multi-agent systems to intelligent organizations: Philosophy, psychology, computer science. Moscow: Editorial URSS; 2002. 352 p. (In Russ.).

31. Kantorovich L.V. Mathematical methods of organizing and planning production. Leningrad: Leningrad State University; 1939. 96 p. (In Russ.).
32. Shao J., Krishnan H., McCormick S.T. Incentives for transshipment in a supply chain with decentralized retailers. *Manufacturing & Service Operations Management*. 2011;13(3):361–372. DOI: 10.1287/msom.1110.0326
33. Huang H., Ke H., Wang L. Equilibrium analysis of pricing competition and cooperation in supply chain with one common manufacturer and duopoly retailers. *International Journal of Production Economics*. 2016;178:12–21. DOI: 10.1016/j.ijpe.2016.04.022
34. Glock C.H., Kim T. The effect of forward integration on a single-vendor-multi-retailer supply chain under retailer competition. *International Journal of Production Economics*. 2015;164:179–192. DOI: 10.1016/j.ijpe.2015.03.009
35. Chen K., Xiao T. Pricing and replenishment policies in a supply chain with competing retailers under different retail behaviors. *Computers & Industrial Engineering*. 2017;103:145–157. DOI: 10.1016/j.cie.2016.11.018
36. Karimi M., Khademi-Zare H., Zare-Mehrjerdi Y., Fakhrzad M.B. Optimizing service level, price, and inventory decisions for a supply chain with retailers' competition and cooperation under VMI strategy. *RAIRO — Operations Research*. 2022;56(2):1051–1078. DOI: 10.1051/ro/2022039

## ABOUT THE AUTHOR

***Rodion S. Rogulin*** — Cand. Sci. (Econ.), Associated Professor at the Department of Mathematics and Modeling, Vladivostok, Russia
https://orcid.org/0000-0002-3235-6429
rafassiaofusa@mail.ru

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# Study of Smart Cities Based on Human Capital (Case of Russian Research-Driven Towns as Proto-Smart Cities)

**S.G. Kamolov[a, c], K.S. Kim[b], N.D. Aleksandrov[c]**
[a] Financial University, Moscow, Russia; [b] Yonsei University, Seoul, Korea; [c] MGIMO, Moscow, Russia

## ABSTRACT

Existent philosophical literature has been largely focusing on the ethical aspects and controversies of developing and using smart technologies such as AI and big data, whereas human capital and infrastructural environment as pre-existing factors have been covered by AI Ethics in a lesser extent. Most of the current research focuses on technical infrastructural aspects in the implementation of complex "smart projects", while insufficient attention is paid to the role of social capital. In order to widen the focus and to include human capital and infrastructural developments coming along with the increasing role of AI, the paper takes a novel look at philosophical underpinnings of smart cities and discusses the concept of the Russian Naukograd (literally from Russian — City of Science, or Researchers' city, meaning a city which is developing as a community of scientists and academics) as a historical approach for smart city concept implementation. The authors apply theoretical methods of cognition (analysis, synthesis) as well as the case study approach to the Russian (Soviet) experience in forming research-driven cities in order to highlight the value of high scientific, industrial and educational capital ("smart nation") as a fundamental factor for the stable long-term development of modern cities. The findings suggest that some concepts of the Russian Naukograd for example the focus on research and education are valuable and that investment in social capital (i.e., people) should stand on the same footing as investment in technology developing a smart city. In this approach the prefix "smart" may stand for "smart citizens/nations" as a pivotal framework at the initial stages of smart cities development.

***Keywords:*** Smart City; Science City; Research-Driven City; Technopolis; Urbanism; Information Technology; Social Capital; Smart Nation

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## INTRODUCTION

The growing economic and demographic relevance of modern cities poses completely new challenges for urban planning and management across the world. Increased migration and population density, rising housing prices, transportation, and environmental problems, changing demands of business communities and citizens urging for better quality of urban life present a series of challenges that a metropolis encounters nowadays. As a result, urban development management has been in constant search for new perspectives and concepts to manage and mitigate the ongoing tectonic shifts. In wake of the emerging discourse on AI and digitization, the spotlight has been largely shed on advanced technological solutions with the aim to create a digital urban environment that would handle emerging challenges, to meet the needs of all stakeholders (government bodies, businesses, and residents), as well as to provide more efficient integration of urban infrastructure elements. To embrace those changes, scientists coined the term "smart city". This concept has been interpreted in different ways, however, the core of any interpretation centres on information and communication technologies that qualitatively improve and simplify the daily processes of urban life and help solve problems through citizens' engagement. Although smart cities have been widely discussed in literature, the role of the

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inhabitants in smart cities has been discussed in a lesser extent. Do smarter cities require smarter individuals? What kind of individuals should smart cities be designed for and will the inhabitants of those cities will adapt to the changes coming along with the role out of technical solutions?

The role of human beings in the development of the entire city community stems from ancient philosophy. The Greek world "polis", which has the meaning of city, but also of political organization in general, referred rather to political entities with a smaller territory. This is not surprising and owes to the fact that the perpetual striving of city-states for regional hegemony characterized Greek civilization before the advent of Hellenism and not the establishment of large empires. Consequently, the works of Plato and Aristotle have to be seen in this specific civilizational context [1]. However, Greek philosophy did not substitute the notion of the state with the polis, merely because of the absence of larger political structures. Plato's thoughts deliberately focused on the city as centre of human interaction and even included detailed provisions for the perfect number of inhabitants or the right arrangement of the city's fortifications. Besides, Plato and Aristotle shared some essential views on the intrinsic value of human co-existence and the purpose of the city to provide individuals with a "healthier" and "happier life" [2]. While Plato argued in the Politeia that the "smartest ones" should be in charge governing the city, Aristotle envisioned a political system based on "checks" and "balances" and a strong middleclass as the most stable and reliable political constitution. The Aristotelian approach was based on the socio-economic exclusion of a sizeable part of the population conflicting with modern assumptions on just and fair policies. Although both enlightenment and contemporary philosophy have challenged many of the views and concepts established by Plato and Aristotle, we still ground our future-driven research on their views and thoughts to carve out moral and philosophical purpose of smart cities. Plato and Aristotle have elaborated on the mission statement of the city and have put the role of human beings at the centre of their considerations [3].

The current stage of urban development is characterized by the rapid introduction of innovative and "smart" technologies to improve the well-being of citizens, respond to global challenges, and enhance governance. However, practice has shown an orientation towards economic incentives for the introduction of novel technological solutions, where less attention is paid to the level of education and qualifications of citizens [4].

So, the **hypothesis** states that development of modern "smart cities" should primarily focus on investment in human capital rather than economic incentives solely related to building technological infrastructure. The **research goal** is to examine the Russian concept of Naukograd as one of the approaches to shaping the human capital in the context of urban governance with its application in smart cities.

The paper is structured as follows: theoretical underpinnings of the role of citizens in modern smart city governance, the analysis of Russian approach to research-driven cities, the current state of research-driven cities' development as well as the cases of smart solutions' implementation.

## MATERIALS AND METHODS

The character of a modern city is multidimensional and complex. The studies on this topic have long ceased to be the domain of architects, planners, economists, utilities, etc. Specialists, developing cities, can no longer remain "narrow" professionals: they need interdisciplinarity, the ability to see the object volume, understand multiple and complex relationships and consequences. In addition, in a post-industrial society, the role of people, their interests and preferences are growing — they are gradually becoming existential for the development of certain territories and agglomerations. And the area itself is becoming increasingly interesting to more residents who want to participate in the process of development and improvement of their cities.

Currently the opportunities for city residents to participate in the formation of managerial decisions within the framework of the "smart city" concept are provided through a wide range of digital services integrated into a unified smart city infrastructure. In order to involve citizens in urban governance, it is necessary first of all to meet the tasks of popularizing and promoting the concept of a "smart city" among various groups of the population, providing technical opportunities for participation in

urban management through online services and increasing the availability and openness of national and city data [5].

Residents of the city, living in an environment that is being digitally modernized influence the decision-making using city information portals through questionnaires that relate to the need to introduce certain technologies, or the assessment of citizens' opinions regarding certain areas [6]. With the help of the citizens' appeals functions, residents have the opportunity to pay attention to any urban problems or offer their initiatives. Based on the information received, after surveys and studying appeals, the city authorities can form a strategy for the modernization of certain domains of the urban economy [7]. It provides an opportunity to increase the degree of involvement of city residents in urban management, as well as to allow the governance bodies to increase the openness and accessibility of information taking into account the citizens' applied needs.

Besides it is important to take into account that the "admittance" of citizens to influence managerial decision-making should also be fundamentally worked out. Urban governance is a multidisciplinary field that requires a number of competencies, therefore, citizens must have the appropriate (minimum) skill levels. The development of smart cities is increasingly based on the principles of knowledge management. This leads to new management challenges that reflect the complexity of governance and process problems in smart city projects, as well as the need for knowledge management that arise both inside and outside the project boundaries.

In dealing with smart city governance issue when internal knowledge is managed, scientific force usually acts as knowledge intermediaries, while they act as knowledge gatekeepers when governance relationships involve external knowledge. Moreover, they act as knowledge providers in the process of knowledge creation within the boundaries of smart city projects and they may have an important role as evaluators of knowledge residing outside projects' boundaries [8]. Such integration efforts require smart city projects to be composed of public and private players, the academia, and the wider community [9]. This increases the pool of available knowledge and the possibility to address the development of smart city initiatives from multiple perspectives [10]. Knowledge is not a static resource, it entails a continuous, dynamic management of processes of creating, integrating, and applying knowledge out of knowledge [11]. These processes also have different ultimate objectives and are primarily managed by different organizations/actors, which may change over time according to the specificity of related goals. Accordingly, novel knowledge and solutions to address a city's specific needs must be created before initiating a smart city project. Here attention is placed on the actors involved and their contribution to each process, with particular regard to the academic sector. Indeed, the academia is often viewed as the creator of scientific knowledge, although it may increasingly play a crucial role in the validation, transfer, and application of knowledge.

Just like any organization or innovative ecosystem, smart city projects include knowledge that resides within and beyond their boundaries. In other words, according to the open innovation paradigm [12], the development of smart cities can be driven by combining knowledge generated and owned by projects partners with knowledge that originates elsewhere. In fact, on the one side, smart cities necessitate that governments and citizen provide the local knowledge to shape cities with respect to local resources, priorities, values, and needs [13]. Likewise, firms and universities working on smart city projects are asked to contribute with their technical and scientific know-how to the development of smart cities [14].

Therefore, the authors apply the methods of theoretical analysis and a case-study approach to the Russian (Soviet) concept of "Naukograd" as the prototype of a smart city, which is primarily based on its social capital, and the introduction of technological infrastructure is driven by the stages of scientific and technological development of the city as an integral ecosystem.

## RESULTS

In the Russian context, the concept "Naukograd" (used only in Russia) was coined in the early 1990s and signified an emergent city where knowledge-intensive industries and scientific organizations are at the frontline of its growth strategy. In 1999, the Federal Law was adopted to regulate the process of assigning the status of Russian Research-Driven City to municipalities

that comply with established criteria and agree on specific development program[1]

Although the term Naukograd has found its entry in Russian law in the 1990s, it depicts a unique phenomenon in the history of world science and is based on pre-existing historical experiences and perceptions. Leninist philosophy itself had a strong focus on education and literalization was one of the most important pillars of Socialist education policies in developing countries. In the context of higher education and genuine research, the concept is associated with the Soviet era of research and innovations development when under the soviet administrative principles, most of these "restricted access" cities were established in the area of functional municipalities to resolve complex issues of the defence industry (*Figure*). The main idea behind this concept was to create a space for scientists and for intellectuals to exchange and to create a place where smart people interact with each other. The best scientific and research personnel of the country lived and worked in such cities, the model of reproduction of highly skilled specialists was created by launching subsidiaries of industry-specific institutes. This connects to the moral general notions of Socialism such as the idea of an avant-garde, which is leading technological, cultural, or political progress or the strong focus on the promotion of sciences.

## SPECIALIZATION OF RUSSIAN SCIENCE CITIES

State incentives notwithstanding, opacity and secrecy have led to negative consequences, which still can be observed to some extent today. For example, the state was the only consumer of products and scientific developments of such cities. After the fall of the Soviet Union, Naukograds were declassified, and their functions were redirected to the use of existing potential for the development of regions of the country, particular cities, and the whole country. At the same time, links of cooperation with other regions or countries were not developed since planning and activities of Research-Driven Cities were carried out from the Federal Centre or in Soviet times from the Union Centre As mentioned, the exclusiveness of many smart cities also contributed to their relative isolation within the country. Drastic cuts of government funding for research and development and turbulent military-industrial sector in the 1990s led to decline of socio-economic status of Naukograds. Major city employing businesses were not able to provide their workers with a decent income. Therefore, there was a migration of highly qualified specialists and economically active population from Naukograds not only to nearby regional centres, but also abroad (the so-called brain drain).

Nevertheless, Russian case of Naukograds played a crucial role in shaping the pillars of innovations' system in the Russian Federation in terms of conditions for innovative business, new technologies and production of competitive high-tech products, including import substitution products. It was an effective innovation environment for advancing scientific ideas and production development. Naukograds' contribution also consists of:

- creation and development of a creative municipal education management system as a means of fulfilling the city's socioeconomic development objectives;
- facilitating the entry of high-tech investment projects into the municipal entity in scientific and technical clusters;
- life-long learning frame-setting;
- enabling advanced fundamental R&D of new goods;
- producing assets for national defence purposes, the economy, foreign policy, and other security-related issues;
- production of goods for the sake of national defence, the economy, foreign policy, and other national security-related topics;
- safeguarding the advancement of fundamental science, higher education and the monetisation of information learned through the creation of high-tech enterprises.

The overall Naukograds development policy is presently aimed at exploiting the existing scientific and innovative potential of Naukograds to realize the goals and objectives of the country's development, as well as to ensure the

[1] Federal law of the Russian Federation "On the status of Naukograd of the Russian Federation of April 7, 1999 No. 70-FZ. URL: https://base.garant.ru/180307/

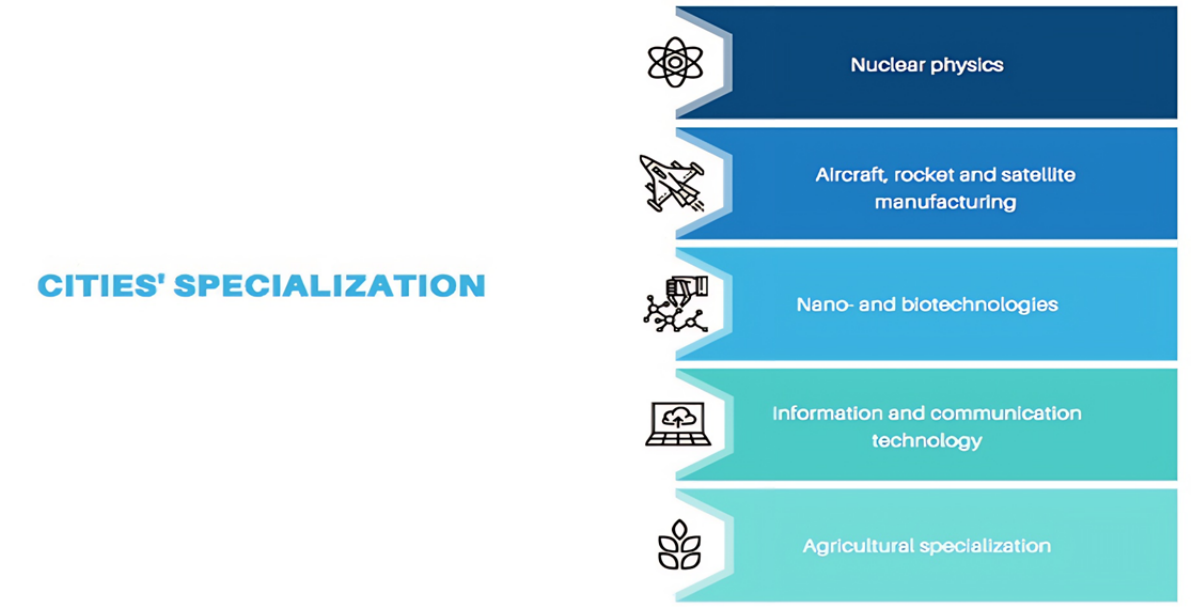


*Fig.* **Specialization of Russian science cities**

*Source:* Compiled by the authors based on [15].

attractiveness for Russian and foreign leading scientists and young promising researchers, the development of the social capital of Naukograds.

Comparing the traditional approach to smart city with the Russian notion of Naukograd, there are explicit differences in terms of centralization and decentralization. Although the Russian model of smart cities driving from Socialism and the Western model deriving from market liberalism are both based on the notion of enlightenment that progress constitutes a major aim of policymaking, there are some striking differences. Russian Naukograds were primarily designed as a centralized place to create knowledge based on mutual exchange. The Russian focus was therefore not so much to incentivize smart people by material interests, but rather by professional skills and social promotion. The notion of a scientific-avant-garde played therefore a crucial role for comprehending the Soviet model. Similar aspects can be observed in the promotion of scientists in other socialist societies such as North Korea or Cuba. As a result, Russian Naukograd focused rather on the investment in people (education and spill-over effects) than on investment in technologies or infrastructural aspects. The powerful and resourceful teams capable of finding a quick solution to scientific and technical issues were guaranteed by the "import" of highly qualified specialists from other regions. The need for the training of young staff by research centres was satisfied by special departments of the country's leading universities. This contrasts with the American approach to the Silicon Valley, which was rather based on a decentralized system. The emergence of the Silicon Valley with its start-up culture and universities is a perfect example of the interplay for these forces. In contrast to the Russian case, the notion of incentives and the cooperation between private companies currently represented by the likes of Amazon, Microsoft, Facebook, and Alphabet played an extra-ordinary role in shaping the Silicon Valley, including the many start-ups which emerged in the vicinity of the tech industry. Another pivotal difference concerns the mode of interaction in these smart cities. While the technologies in the West developed against the background of a liberalized labour, capital and specifically real estate markets, Russian science cities were based on state planning of all these areas.

The prioritization of investment in human beings characterizes the Russian definition of Naukograd and

the criteria for obtaining that status, which include the following criteria:

- share of employees in R&D sector should be minimum 20% of total employment in the city's economy;
- share of researchers should exceed 20% of the total employment within the R&D sector;
- R&D companies' turnover should constitute minimum 50% of the total city's economic turnover.

Based on the mentioned definition, 13 cities have the status of Naukograd of the Russian Federation: Biysk, Koltsovo, Pushchino, Troitsk, Dubna, Reutov, Zhukovsky, Korolev, Fryazino, Obninsk, Michurinsk, Protvino, Chernogolovka. Looking at the size of these areas, one can see that individuals were detached outside of the epicentre to conduct research far away from distraction creating an interesting habitat with the smart people.

*Table* presents data of Russian Naukograds' requirements implementation monitoring as of 2021.

The above-mentioned requirements give enough evidence to conclude that the Russian (Soviet) approach was to invest in human capital, that is, to gather and form intelligent (smart) people capable of further creating technological solutions for the benefit of the entire society. In addition, relying on statistics, it's evident that Naukograds still fulfil the established requirements, which indicates that in the scientific and industrial system of the Russian Federation Naukograds remain one of the most important engines of innovative development. The existing scientific and innovative potential of Naukograds should be used to realize the goals and objectives of the development of the Russian Federation, as well as to ensure the attractiveness of employment in Naukograds for Russian and foreign leading scientists and young promising researchers, the development of the human potential. Thus, such initiatives may also develop into the formation of a "smart city" (where prefix "smart" stands for qualified people).

At the same time, the development of Naukograds as "smart cities" is influenced by the following factors:

- Fundamental scientific and educational institutions: the presence of universities, research centres, laboratories which play an important role in the formation of educational and research framework;
- Introduction of innovative technologies that fundamentally change the structure and principles of the main economic processes;
- Environment and quality of life: smart cities should be comfortable for life with quality infrastructure, public spaces, high safety and sustainable environment;
- The life cycle of the population: the population of the city should be diverse in age and social aspects, covering people of all ages and social groups;
- Governance and public participation: A smart city should be a product of interaction between local authorities, entrepreneurs and the community;
- Economic growth: Smart cities should have a developed economy and be able to generate highly-qualified employment.

The "Economic indicators of Russian science cities" (*Appendix, Table*) presents the main socio-economic indicators of Russian Naukograds in comparison with the regions of the Russian Federation. The presented data indicate that investment in social sphere dominates the overall structure of budget spendings. These data confirm the hypothesis that Naukograd governance policy first of all asumes investments in social capital, not infrastructure.

So, the Russian case can be considered as an alternative co-existing approach to smart city development in terms of forming a "smart nation".

## DISCUSSION

The Russian model of Naukograds concentrates on the role of scientists, which is why the integration of smart technologies in those places requires a special attention. When reflecting on the history of Naukograd, some scholars posit the existence of a universal cycle- or waves-like pattern of research-driven generations [16]:

- The First Wave — new purpose-built cities within the state policy on the development of fundamental science and technology, usually lacked a strong urban character and carried a certain level of confidentiality.
- The Second Wave — applied research centres created in the city outskirts that provide innovative development opportunities for industrial clusters, technoparks, technopolis.
- The Third Wave — contemporary cities of science designed to ensure growth through the progress in

*Table*

**Statistics on the activities of Naukograds scientific and industrial complex in 2021**

| Naukograd | Number of entities | The total number of employees | Number of researchers | Number of professors and lecturers | The total volume of goods and services produced (millions of US dollars) | The cost of investments in fixed assets (millions of US dollars) |
|---|---|---|---|---|---|---|
| Biysk | 10 | 4026 | 632 | 246 | 288.3 | 7.6 |
| Dubna | 26 | 12 322 | 2039 | 564 | 618.9 | 21.1 |
| Zhukovsky | 7 | 10 564 | 4372 | 0 | 398 | 34 |
| Koltsovo | 6 | 4237 | 1432 | 5 | 378.4 | 24.2 |
| Korolev | 14 | 23 339 | 7506 | 327 | 2019 | 64.6 |
| Michurinsk | 12 | 5604 | 1237 | 351 | 145.9 | 2.9 |
| Obninsk | 39 | 12 863 | 3025 | 217 | 996.6 | 53.4 |
| Protvino | 11 | 2401 | 903 | 67 | 118.5 | 3.1 |
| Pushchino | 25 | 1887 | 1096 | 110 | 55.1 | 5.3 |
| Reutov | 6 | 4477 | 1808 | 62 | 870.5 | 36.7 |
| Troitsk | 18 | 2668 | 1286 | 78 | 127.2 | 28.8 |
| Fryazino | 18 | 11 417 | 2330 | 194 | 918.2 | 16.7 |
| Chernogolovka | 13 | 3555 | 1317 | 41 | 111.8 | 8.7 |

*Source:* compiled by the authors based on report on the assessment of compliance of indicators by Naukograds' scientific and industrial complexes with the requirements established by Federal law in 2021. Ministry of Science and Higher Education of the Russian Federation. 2022. URL: https://minobrnauki.gov.ru/upload/iblock/278/32o3d3q3pdxr7qep8govhw57dij9g3gx.pdf (accessed on 15.11.2022).

science and development of technologies characterized by a high level of social inclusion and cooperative ties between various subjects of innovative activity — universities, authorities, businesses, and public organizations.

Soviet science cities belonged to the first wave and were established to resolve scientific and technological issues incurred by the government, in particular in the area of defence. The smart city concept is well reconciled with the third wave, not only because of its technological effectiveness, but also due to being human-centric. In fact, it is to the third wave that Russian research-driven cities must strive for. Prior studies generally confirm that the challenge of using the unique potential of science cities is of national importance as it may lead to a quality change in the Russian urbanization [17]. On top of that, innovative development of the economy nowadays heavily depends on preservation and effective use of the rich scientific, technical, and intellectual capabilities of these cities [18, 19].

As previously mentioned, the Russian Naukograds rather centered on investment in people and not so much in technologies, which is evident in terms of digitization of Russian Naukograds. Naukograd cities have taken on increased obligations for the project implementation and will fulfil not only the basic requirements of the Russian Smart City standard, but also other digitalization incentives in the spheres of governance, utilities, transportation, environment innovations, etc. All these directions are reflected in the standard.[2] In order the cities pioneering this concept, the Russian Ministry of Construction provides methodology and administrative support. The Ministry of Construction also created the "Cities IQ" index (rating), which determines the digitization level of urban areas as well as applicability of smart solutions that municipal entities implement. "Cities IQ" ranks cities basing on evaluation of the dynamics in the following key areas: intelligent public and environmental safety systems,

[2] Basic and additional requirements for smart cities (Smart City standard) Ministry of Construction and Housing and Communal Services of the Russian Federation. 2019. URL: https://minstroyrf.gov.ru/upload/iblock/74f/Standart.pdf (accessed on 18.05.2022).

smart utilities, urban environment advances, smart urban transportation, tourism and service, intelligent public services systems, economic status and investment climate, communications network infrastructure. The index shows that in 2021 there is an evident progress in the digitalization of Naukograds, however the coverage across the country is heterogeneous. Korolev (83 points) and Zhukovsky (79 points) are leading in their subgroup of most populated small towns, Dubna (78 points) and Koltsovo (71) showed average results, Biysk (58 points) and Obninsk (60 points) are still at the beginning of their digital path. In this regard, we validated the presence of smart technologies and solutions for citizens comfort which are introduced into the everyday life of a Naukograds.

It is crucial to note the advantages of the classic Naukograd model over the "framework" factors, which attribute cities to the class of "smart". These factors inherently reflect an approach to focusing on investments in human capital rather than infrastructure:

1. Concentration of scientific and technological institutes and enterprises: Naukograds are inherently powered by large scientific centers and high-tech enterprises, which can contribute to the innovative development of the region and facilitate the transfer of knowledge between scientific institutes;

2. Better access to highly qualified specialists: Naukograds are usually located close to major universities and other educational institutions, which facilitates access to highly qualified specialists and talented students;

3. Opportunities for research and development: thanks to the concentration of institutes and enterprises Naukograds provide opportunities for conducting research and development (R&D) at a new level and to a far greater extent than smart cities;

4. Creating a community: the possibility of placing people working in the same industry next to each other can help establish connections and create networks of professionals.

The Russian case is notable and shows that the integration of smart technologies has proved more difficult to obtain than in the case of the Silicon Valley or in the case of China's Shenzhen, where technological adaption has been faster, and where smart city hubs were connected to large business centres and not placed in remote areas rendering the costs of technological change higher. Besides, the existing major Russian private IT companies have not settled in Naukograds, but rather maintained their presence in the capital cities Moscow and Sankt Petersburg. This strikingly differs from the USA case, where most companies are headquartered in tech hubs and not in political or administrative centres. As a result, the most pressing issues has concerned financing, as the absence of commercial partners enhances the cost for the state budget. Under the existing funding mechanism, the federal transfers are determined in the proportion of Naukograd's permanent population, while the size of the territory of urban districts and the state of infrastructure are disregarded [20]. The resources needed for smart city are not only necessary for providing incentives to skilled labour, but also for investment in the technical infrastructure.

In the Russian case, there has been some progress in adapting technologies in these areas. In Biysk, in the context of the Smart City project, the transport portal "Bus22" together with its mobile version was created to track online the trajectories of public transport. Citizens who use public transport could pay for travel using a bankcard or a social card of a city resident.[3]

Dubna has opened a municipal regional management centre, which is integrated with the Smart City competence centre. Its employees are engaged in online monitoring of the housing and utility sector, power, healthcare, and education, and are efficient at tackling city's problems.[4] Smart stops appeared in Zhukovsky. The objects are equipped with CCTV cameras, connected to the "Safe Region" System, equipped with extra lighting, free Wi-Fi, and USB ports for recharging portable devices.[5] More than that, the first Centre for Prototyping and Digital Technologies in the Moscow Region also operates in

[3] How to turn a science city into a smart city. Official website of the Biysk Municipality. 2019. URL: https://biysk22.ru/about/info/news/? ELEMENT_ID=4085 (accessed on 20.11.2022).

[4] The implementation of the "digit" in the life of the city was discussed in Dubna. 360TV. Nov. 27, 2019. URL: https://360tv.ru/news/mosobl/vnedrenie-tsifry-v-zhizn-goroda-obsudili-v-dubne/ (accessed on 22.08.2022).

[5] "Smart stops" with Wi-Fi installed in Zhukovsky. Interfax Russia. Aug. 30, 2019. URL: https://www.interfax-russia.ru/center/novosti-podmoskovya/umnye-ostanovki-s-wi-fi-ustanovili-v-zhukovskom (accessed on 08.03.2022).

Zhukovsky, where the development and manufacture of various products for the Russian industry based on additive technologies and 3D printing takes place.[6] In Koltsovo a system using the Internet of Things is being deployed. The city is developing a network of smart energy-efficient LED lightings which cover 70% of Koltsovo streets and 80% of the adjacent areas.[7] "Digital Korolev" is a program that integrates on the basis of computer systems, digital communication channels and sensors programs in the field of healthcare, housing and utility services and getting feedback from citizens. It is designed to improve and upgrade the management processes.[8]

Michurinsk has implemented a number of projects in the area of modern technologies introduced in the urban economy and tourism. These are information boards at stopping points, temperature controllers in apartment buildings, digital model of the city and intelligent video.[9] Obninsk was the first settlement of the Kaluga region to adopt an automated metering system for housing and public utilities — smart meters, which provide greater transparency of utility bills and relieve residents of apartment buildings from inconvenience of manually transmitting data.[10] "The Smart City" company is functioning in Protvino: the main activity is the creation of automated technological control systems for various sectors of the housing and utility services and the entire management complex of the municipality. Development strategy of Pushchino ensures activities for improvement of city management, for instance, online interaction of the administration with residents through a single citywide information portal and implementation of IT projects under the concepts of "Smart City", "Safe City", "Open Data" and "E-Government".[11] In Troitsk a Smart Grid technology program is being implemented to increase transmission speed of large volume of data covering operation of substation equipment and power lines and, as a result, make the system more reliable. The facilities are equipped with advanced equipment, thanks to which dispatchers can prevent violations and quickly perform the required actions [21].

The "Istok-Audio" company from Fryazino has a unique design — a smart home for hearing-impaired people, which will make their life more comfortable. In such a house, smoke, moisture, and sound recognition sensors are installed — including a crying baby, a doorbell and speech on the TV.[12] The company "ArtEX" developed several systems specifically for digitalizing the housing and communal services sectors, so that each of them — power, water, and heat supply — cooperate flexibly [22].

An important implication of these findings is that Naukograds presently show adaptability of science-driven approach to city governance in terms of smart city projects implementation. That is to say that such governance structure of the city allows to successfully implement smart solutions in various spheres of life of society, which

[6] The Center for Prototyping and Additive Technologies opened in Zhukovsky. RIAMO. Dec. 12, 2019. URL: https://riamo.ru/article/400366/tsentr-prototipirovaniya-i-additivnyh-tehnologij-otkrylsya-v-zhukovskom.xl (accessed on 13.09.2022).

[7] The Smart City system in Koltsovo will cost more than 200 million. Vesti Novosibirsk. Sep. 17, 2020. URL: https://www.nsktv.ru/news/city/sistema_umnyy_gorod_v_koltsovo_oboydyetsya_v_bolee_chem_200_millionov__170920191906/ (accessed on 18.09.2022).

[8] The digital management program is planned to be implemented in Korolev as part of a development strategy. Moscow Region Government. May 17, 2019. URL: https://mosreg.ru/sobytiya/novosti/myn-obrazovaniya/korolev/intervyu-programmu-cifrovogo-upravleniya-realizuyut-v-koroleve-v-ramkah-strategii-razvitiya-8689 (accessed on 26.09.2022).

[9] Michurinsk presented achievements in the Smart City project implementation. Science City Michurinsk. Mar. 28, 2019. URL: https://мичуринск-наукоград.рф/news/2019–03–28/michurinsk-prezentoval-dostizheniya-v-sfere-realizacii-proekta-umnyy-gorod (accessed on 15.10.2022).

[10] Telemetry from Rostelecom brought comfort to Obninsk's homes, and savings to families. KP40.ru. Oct. 19, 2018. URL: https://www.kp40.ru/site/releases/company/52760/ (accessed on 11.01.2023).

[11] Science city Pushchino submitted a development strategy for approval by the Scientific and Technical Council. Ministry of Investment, Industry and Science of the Moscow Region. 21.10.2016. URL: https://mii.mosreg.ru/sobytiya/novosti-ministerstva/naukograd-puschino-vynes-na-utverzhdenie-nauchnotehnicheskogo-soveta-strategiyu-razvitiya-20161021 (accessed on 15.11.2022).

[12] Fryazino's company introduced a smart home for the hearing impaired to Japanese delegation. 360TV. Jan. 30, 2018. URL: https://360tv.ru/news/nauka/frjazinskaja-kompanija-predstavila-delegatsii-iz-japonii-umnyj-dom-dlja-slaboslyshaschih/ (accessed on 25.11.2022). (In Russ.).

is now also one of the strategic objectives of Naukograds' long-term development.

## CONCLUSION

Western philosophy as envisioned by Plato and Aristotle has traditionally highlighted the city as the natural place of human interaction and focused on intellectual and not mere technological growth. The research-driven cities of the Russian Federation reconnect to this idea and can be a significant local form of organization of innovative activity and the growth factor of the new digital economy. Naukograd would play a pivotal role in the advancement of specific regions and the country as a whole. Moreover, they are based on the important notion that investment in persons plays a more important role than in technologies.

Although Naukograds provide a unique background for scientific collaboration, explicitly in the more remote areas of the Russian Federation, there are major shortcomings. One major aspect is here the low likelihood of spill-overs and the costly technological adaptation of new technologies. Besides, the national innovation and research system should be integrated to unite efforts of governing bodies at all levels, to organizations and businesses in the interests of accelerating use of science and technology. This is required to maintain and increase the future of research-driven cities in order to achieve national development goals and objectives. At the same time, the notion of Naukograd offers also some conceptional value for existing smart city development approaches rather based on the notion of market forces, which ultimately result in a bottom-up process of technological evolution. The notion that technology requires some sort of concentration of resources and specific habitat for research and development might provide some added value for perspectives on smart city planning.

The case of Naukograds can also become a fundamental methodological basis for the smart city planners and developers. The main implication is the approach to the formation of a "smart nation" (qualified and educated), which creates the following innovative and technological value for the country:

1. Favorable conditions for the development of education and scientific potential, provides access to highly qualified specialists and specialized knowledge.

2. Attracting talent: Naukograds offer a favorable environment for attracting talented and ambitious people. They provide the best conditions for research and creative activity, as well as opportunities for career growth and professional development. This attracts scientific and intellectual leaders, who in turn contribute to the economic and cultural development of the city.

3. Cooperation and innovation: Conditions for cooperation between scientists, researchers, students, and entrepreneurs are created in Naukograds. This promotes the exchange of knowledge and experience, joint research, and projects, as well as the development of innovations. Such cities can become centers for the development of new technologies, scientific discoveries, and progressive solutions in various fields.

4. Economic development: Naukograds focused on human capital have the potential to develop a knowledge economy. Highly educated specialists create innovative products and services that can become the basis for economic growth and attract investment. In addition, scientific and research institutes can become centers for attracting foreign investors.

All these factors make Naukograds attractive for the development of human capital and contribute to the creation of a favorable environment for scientific and intellectual achievements.

It's worth noting that the approach to view a smart city from the perspective of a "smart nation" for the development of a city is not opposed to a technology-driven approach, rather complementing it, and suggesting that smart governance should be also considered in terms of a focus on social capital. Such an approach is applicable both in the development of smart cities "from the ground-up" and for cities where a certain technological infrastructure has already been established.

## REFERENCES

1. Annas J. An introduction to Plato's Republic. 1982. Oxford: Oxford University Press; 1982. 370 p.
2. Mohr R.D. Platonic cosmology. Leiden; Boston, MA: Brill Academic Publishers; 2016. 212 p.

3. Geuss R. Philosophy and real politics. Princeton, NJ; Oxford: Princeton University Press; 2008. 128 p.
4. Mancebo F. Smart city strategies: Time to involve people. Comparing Amsterdam, Barcelona, and Paris. *Journal of Urbanism: International Research on Placemaking and Urban Sustainability*. 2020;13(2):133–152. DOI: 10.1080/17549175.2019.1649711
5. Nam T., Pardo T.A. Conceptualizing smart city with dimensions of technology, people, and institutions. In: Proc. 12th Annu. int. digital government res. conf. on digital government innovation in challenging times (College Park, MD, June 12–15, 2011). New York, NY: Association for Computing Machinery; 2011:282–291. DOI: 10.1145/2037556.2037602
6. Cowley R., Joss S., Dayot Y. The smart city and its publics: Insights from across six UK cities. *Urban Research & Practice*. 2018;11(1):53–77. DOI: 10.1080/17535069.2017.1293150
7. Alawadhi S., Aldama-Nalda A., Chourabi H. et al. Building understanding of smart city initiatives. In: Scholl H.J., Janssen M., Wimmer M.A. et al., eds. Electronic government (EGOV 2012). Berlin, Heidelberg: Springer-Verlag; 2012:40–53. (Lecture Notes in Computer Science. Vol. 7443). DOI: 10.1007/978–3–642–33489–4_4
8. Kamolov S.G. Digital public governance: Trends and risks. *Giornale di storia costituzionale = Journal of Constitutional History*. 2017;33(1):185–194. URL: https://www.researchgate.net/publication/319093523_Digital_public_governance_Trends_and_risks (accessed on 12.01.2022).
9. de Jong M., Yu C., Chen X., Wang D., Weijnen M. Developing robust organizational frameworks for Sino-foreign eco-cities: Comparing Sino-Dutch Shenzhen Low Carbon City with other initiatives. *Journal of Cleaner Production*. 2013;57:209–220. DOI: 10.1016/j.jclepro.2013.06.036
10. Ben Letaifa S. How to strategize smart cities: Revealing the SMART model. *Journal of Business Research*. 2015;68(7):1414–1419. DOI: 10.1016/j.jbusres.2015.01.024
11. Del Giudice M., Della Peruta M.R., Maggioni V. The "right" knowledge and spin-off processes: An empirical analysis on knowledge transfer. *Journal of the Knowledge Economy*. 2013;4(3):304–318. DOI: 10.1007/s13132–013–0160–9
12. Campanella F., Della Peruta M.R., Bresciani S., Dezi L. Quadruple helix, and firms' performance: An empirical verification in Europe. *The Journal of Technology Transfer*. 2017;42(2):267–284. DOI: 10.1007/s10961–016–9500–9
13. Kamolov S.G., Smagina A.A. Digital innovation technologies in public governance: Budget geolocation system. In: Popkova E., Sergi B., eds. Scientific and technical revolution: Yesterday, today and tomorrow (ISC 2019). Cham: Springer-Verlag; 2020;467–475. (Lecture Notes in Networks and Systems. Vol 129). DOI: 10.1007/978–3–030–47945–9_52
14. Scuotto V., Ferraris A., Bresciani S. Internet of things. *Business Process Management Journal*. 2016;22(2):357–367. DOI: 10.1108/BPMJ-05–2015–0074
15. Akinfeeva E.V., Abramov V.I. The role of science cities in the development of the national innovation system in Russia. *Studies on Russian Economic Development*. 2015;26(1):91–99. DOI: 10.1134/S 1075700715010025 (In Russ.: *Problemy prognozirovaniya*. 2015;(1):129–139).
16. Miao J., Benneworth P., Phelps N.A., eds. Making 21st century knowledge complexes. London: Routledge; 2015. 322 p.
17. Lappo G.M., Polyan P.M. Science towns in Russia: The forbidden cities of yesterday — the drivers of growth for today. *Mir Rossii. Sotsiologiya. Etnologiya = Universe of Russia. Sociology. Ethnology*. 2008;17(1):20–49. (In Russ.).
18. Lapshinova K. Russian science cities in the innovative economy of modern Russia. *Sotsial'naya politika i sotsiologiya = Social Policy and Sociology*. 2009;(4):134–143. (In Russ.).
19. Glisin F.F., Razin V.L., Khabarova T.V. Science cities in the contemporary Russian economy. *Innovatsii = Innovations*. 2011;(2):71–76. (In Russ.).
20. Gusev A. Science cities: Forgotten issue or revival? *Upravlenie naukoi i naukometriya = Science Governance and Scientometrics*. 2015;10(2):42–60. (In Russ.).

21. Knyaginin V.N., Kuzmina A.S., Lipetskaya M.S. et al. Priority directions for the introduction of smart city technologies in Russian cities: Expert and analytical report. Moscow: Center for Strategic Research; 2018. 178 p. URL: https://www.csr.ru/upload/iblock/bdc/bdc711b002e9651fb2763d98c7f7daa6.pdf (accessed on 20.11.2022). (In Russ.).
22. Kalacheva S. Residents and investors of Chernogolovka are actively turning to the services of the Geoportal of the Moscow region. Nov 16, 2023. URL: https://inchernogolovka.ru/news/novosti_podmoskovya/145-mln-raz-zhiteli-i-investory-obratilis-k-servisam-geoportala-podmoskovja (accessed on 18.11.2023). (In Russ.).

## ABOUT THE AUTHORS

***Sergei G. Kamolov*** — Dr. Sci. (Econ.), Professor, Associate Professor, Department of Asset Management, MGIMO University, Moscow, Russia; Professor of the Department of State and Municipal Management, Financial University, Moscow, Russia
https://orcid.org/0000-0003-1144-4486
*Corresponding author:*
s.kamolov@inno.mgimo.ru

***Kab Sung Kim*** — Professor, Department of Urban Planning and Engineering, Yonsei University, Seoul, Korea
kabsung@yonsei.ac.kr
https://orcid.org/0000-0002-2621-4571

***Nikita D. Aleksandrov*** — PhD student, Department of Asset Management, MGIMO University; Moscow, Russia
https://orcid.org/0000-0002-8659-764X
aleksandrov_n_d@my.mgimo.ru

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## Appendix

*Table*

**Russian Naukograds' economic indicators**

| Naukograd/region | Population | Income per capita (US dollars) | Investments in fixed assets (thousands of US dollars) | Contribution of the city to the region's total investments in fixed assets | Total income (thousands of US dollars) | Contribution of the city to the region's total income | Budget expenditures on ICT and digital technologies (DT) (thousands of US dollars) | Contribution of the city to the region's budget expenditure on ICT and DT | Budget expenditures on social sphere (thousands of US dollars) | Contribution of the city to the region's budget expenditure on social sphere |
|---|---|---|---|---|---|---|---|---|---|---|
| Obninsk | 129584 | 608 | 133 | 0.01% | 71190 | 10.23% | 268 | 0.23% | 12601 | 53.99% |
| Kaluga Region | 342936 | 443 | 1620253 | | 695722 | | 118291 | | 23339 | |
| Koltsovo | 17465 | 784 | 28177 | 2.33% | 10150 | 0.26% | 82 | 0.01% | 765 | 1.64% |
| Sverdlovsk Region | 4239161 | 509 | 1207595 | | 3967386 | | 577507 | | 46505 | |
| Michurinsk | 90451 | 509 | 32729 | 3.27% | 10002 | 1.62% | 615 | 1.35% | 552 | 2.81% |
| Tambov Region | 966250 | 382 | 1000000 | | 617109 | | 45608 | | 19681 | |
| Biysk | 196442 | 1378 | 2000 | 0.13% | 1633 | 0.18% | 19 | 0.02% | 2265 | 5.21% |
| Altai Region | 2333800 | 329 | 1574684 | | 916139 | | 99848 | | 43496 | |
| Protvino | 36985 | 700 | 27127 | 0.87% | 11006 | 3.71% | 131 | 0.24% | 496 | 5.77% |
| Zhukovsky | 110507 | 880 | 22614 | | 36013 | | 63 | | 59 | |
| Korolev | 224248 | 915 | 143 | | 23051 | | 96 | | 396 | |
| Dubna | 74193 | 656 | 1827 | | 40832 | | 593 | | 44 | |
| Pushchino | 19392 | 720 | 1359 | | 5879 | | 262 | | 5285 | |
| Troitsk | 70301 | 629 | 3119 | | 46161 | | 185 | | 4661 | |
| Fryazino | 60580 | 961 | 62444 | | 15866 | | 831 | | 832 | |
| Chernogolovka | 22627 | 866 | 1783 | | 17222 | | 702 | | 567 | |
| Reutov | 147000 | 827 | 2676 | | 53165 | | 156 | | 415 | |
| Moscow Region | 8591736 | 680 | 14101265 | | 6725151.9 | | 1278050 | | 221084 | |

*Source:* compiled by the authors based on the data of Rosstat. URL: https://eng.rosstat.gov.ru/folder/75924

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# Identification of Factors Influencing the Construction of Supply Chains in China's Transport and Logistics Systems

**W. Xiugang, A.A. Lysochenko**
South Federal University, Rostov-on-Don, Russia

**ABSTRACT**

The purpose of the study is to find approaches to identifying factors influencing the construction of supply chains in China's transport and logistics systems, which is becoming especially relevant in the context of the country's "new economy" dictated by the active development of digital technologies, e-commerce and changing consumer behavior. Based on a multidimensional analytical review of scientific sources, the classification of internal and external factors affecting supply chain management in China's transportation and logistics systems is substantiated. The author's configuration of these factors is proposed, taking into account regional differences, and the structure of the factor field is formed. The result of the research from a scientific point of view was an assessment of the functional effectiveness of supply chain management from the perspective of traditional factors such as natural resources, capital, labor and land, as well as transformational and transactional, including human (skills, qualifications, knowledge), scientific and technological (research, innovation, technology) and material (infrastructure, equipment, materials) factors. The theoretical significance of the study lies in the formation of a configuration of internal and external factors affecting supply chain management in China's transport and logistics systems, taking into account regional differences. The results of the work include the development of recommendations aimed at optimizing logistics processes, diversifying risks and adapting to changing conditions in the global market.

***Keywords:*** supply chain management; identification of factors; classification; external factors; internal factors; transportation and logistics systems; China

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## INTRODUCTION

Digitalization of transport and logistics supply chains (SCs) in order to increase the efficiency and transparency of logistics processes is one of the priority areas for the development of the Chinese economy [1]. In addition to social and production issues, in the course of implementing the "dual circulation" strategy, the Chinese expert community draws attention to the need for the effective development of transport logistics in general and internal supply chains in particular, which allows for greater connectivity and efficiency of the country's domestic market [2].

According to Chinese expert He Dengcai, the integration of logistics into the digital ecosystem is of great importance both for meeting society's needs for quality logistics services and for improving living standards in general. In turn, Professor Dongbei Wang Xuhui emphasizes the importance of integrating digital technologies into the logistics industry and using the "online Silk Road" to strengthen ties between Chinese regions [3, p. 16].

However, in the context of global economic crises, political instability and sanctions pressure, the transport and logistics systems of the PRC are faced with certain factors that significantly affect their functionality and sustainability. In particular, sanctions aimed at restricting international trade and economic relations serve as additional challenges for them and have a certain impact, creating instability and breaks in supply chains.

However, restrictions on exports and imports can cause supply problems (affecting production processes and global availability of goods), while difficulties with banking procedures, the use of alternative currencies and changes in customs regulations create additional complexities in financial transactions, affecting on the efficiency of logistics operations.

In order to identify factors influencing the construction of supply chains in transport and logistics systems in China, it is proposed:

a) review existing methodological approaches to solving this problem;

b) systematize internal and external factors influencing supply chain management in transport and logistics systems;

c) propose the author's configuration of these factors and their assessment, taking into account regional differences within the country.

The research methodology involves the use of analytical and statistical, as well as general scientific methods (generalization and analogy, comparison, juxtaposition, interpretation, etc.), as well as taking into account the opinions of experts in the field of logistics and international relations and the results of empirical research carried out by the author. In addition, they reviewed strategic planning documents of the Chinese Government, scientific publications by economists, reference and analytical materials. All this ensured the scientific validity of the work carried out and the reliability of its results.

The scientific novelty of the study lies in the author's proposal of a configuration of factors influencing supply chain management in China's transport and logistics systems, taking into account the differences inherent in the country's regions.

## METHODOLOGICAL APPROACHES TO IDENTIFYING FACTORS INFLUENCING THE CONSTRUCTION OF SUPPLY CHAINS

The work of a number of specialists is devoted to the study of factors influencing the construction of SC in transport and logistics systems, namely the analysis of their efficiency and sustainability. For example, article [4] talks about the impact of risk management

*Table 1*

**Scientific approaches to the identification of factors influencing the construction of supply chains**

| Approach | Representatives | Description |
|---|---|---|
| Systematic approach | Donald Bollu Hull Lou, Martin Christopher | Considers supply chains as a complex system consisting of interconnected elements and processes |
| Strategical approach | David Simchi-Levi Sander de Liger, Robin Lamberson | Focuses on strategic supply chain management and identifies strategy drivers |
| Technological approach | Howie Lee, James Lapidus, Robert Handfield | Focuses on technological innovation and its impact on supply chain management |
| Client-oriented approach | Mark Barnes, Christopher Sauer Daniel King | Focuses on customer needs and requirements and analyzes factors that satisfy their needs |

*Source:* compiled by the author.

on the resilience and vulnerability of supply chains. The publication [5] identified problems and challenges associated with risk management in SCs in the automotive and electronics industries. The results presented by the authors are based on an analysis of the sources of risks, as well as methods of managing them and measures to reduce risks in these industries. T.N. Odintsova and I. Yu. Yaguzinskaya consider methodological issues of systematization of risks in logistics processes when building supply chains, their identification, assessment of the reasons for their occurrence and methods of minimization [6], and Yu.A. Ilyina studies the influence of the macroenvironment on the supply chain, in particular, under conditions of economic restrictions [7].

The contribution of Chinese scientists to the study of this problem is significant. Thus, Y. Zhang analyzed both the practical experience of the policy of reform and opening up, as well as the limiting factors and main components of SC management in transport and logistics systems [8], and Y. Caping analyzed global trends and management challenges, as well as its inherent limitations and key elements [9]. The works of H. Zhang [10] are aimed at taking into account the infrastructure and technological aspects of the country's transport and logistics systems; D. Zhao [11] identified factors that hinder the effective operation of logistics companies in China.

Foley & Lardner LLP has focused on optimizing logistics processes and resources in SC management.[1]

If we talk about scientific approaches to identifying factors influencing the construction of supply chains, then among them there are 4 main ones (*Table 1*). They are interconnected and can be combined.

In the context of the identified approaches, factors can be classified according to various criteria, including their nature or origin, including [12, 13]:

1. Structural factors related to the basic structure and configuration of the supply chain: geographic location, number and location of warehouses, production facilities

[1] How has supply chain management changed due to COVID-19? Herz Corporation (official website). URL: https://herzcorporation.com/ru/news/supply-chain-management-shifts-covid-19/

and technical infrastructure. For example, a certain warehouse capacity or physical logistics capabilities may be structural limiting factors.

2. Commercial factors related to customer requirements, seasonal fluctuations in demand, market conditions or product quality. For example, changes in demand for a certain product or customer conditions regarding delivery times can become commercial limiting factors.

3. Operational factors associated with activity processes in the SC, such as supply planning processes, inventory management, delivery logistics, etc. Operational limit factors may include production time constraints, delivery delays, or resource shortages.

4. Functional factors related to the interaction between different functional units within the company or partners in the supply chain. These include coordination between sales, production and logistics departments, information exchange and synchronization of actions. Lack of coherence in the activities of departments within the organization or when interacting with partners can become a functional limiting factor.

Optimizing your supply chain structure by taking into account the above factors will achieve optimal SC management, provide a competitive advantage and satisfy customer needs.

Some experts [14, 15] classify factors of the internal and external environment of supply chains, taking into account uncertainty and risk:

1. System complexity: SCs include many interconnected elements, processes and actors. Difficulties may arise due to the large number of participants, the variety of goods and services, and various processes and stages. Managing such a system requires special approaches and methods.

2. Uncertainty and stochasticity of parameters such as demand, transport conditions, prices, customs procedures, etc. All this can create problems and lead to uncertainty in the planning and management of the SC.

3. Conflicting Interests of Entities: Supply chain participants — suppliers, manufacturers, distributors, retailers, and others — have their own unique interests, strategies, and priorities, which can lead to a number of conflicts and difficulties in the collaboration process.

4. Supply chain dynamism: the ability to adapt and respond to constantly changing environmental conditions, such as changes in legislation and standards, globalization and geopolitical factors, market and consumer demands, technological innovation, etc., which allows maintaining a high level of business flexibility processes in the SC and invest in technologies and strategies that promote adaptation.

For a more detailed understanding of the role of limiting factors in CPU management, we can divide them into geographical and level ones.

It is worth noting that the concept of "limit factor" (in the context of supply chain management) is a management category. This concept is used to refer to limiting or slowing factors that can affect the efficiency and performance of the SC [16].

The level structure of limit factors includes:

1. Global limit factors. Represent a key level of constraint factors that can significantly impact global supply chain management (including supplier selection, delivery strategies and overall coordination). These include: political stability, international trade agreements, the global economic situation, trends and changes in consumer demand, the competitive environment and innovations in world markets.

2. National limit factors. They include various aspects of political, economic, legal and socio-cultural conditions that influence the management of SC in a particular country. For example, legal requirements, tax policy, tariff barriers, infrastructure, availability of resources, etc.

3. Regional limit factors. They play a key role in shaping and defining supply chain management strategies in specific regions and represent various aspects (geographical features, climatic conditions, cultural differences, the specifics of local markets, including consumer preferences, competitive environment and local trading practices, regional infrastructure). These factors can vary significantly from one region to another and influence the choice of warehouse locations and transport routes, inventory management strategies and other aspects of SC management.

4. Local limit factors. These are location-specific conditions and can significantly impact the effectiveness of supply chain management at the city, district, or even site level. These include the availability of transport infrastructure, the availability of qualified personnel, local legal and regulatory requirements, cultural and linguistic characteristics of the participants in the SC. All this may require adaptation of communication and management approaches for effective collaboration [17, 18].

In addition to these, there are many factors in various areas that can significantly influence supply chain management, such as those related to logistics, technology, market competition, legislation, finance and other aspects [19, 20]. Considering additional factors can help create a more comprehensive and adaptive strategic approach to SC management.

Summarizing the analysis of studies and reviews in the field of supply chain management in transport and logistics systems, we can conclude that most experts emphasize the need for a comprehensive analysis of limit factors affecting supply chain management (*Table 2*).

For systematization and analysis, the identified factors in SC management can be classified into main categories (*Table 3*).

## FEATURES OF SUPPLY CHAIN MANAGEMENT IN CHINA

In China, as in other countries, there are a number of unresolved problematic issues related to supply chain management in transport and logistics systems. Communications and information technologies play an important role in the development of the country's "new economy" and its functioning, the emergence of which has created new opportunities for entrepreneurship, e-commerce and information exchange [21, 22].

National characteristics of China associated with new technologies include the following aspects:

- Scale and density of Internet users. China is the world's largest Internet market, which creates great opportunities for the development of e-commerce, online platforms and digital services.
- Mobile communications. Mobile Internet plays a key role in transforming various aspects of daily life and business in the country and serves as a tool for mobile commerce, online payments and other mobile services.
- Digital platforms and e-commerce. China has developed various digital platforms, such as Alibaba (Taobao, Tmall), JD.com, Pinduoduo, etc., which provide infrastructure for e-commerce, facilitate interaction between sellers and buyers, and offer various services and business opportunities.

*Table 2*

**Factors influencing supply chain management in transportation and logistics systems**

| Criterion | Limit Factor | Key Factors Affecting Supply Chain Efficiency |
|---|---|---|
| 1. Transport infrastructure | Insufficient development of the transport network, limited accessibility and capacity of ports, road and railway infrastructure | Availability of a well-developed and efficient transport infrastructure, quality of roads, ports, warehouses and other logistics facilities |
| 2. Customs procedures and regulation | Difficulties and delays in customs clearance, certification and licensing requirements, changes in customs legislation, restrictions on the import/export of goods can limit the smooth movement of goods through supply chains | The development of efficient and automated customs clearance systems can reduce delays at border crossings. The introduction of electronic systems for declaration and exchange of information between customs and supply chain participants allows speeding up processes and increasing transparency |
| 3. Geographical features | Long distances, difficulty of delivery to remote areas, inaccessibility of certain regions | Investments in the development of transport networks (including roads, railways, ports and airports, improving the quality and efficiency of transport infrastructure can improve accessibility to remote areas and facilitate faster and more reliable delivery of goods |
| 4. Technologies and information systems | Insufficient use of modern technologies and information systems in supply chain management can limit automation and process optimization | The use of modern information technologies and management systems, such as inventory management systems (WMS), cargo tracking, etc., helps to increase efficiency and transparency in supply chain management |
| 5. Partners, suppliers and contractors | Imperfections in the work of suppliers and partners, problems with the quality of goods or services, ineffective cooperation | Collaboration and information sharing among supply chain participants promote coordination and collaborative problem solving |
| 6. Financial aspects | Constraints on capital availability, high financial costs, exchange rate instability | Developing a strategy to diversify funding sources can reduce dependence on limited capital availability. Implementing effective financial systems and processes, such as automated accounting and payment systems, helps manage financial risks and reduce transaction costs |

*Source:* compiled by the author.

*Table 3*

**Classification of internal and external factors affecting supply chain management in transport and logistics systems**

| Factor | Description |
|---|---|
| **External factors** | |
| Economic factors | Macroeconomic situation, inflation, exchange rate fluctuations, interest rates, unemployment rate, etc. |
| Political and legal factors | Political stability, legislative requirements, tax policy, international documents, etc. |
| Sociocultural factors | Demographic changes, social and cultural trends, consumer preferences, safety standards and ethical requirements |
| Technological factors | Technology development, digitalization, automation, Internet of Things (IOT), artificial intelligence (AI) and other technological innovations |
| **Internal factors** | |
| Strategic factors | Strategic planning, goals and mission of the organization, selection of market segments and positioning, competitive advantages, etc. |
| Organizational factors | Organizational structure, management system, distribution of responsibilities and roles, coordination and communication within the organization |
| Logistics factors | Inventory management, warehouse activities, transport, packaging, transportation and delivery, coordination and synchronization of logistics processes, other aspects of logistics |
| Informational factors | Availability and quality of information, information management systems, data exchange within and outside the supply chain, analytics and forecasting |

*Source:* compiled by the author.

*Table 4*

**Breakdown of China's regions to assess the level of supply chain management in the country's transportation and logistics networks**

| Region | Peculiarities |
|---|---|
| Northern China | Developed infrastructure and high level of technological maturity. Dense network of production and logistics centers. High demand for digital solutions for supply chain management |
| Northeast China | Historical industrial regions with potential for innovation. Availability of advanced manufacturing and technology companies |
| Eastern China | Availability of technology centers and innovations. Advanced international connections and diversity of economic sectors influencing the specificity of supply chains in this region |
| South China | Leading technology centers focused on innovation and digital transformation |
| Central China | Emerging regions with potential to improve supply chain management systems using digital technologies |
| Southwest China | Unique regions with digitalization needs to manage complex supply chains |

*Source:* compiled by the author.

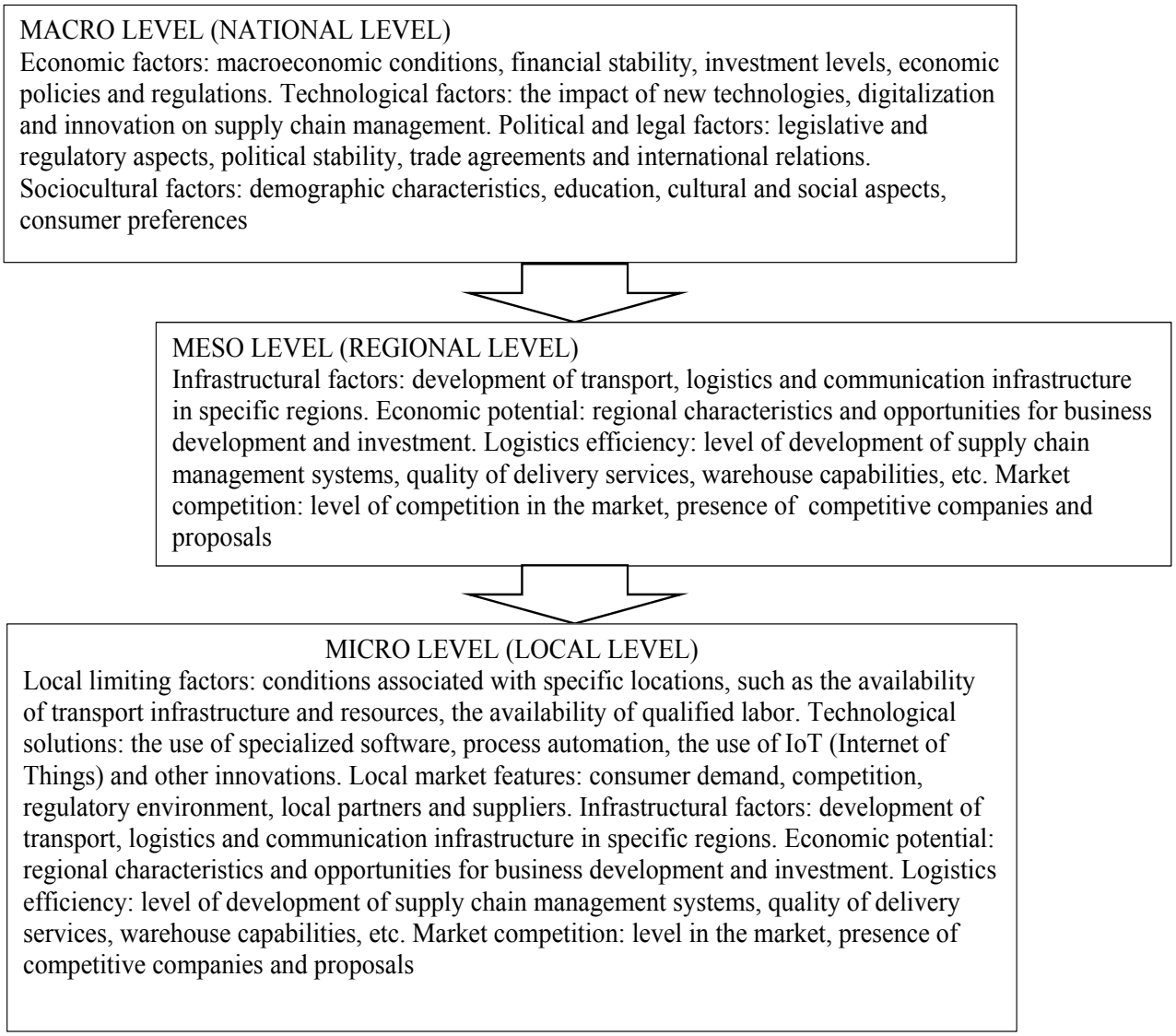


*Fig. 1.* **Configuration of factors affecting supply chain management in China's transport and logistics systems**

*Source:* compiled by the author.

• Social media and consumer interaction. Popular social media platforms such as WeChat, Weibo and Douyin (TikTok) provide opportunities not only for communication, but also for shopping, ordering services and even participating in online events.

• Innovation and technological progress. China takes a leading position in the development of information technologies (such as artificial intelligence (AI), blockchain, big data and others), which are actively developed and applied in various sectors of the economy. They contribute to the creation of new business models, improving the lives of citizens and increasing the competitiveness of the country's economy in the world market.

These features create new challenges and require additional study to effectively adapt to changing conditions.

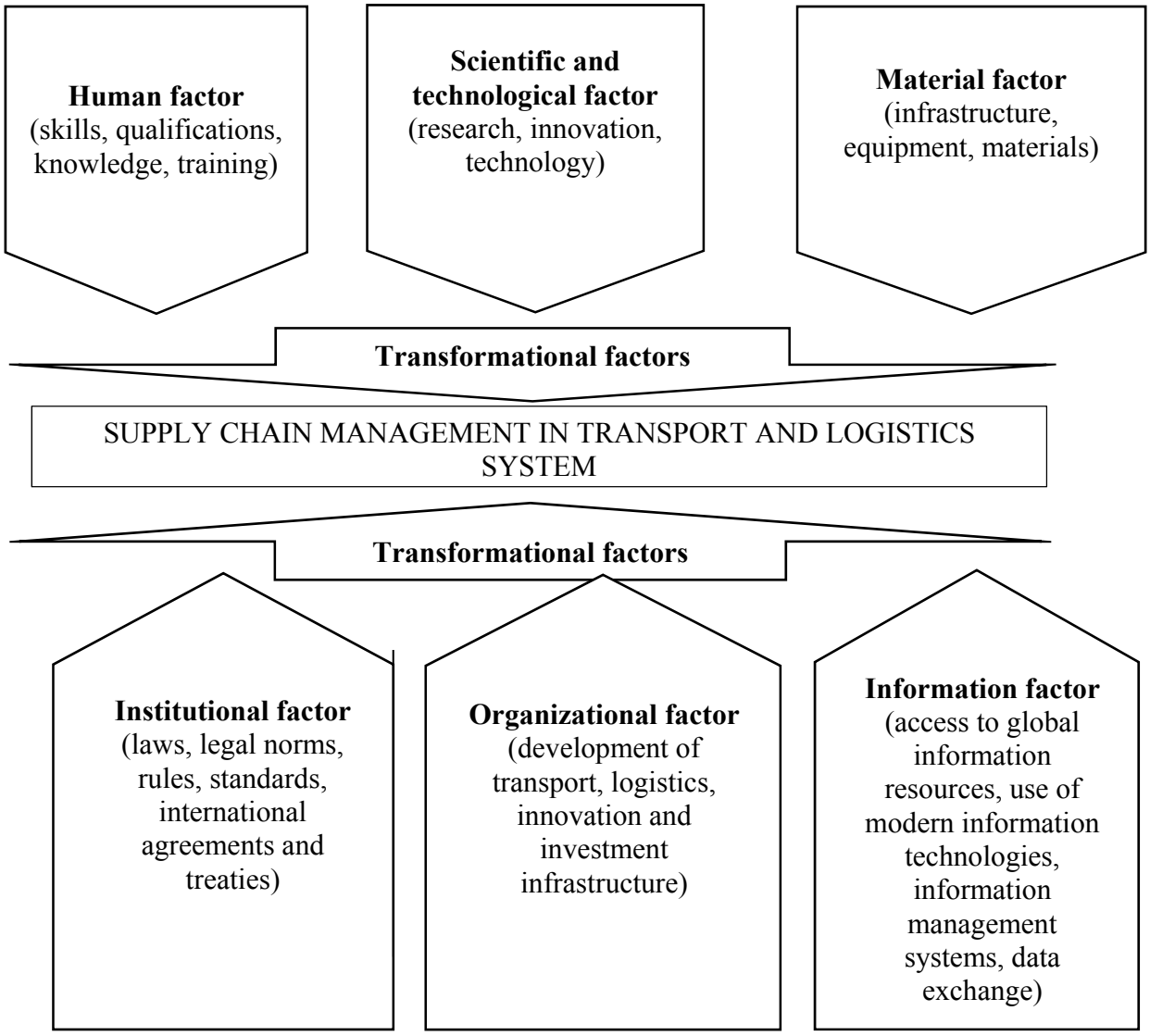


*Fig. 2.* **Structure of the factor field in the sphere of supply chain management in China's transport and logistics systems**

*Source:* compiled by the author.

## CONFIGURATION OF FACTORS AFFECTING SUPPLY CHAIN MANAGEMENT IN CHINA'S TRANSPORT AND LOGISTICS SYSTEMS

Most SC management experts use a small number of factors based on survey data and regression models [23]. However, the use of regression models to analyze a wide range of factors can lead to ambiguous results [24]. Supply chain management is a complex system involving many interrelated factors, and formalized models may be less suitable for describing complex dynamic structures, making it difficult to interpret and assess the impact of each factor individually. However, specific recommendations for developing research policies are often not offered [25].

The author of this article has attempted to formulate a new approach to identifying factors influencing the formation of a

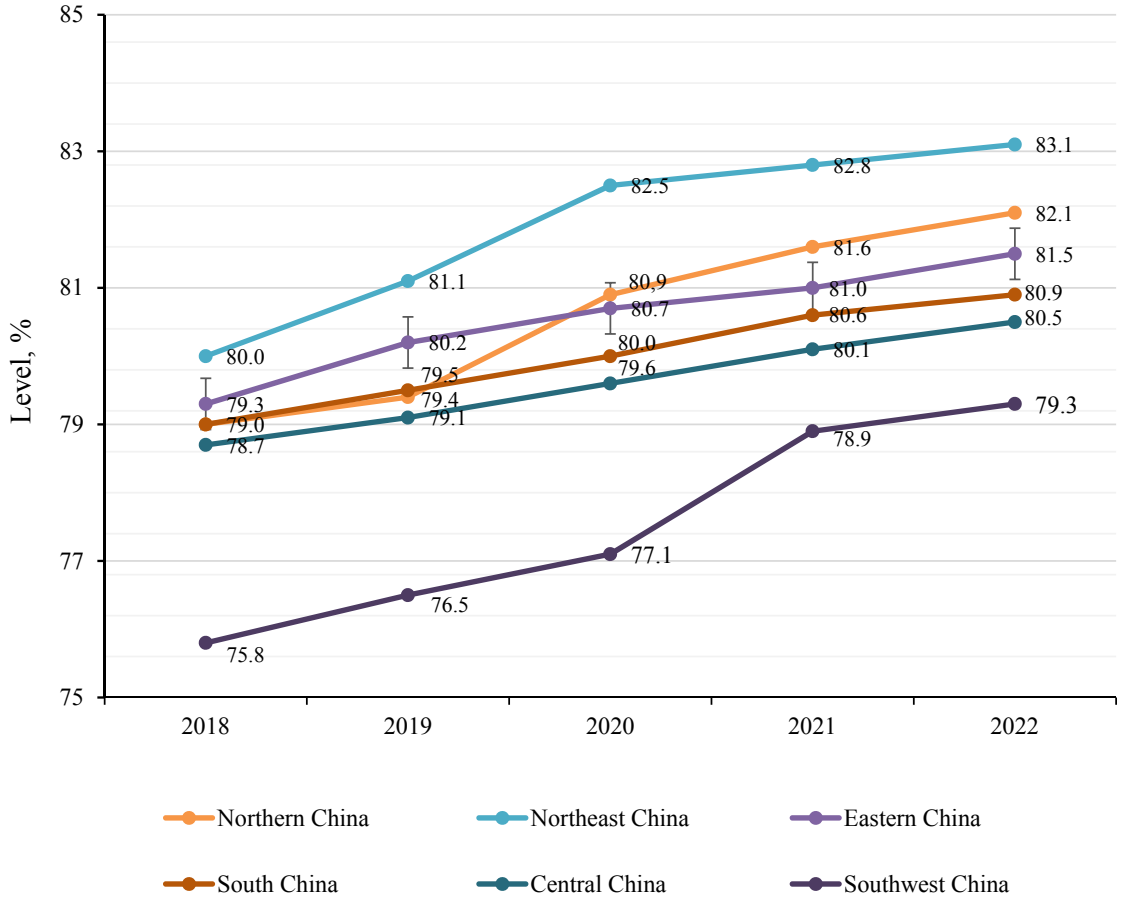


*Fig. 3.* **Assessment of the level of development of transport, logistics, innovation and investment infrastructure in the regions of China, %**

*Source:* compiled by the author.

promising supply chain management system in transport and logistics networks in China, which takes into account regional differences in the level of logistics development, especially in the new economy [26] (*Table 4*). This will allow us to offer solutions that meet the specifics of each region.

Taking into account existing methods and the characteristics of the regions, as well as the importance of the level of technology and digitalization in this area, we will systematize the factors influencing the management of SC in the transport and logistics systems of China, and present their author's configuration (*Fig. 1*). When forming it, macro-, meso- and micro-level aspects were taken into account, taking into account the characteristics of the country and helping to improve the efficiency of SC management at various levels.

The configuration of factors takes into account:

- the territorial specifics of China;
- long distances, the difficulty of delivery to remote areas and the inaccessibility of certain regions. These factors, which influence the sustainability and efficiency of supply chains, require adaptation of existing management strategies;
- quality indicators — assessment of infrastructure (roads, ports, warehouses and other logistics facilities), as well as interaction and cooperation with suppliers and

*Table 5*

**Calculation of the concentration index of transport and logistics networks in the region of China, %**

| Region | Index of digitalization of the regional economy, % | Level of development of transport, logistics, innovation and investment infrastructure in the region, % | Concentration index | Interpretation |
|---|---|---|---|---|
| Northern China | 35.4 | 82.1 | 0.43 | Sustainable territories. They have a certain concentration of transport and logistics networks and central processing centers that operate stably and create potential for further development |
| Northeast China | 35.1 | 83.1 | 0.42 | |
| Eastern China | 31.9 | 81.5 | 0.40 | |
| South China | 31.5 | 80.9 | 0.39 | Territories of stagnation. There is a certain concentration of transport and logistics networks and central processing centers, but they are functioning unstable and need further development |
| Central China | 29.9 | 80.5 | 0.37 | |
| Southwest China | 29.1 | 79.3 | 0.36 | |

*Source:* compiled by the author.

contractors. These conditions are essential to ensure the smooth and efficient movement of goods through the SC.

The effectiveness of supply chain management in China's transport and logistics systems depends not only on traditional ones (natural resources, capital, labor and land), but also on transformational and transactional factors — the structure of the system's factor field is shown in *Fig. 2*.

Transformation factors include a resource component that determines the capabilities and means that are supposed to be used for effective management of the SC, and combines human (skills, qualifications, knowledge), scientific and technological (research, innovation, technology) and material factors (infrastructure, equipment, materials).

Transactional, or operational, includes institutional (laws, norms, rules), organizational (structure, organizational processes), information (information management systems, data exchange) factors that determine the connections, relationships and processes in which resources are involved for effective management SC.

The assessment of the development of transport, logistics, innovation and investment infrastructure in the regions of China, carried out as part of the study, highlights the differences in the level of their development. A high level is typical for the Northern (82.1%),

Northeastern (83.1%), Eastern (81.5%) and Southern (80.9%) regions of China; the smallest is observed in the Center (80.5%) and in the South-West of the country (79.3%) (*Fig. 3*).

The calculation of the concentration index of transport and logistics networks in the regions of China is given in *Table 5*.

Thus, regional differences in the level of construction of a country's logistics infrastructure are obvious, and it is important to continue to work on improving it in less developed areas to ensure more efficient operation of supply chains as a whole. Adaptation of SC management strategies must take into account the specifics of each region to optimally use its potential.

## CONCLUSION

The article attempts to formulate a new approach to identifying factors influencing supply chain management in China's transport and logistics systems, taking into account regional differences.

The author shows that the functional efficiency of SC management depends on a wide range of factors — traditional (natural resources, capital, labor and land), transformational (technology, information systems and organizational approaches) and transactional (interaction between various supply chain participants, including suppliers, manufacturers, distributors and customers).

The author shows that the functional efficiency of SC management depends on a wide range of factors — traditional (natural resources, capital, labor and land), transformational (technology, information systems and organizational approaches) and transactional (interaction between various supply chain participants, including suppliers, manufacturers, distributors and customers).

Taking into account the configuration of factors when designing the operation of logistics systems is key to assessing their compliance with the principles of sustainable development. This approach allows not only to increase the sustainability and efficiency of SCs, but also to reduce their negative impact on the environment. The results of the study provide a basis for further development of criteria and indicators for assessing supply chain management systems.

## REFERENCES

1. Xiugang W. Digitalization of transport and logistics supply chains: Particularities and prospects in China. *Kreativnaya ekonomika = Journal of Creative Economy*. 2023;17(4):1493–1512. (In Russ.). DOI: 10.18334/ce.17.4.117562
2. Liu X., Zhang K., Chen B., Zhou J., Miao L. Analysis of logistics service supply chain for the One Belt and One Road initiative of China. *Transportation Research Part E: Logistics and Transportation Review*. 2018;117:23–39. DOI: 10.1016/j.tre.2018.01.019
3. Kashin V.B., Pyatachkova A.S., Smirnova V.A., Litvinov A.A., Potashev N.A. Chinese experts on the new five-year plan of the PRC. Analiticheskaia zapiska K6/03/2021. NRU HSE Center for Comprehensive European and International Studies. URL: https://cceis.hse.ru/data/2021/03/29/1386510407/14-я%20пятилетка.pdf (accessed on 20.05.2023). (In Russ.).
4. Jüttner U., Maklan S. Supply chain resilience in the global financial crisis: An empirical study. *Supply Chain Management*. 2011;16(4):246–259. DOI: 10.1108/13598541111139062 (In Russ.: *Logistika segodnya = Logistics Today*. 2012;(1):42–63.).
5. Blos M., Quaddus M., Wee H.M., Watanabe K. Supply chain risk management (SCRM): A case study on the automotive and electronic industries in Brazil. *Supply Chain Management*. 2009;14(4): 247–252. DOI: 10.1108/13598540910970072

6. Odintsova T.N., Yaguzhinskaya I. Yu. On risk management in logistic processes of supply chains. *Aktual'nye problemy ekonomiki i menedzhmenta = Actual Problems of Economics and Management*. 2020;(1):128–135. (In Russ.).
7. Il'ina Yu.A. Stability of global supply chains in an unstable external environment. *Aktual'nye voprosy ekonomicheskikh nauk*. 2016;(52):75–79. (In Russ.).
8. Zhang Yu. The experience of Chinese economic reforms and their theoretical significance. Transl. from Chin. Moscow: Shans; 2017. 239 p. (In Russ.).
9. Keping Yu. Global governance trends and China's strategic choices. *Guówài lǐlùn dòngtài = Foreign Theoretical Trends*. 2012;(10):7–10. (In Chin.).
10. Zhang H. Analysis of the achievements of China and Russia in building national innovation systems. *Segodnya i zavtra rossiiskoi ekonomiki = Today and Tomorrow of Russian Economy*. 2010;(33):49–54. (In Russ.).
11. Zhao D. Analysis of China's logistics system in the context of the COVID-19 epidemic. *Izvestiya Sankt-Peterburgskogo gosudarstvennogo ekonomicheskogo universiteta*. 2020;(3):180–184. (In Russ.).
12. Postnikova T.V. Analysis of factors influencing the formation of supply chain subject to constrained logistic infrastructure. *Nauka i obrazovanie: nauchnoe izdanie MGTU im. N.E. Baumana = Science and Education of Bauman MSTU*. 2012;(5):234–244. (In Russ.). DOI: 10.7463/0512.0400544
13. Ivanov D.A., Ivanova M.A. Uncertainty and risks in supply chains: Classification of tasks and directions of future research. *Rossiiskii zhurnal menedzhmenta = Russian Management Journal*. 2015;13(2):99–128. (In Russ.).
14. Aristov V.M. Assessing methods of supply chain security of organizations in the conditions of uncertainty and risk. *Ekonomicheskii vector = Economic Vector*. 2015;(4):6–10. (In Russ.).
15. Gorishnyaya A.A., Chmut G.A. Digital technologies in transport logistics. *Vestnik universiteta (Gosudarstvennyi universitet upravleniya)*. 2021;(8):34–40. (In Russ.). DOI: 10.26425/1816–4277–2021–8–34–40
16. Smeshko O.G. Regional economy: Factors of development. St. Petersburg: St. Petersburg University of Management Technologies and Economics; 2014. 266 p. (In Russ.).
17. Yao Y., Chzhan Y. Dampers of the Sino-Russian cross-border e-commerce. *Kreativnaya ekonomika = Journal of Creative Economy*. 2020;14(8):1725–1736. (In Russ.). DOI: 10.18334/ce.14.8.110738
18. Yan Lvxin. Problems in the development of cross-border e-commerce logistics in China and ways to solve them. *Shangyejingji = Business Economics*. 2016;(4):11–12. (In Chin.).
19. Vershinina E.I., Novikov A.V. Trends and prospects of transport and logistics development. *Vestnik nauki*. 2021;3(12):173–183. (In Russ.).
20. Osintsev N.A., Kazarmshchikova E.V. Factors of sustainable development of transport and logistics systems. *Sovremennye problemy transportnogo kompleksa Rossii = Modern Problems of Russian Transport Complex*. 2017;7(1):13–21. (In Russ.). DOI: 10.18503/2222–9396–2017–7–1–13–21
21. Tomaichuk L.V. Digitalization of China's economy: Risks and opportunities for society. *Evraziiskaya integratsiya: ekonomika, pravo, politika = Eurasian Integration: Economics, Law, Politics*. 2019;(3):31–36. (In Russ.).
22. Zhang L., Chen S. China's digital economy: Opportunities and risks. *Vestnik mezhdunarodnykh organizatsii: obrazovanie, nauka, novaya ekonomika = International Organisations Research Journal*. 2019;14(2):275–303. (In Russ.). DOI: 10.17323/1996–78452019–02–11
23. Greiz G.M., Kuzmenko Yu.G. Evaluation of the effectiveness of regional transport and logistics systems. In: The Urals as the driver of neo-industrial and innovative development of Russia. Proc. 2nd Ural. ekon. forum (Ekaterinburg, October 21–22, 2020). In 2 vols. Vol. 2. Ekaterinburg: Ural State Economic University; 2020:142–144. (In Russ.).

24. Sun Q. Empirical research on coordination evaluation and sustainable development mechanism of regional logistics and new-type urbanization: a panel data analysis from 2000 to 2015 for Liaoning Province in China. *Environmental Science and Pollution Research.* 2017;24(16):14163–14175. DOI: 10.1007/s11356–017–8980-y
25. Chen S., Chen D., Gang M. The regional logistics hubs location problem based on the technique for order preference by similarity to an ideal solution and genetic algorithm: A case of Sichuan. *Journal of Computational & Theoretical Nanoscience.* 2016;13(9):6065–6075. DOI: 10.1166/jctn.2016.5529
26. Xiugang W. Analysis of the development of China's transport economy management. *Ekonomika: vchera, segodnya, zavtra = Economics: Yesterday, Today and Tomorrow*. 2022;12(5–1):145–152. (In Russ.). DOI: 10.34670/AR.2022.88.78.045

## ABOUT THE AUTHORS

***Wang Xiugang*** — PhD student, Department of Management of South Federal University, Rostov-on-Don, Russia
https://orcid.org/0000-0002-4080-0614
*Corresponding author:*
476234770@qq.com

***Alla A. Lysochenko*** — Dr. Sci. (Econ.), Professor, Faculty of Management of South Federal University, Rostov-on-Don, Russia
https://orcid.org/0000-0002-9173-6667
alla44@yandex.ru

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# Study on the Development of Interregional Synergistic Construction (Taking the China-Belarus Industrial Park and the International Land Port of Gansu as Examples)

**T. Qu**
Northwest Normal University, Lanzhou, People's Republic of China

## ABSTRACT

The year 2023 marks the 10th anniversary of the initiation of the "One Belt and One Road" initiative. Belarus, as one of the countries along the One Belt and One Road, is actively responding to the initiative's call and participating in its joint implementation. The author creatively establishes a connection and conducts a profound analysis of the China-Belarus Industrial Park and the International Land Port of Gansu (Lanzhou). The article assesses the present status and development progress of the two projects, identifying pertinent issues and proposing solutions through a methodical approach that combines theoretical analysis with practical application. A theoretical framework for these two projects is presented, aiding in surmounting challenges and charting the future trajectory of collaboration. The study's objective is to introduce novel developmental concepts for Park administrators and policymakers, while also pinpointing fresh avenues for growth within the Park development of both countries, to contribute to economic advancement more effectively.

***Keywords:*** Belt and Road Initiative; interregional development; industrial park; land port; China; Belarus

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## INTRODUCTION

In 2013, President Xi Jinping introduced the "One Belt, One Road" initiative[1] [1], inaugurating a fresh phase of rejuvenating the historic Silk Road.[2] As a result, the China-Belarus Industrial Park and International Land Port of Gansu (Lanzhou) were established. Numerous scholars are captivated by this initiative and the two aforementioned projects. Jiang Ling's [2] research examines the developmental facets of the logistics and warehousing industry within the International Land Port of Gansu. Jin Yuqing [3] delves into strategies for augmenting the competitive edge of the International Land Port of Gansu. Deborah B. and Tang X.Y. [4] center their research on structural transformation and China's special economic zones abroad. Salmygina's [5] study develops the topic on the potential of multilateral economic cooperation between China and Belarus.

It is evident that numerous scholars have conducted extensive research on the aforementioned two projects from various perspectives. Nevertheless, a research gap exists concerning the cross-regional synergistic development of the China-Belarus Industrial Park and International Land Port of Gansu. Given the evolution of global economic integration and the emergence of regional conflicts and other unpredictable factors, it becomes imperative to explore new avenues for the growth of the China-Belarus Industrial Park and International Land Port of Gansu, thereby propelling regional economic advancement.

This paper introduces an innovative approach, proposing a strategy for the cross-regional synergistic

[1] State Council Information Office held a conference on "Building the Belt and Road Initiative: Progress, Contributions and Prospects". URL: https://www.yidaiyilu.gov.cn/p/86763.html (accessed on 22.04.2019).

[2] United Nations Development Program in China: Report on China's Belt and Road Overseas Economic and Trade Cooperation Zones Contributing to Sustainable Development — Analysis and Practical Guidelines Based on Economic, Social and Environmental Frameworks, April 25, 2019. Institute of International Trade and Economic Cooperation of Ministry of Commerce of China.

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development of the China-Belarus Industrial Park and the International Land Port of Gansu. By analyzing the current state of the aforementioned projects, identifying practical challenges, and leveraging their distinct strengths and features, this study creatively advances the concept of cross-regional synergistic development at various levels. The aim is to address complex issues and offer fresh insights and developmental concepts to Park administrators and policymakers. Furthermore, this approach seeks to uncover additional economic prospects and foster enduring regional economic progress for both Parks.

This paper employs the following research methodologies:

- literature research method — by collecting official information and data related to the China-Belarus Industrial Park and the International Land Port of Gansu, this method comprehensively organizes the developmental history and current status of these projects;
- comparative method — through comparative analysis with other European and Chinese industrial parks, this method highlights deficiencies in areas such as financing, market access, logistics, policies, and supporting facilities. This offers a factual foundation for subsequent problem-solving approaches;
- deductive reasoning method — feasibility analyses and specific recommendations are formulated for the Parks concerning policy formulation, investment attraction, logistics, scientific research, and innovation.

## 1. ABOUT CHINA-BELARUS INDUSTRIAL PARK AND INTERNATIONAL LAND PORT OF GANSU (LANZHOU)

The **China-Belarus Industrial Park**, also known as the "Great Stone" Industrial Park, is a specialized economic zone established through an intergovernmental agreement between the People's Republic of China and the Republic of Belarus [6]. In September 2011, an intergovernmental agreement was signed to establish the China-Belarus Industrial Park. On May 12, 2015, Belarusian President Alexander Lukashenko and Chinese President Xi Jinping visited the construction site of the first phase of the China-Belarus Industrial Park [7, 8]. By November 2019, the initial phase of infrastructure development, including roads, pipeline networks, and other facilities, covering an area of 8.5 square kilometers, had been completed in the China-Belarus Industrial Park. The number of officially recognized residents within the park had reached 60 by that time[3] [9].

By May 2023, the China-Belarus Industrial Park boasts a total of 108 resident companies, there are 50 Chinese-funded enterprises, 38 Belarusian enterprises, and 20 enterprises from Europe, America, and other countries in the park, signifying a significant accomplishment in terms of investment attraction. The park's infrastructure and comprehensive support services offer a wide spectrum of business growth prospects, including all-encompassing office complexes, a center for science, technology, and innovation, over ten industrial-standard factory structures, residential accommodations, business-oriented hotels, financial institutions, and various other amenities.

Belarus, being a significant node of the Silk Road Economic Belt, was among the earliest nations to embrace China's "One Belt, One Road" initiative and took active part in it. The collaborative effort resulting in the China-Belarus Industrial Park has witnessed a decade of progress, emerging as a landmark undertaking in the collaborative endeavors between China and Belarus to construct the Silk Road Economic Belt. Moreover, it stands as the largest overseas trade and economic cooperation zone for China, characterized by the highest level of cooperation [10–12].

**International Land Port of Gansu (Lanzhou).** In 2013, President Xi Jinping put forward the "Belt and Road" initiative, inaugurating a fresh phase in the renaissance of the historic Silk Road. Subsequently, in 2016, the province of Gansu and the city of Lanzhou collaboratively embarked on the establishment of a pivotal hub, serving as Gansu Province's gateway to participate in the "Belt and Road" initiative. This endeavor materialized as the International Land Port of Gansu (Lanzhou).

The International Land Port of Gansu (Lanzhou) serves as a significant platform for Gansu Province to facilitate its western opening-up efforts, functioning as a pivotal

[3] China-Belarus Industrial Park. URL: https://industrialpark.by/ (accessed on 10.08.2023).

"Belt and Road" international logistics transit hub and an international trade materials distribution center. During his visit to Gansu, General Secretary Xi Jinping highlighted that the "Belt and Road" presents the greatest opportunity for the province. Moreover, the International Land Port of Gansu (Lanzhou) holds the distinction of being among the pioneer batch of land port-type national logistics hubs, national demonstration logistics parks, inaugural national multimodal intermodal transportation demonstration projects, national-level railway logistics bases, and one of China's 18 railway container centers.[4]

## 2. BOTH OF THE AFOREMENTIONED INITIATIVES HAVE ACHIEVED CERTAIN SUCCESSES IN RECENT YEARS. HOWEVER, THEY ALSO ENCOUNTER CHALLENGES THAT NEED TO BE ADDRESSED

The China-Belarus Industrial Park is currently facing the following issues:

1. **Financial and Market Challenges**. The development of Belarus and the industrial park has been impacted by regional conflicts, leading to specific challenges. From the onset of the Russian-Ukrainian regional conflict in 2022 to the first quarter of 2023, Belarus' economic growth has experienced a downward trajectory. Based on the official data from the State Statistics Committee of Belarus, preliminary estimates indicate that Belarus' GDP in 2022 was approximately 191.4 billion Belarusian rubles (equivalent to about 73.05 billion U.S. dollars at the annual exchange rate of the Central Bank of Belarus). This marked a decline of 4.7% compared to the corresponding period in the previous year. Additionally, in the first quarter of 2023, Belarus' GDP amounted to about 46.5 billion Belarusian rubles, reflecting a decrease of 2.1% compared to the same period in the prior year. The GDP deflator during this time was at 109.4% when compared to the corresponding period last year.[5]

The Belarusian financial system is relatively underdeveloped, primarily focusing on basic financial services. It offers limited financial derivative products and services, and the commercial insurance system is not well-established. Furthermore, the imposition of economic sanctions on Belarus has exacerbated its financial challenges. Notably, Belarusian banking organizations are no longer accepted within the SWIFT system. Moreover, European and American investors face restrictions in collaborating with the National Bank of Belarus and accessing its financial markets.

The combination of various internal and external factors has triggered a sequence of issues. Firstly, Belarus is grappling with a shortage of foreign investment and loans. Additionally, organizations such as the World Bank have ceased offering support for medical, educational, and technical projects in Belarus, contributing to economic decline, fluctuations in exchange rates, and an increase in inflation. Consequently, this has led to a rise in local unemployment rates. These external dynamics have presented significant hurdles for the financing and payment channels of enterprises in the industrial park. They have also escalated investment risks, resulting in practical challenges for the timely implementation of infrastructure and the creation of a conducive business environment by these enterprises. The original sanctions against Belarus in Europe and the United States mainly targeted Belarusian enterprises and individuals; the assets of the sanctioned individuals in Europe were frozen, the sanctioned individuals were banned from entering the European Union, and European Union individuals and enterprises were not allowed to provide funds to the sanctioned individuals. Belarusian products such as timber, steel and potash were banned from being exported to EU countries.

Following the escalation of the Russian-Ukrainian conflict, Europe and the United States broadened their sanctions against Belarus, extending them beyond the previous economic sanctions. These sanctions are progressively encompassing a wider range of products manufactured in Belarus. This extension includes products resulting from collaborations between Belarus and businesses in other nations. As a consequence, the enterprises within the China-Belarus Industrial Park have encountered constraints and limitations due to these sanctions. These sanctions have led to a significant impact on the businesses operating within the industrial park. Their ability to sell products in the European Union

[4] International Land Port of Gansu (Lanzhou). URL: http://lzitlp.lanzhou.gov.cn/ (accessed on 10.08.2023).

[5] National Statistical Committee of Belarus. URL: https://www.belstat.gov.by/ (accessed on 10.08.2023).

market has been severely hindered. Consequently, these enterprises have suffered losses in terms of market access and market share in Europe and the United States.

These sanctions have had a profound impact on Belarus, severely impeding its regular socioeconomic progress. They have amplified the nation's financial deficiencies and caused disruptions in the country's economic supply chain. Consequently, numerous Chinese and Western investors have halted their investment intentions within Belarus. The advantages of the China-Belarus Industrial Park, initially conceived as a strategic gateway for Belarus to access the European Union market, have undergone certain modifications due to these circumstances. As a result, the task of attracting investments has become notably more challenging.

2. **Logistic Challenges.** Belarus heavily relies on imports for its domestic manufacturing, exhibiting a significant dependence on imported raw materials and equipment. The ongoing escalation of the crisis in Ukraine and the repercussions of sanctions have directly impacted logistics, resulting in a reduction in the nation's production capabilities. The European Union and Belarus have imposed mutual trade embargoes, leading to current restrictions on Belarusian road, rail, and air cargo transportation to European countries [13]. Furthermore, transportation towards Ukraine has been completely halted. As reported by the Belarusian Border Committee, the volume of truck traffic entering Belarus from the Lithuanian direction has plummeted by 70% since the regional conflict emerged. This disruption has severely impacted the Belarusian production logistics chain, resulting in a significant decrease in freight turnover.

The successful development of industrial parks necessitates a robust logistics system to support the construction of infrastructure and the operational needs of enterprises, particularly in terms of raw material imports. However, the current logistics situation in Belarus is challenging. This predicament is anticipated to significantly impede the progress of industrial park construction and the import and export operations of businesses. Despite the completion of the initial phase of infrastructure construction within the industrial park, the resident enterprises are grappling with escalated expenses in procuring raw materials, significant pressures to maintain regular productivity levels, and extended production cycles. The logistics-related hindrances have created difficulties in transporting raw materials and machinery to the site, inevitably disrupting the smooth operation of businesses. This situation is not conducive to the progression of the park's second phase of construction and its envisioned high-quality development in the future.

3. **Challenges in Industrial Support.** During the initial establishment of the China-Belarus Industrial Park, emphasis was placed on key sectors such as warehousing and logistics, machinery manufacturing, electronic information, biomedicine, fine chemicals, new materials, e-commerce, big data processing, research and development, as well as social and cultural industries. The selection process for enterprises to be located within the park favored those with high-tech attributes.

However, at present, Belarus lacks adequate supporting conditions to fulfill the developmental needs of high-tech enterprises in areas such as traditional industries, talent acquisition, financial infrastructure, logistics, economic regulations, taxation, customs procedures, and information security. Given the absence of well-defined strategic positioning, development direction, market assessment, development focal points, delineated responsibilities, and institutional structures, embarking on rapid expansion and heightened standards could result in a range of issues. For instance, this approach might lead to overinvestment within a short timeframe, creating future burdens; prolonged investment cycles that challenge risk management; intricate challenges in balancing diverse interests; and sluggish outcomes that may not align with anticipated results.

Problems faced by the International Land Port of Gansu (Lanzhou):

1. **Internal factors** have presented challenges for the International Land Port of Gansu (Lanzhou). On one hand, the China Railway Express has been striving to secure cargo sources from the maritime market, resulting in price suppression. This dependency on financial subsidies from the local government for its operational maintenance and the high operational freight costs, without sufficient independent market-based revenue, highlight a notable lack of marketization within its operation.

On the flip side, the International Land Port of Gansu (Lanzhou) lacks coordination with other central land

ports like Chengdu, Xi'an, and Xinjiang. These ports share similar management models, freight transportation methods, and face the challenge of homogeneity [14–16]. Consequently, the port struggles to establish distinct competitive advantages, making it less appealing to shippers and hindering its ability to become the preferred land port. Furthermore, in comparison to traditional seaports, the International Land Port of Gansu (Lanzhou) falls short in terms of area construction and lacks comprehensive logistics, information services, business, and industrial functions. Particularly, its information infrastructure remains inadequate. Unless pivotal entities such as logistics companies, financial institutions, inspection and quarantine authorities, and customs are integrated into the e-commerce platform and the land port, there's a risk of reduced operational efficiency and diminished economic benefits for the international land port.

2. From an **external perspective**. The infrastructure along the Silk Road Economic Belt is insufficiently developed, with weak existing municipal foundations. The road leading to the land port in Lanzhou City is constrained by limitations, given its considerable distance and remote location. Moreover, the area lacks population concentration and a robust business ambiance.

For development, talent is of paramount importance. In contrast to the southeastern regions, the northwest as a whole suffers from diminished economic dynamism and struggles to attract skilled individuals. This deficiency hampers the region's ability to establish a virtuous economic cycle. The underdeveloped state of the port industry coupled with the proliferation of China-European trains has led to port congestion. This congestion, in turn, has exacerbated the shortage of essential resources along the routes, such as cranes and berths. The frequent changing of rails has further contributed to an overall reduction in the ports' throughput capacity.

## 3. FEASIBILITY OF INTERREGIONAL SYNERGISTIC DEVELOPMENT BETWEEN CHINA-BELARUS INDUSTRIAL PARK AND INTERNATIONAL LAND PORT OF GANSU (LANZHOU)

The International Land Port of Gansu (Lanzhou) serves as a pivotal platform for Gansu Province's engagement with western regions, functioning as an international logistics transit hub and a center for distributing international trade materials. The China-Belarus Industrial Park in Minsk, the capital of Belarus, was a joint endeavor initiated and promoted by the leaders of China and Belarus. This landmark project is a testament to the collaborative efforts of both nations within the framework of the "Belt and Road" initiative, symbolizing the embodiment of their mutually beneficial partnership. Regarded as the "Pearl on the Silk Road Economic Belt", the China-Belarus Industrial Park stands as the largest overseas economic and trade cooperation zone in terms of its planned area, development scale, and the highest level of collaboration China has engaged in for investment and development.

During his visit to Gansu, General Secretary Xi Jinping emphasized that the "Belt and Road" initiative presents the most significant opportunity for the development of Gansu. The International Land Port of Gansu (Lanzhou), distinguished as one of the initial group of land port-type national logistics hubs, national demonstration logistics parks, as well as the pioneering batch of multimodal intermodal transport demonstration projects, national-level railway logistics bases, and one of China's 18 railway container centers, should assertively take the lead in competition against Chengdu International Land Port, Xi'an International Land Port, and Xinjiang International Land Port. This moment is crucial to seize the "Belt and Road" opportunity and expedite the advancement of the International Land Port of Gansu (Lanzhou) in alignment with the "One Belt, One Road" initiative.

The International Land Port of Gansu (Lanzhou) and China-Belarus Industrial Park should leverage each other's strengths in terms of resources and industries, enhance the foundation of cooperation, foster extensive collaboration, and share the outcomes of their joint efforts to attain a mutually beneficial outcome.[6]

[6] Vision and Actions on Jointly Building Silk Road Economic Belt and 21st Century Maritime Silk Road. NDRC, MFA and MOC (National Development and Reform Commission, Ministry of Foreign Affairs and Ministry of Commerce of the People's Republic of China with State Council authorization). URL: https://www.ndrc.gov.cn/xwdt/xwfb/201503/t20150328_956036.html (accessed on 28.03.2015).

Cooperation can be explored in the following areas:

**1. Policy Formulation.** Implement a "government-led, market-oriented operation" model by integrating funds from financial and social aspects for construction. Interpret and align investment policies of the International Land Port of Gansu (Lanzhou) and the "Decree of the President of the Republic of Belarus on the Special Legal Regime of the 'Great Stone' China-Belarus Industrial Park", among other documents. Enhance coordination of trade laws and regulations and mutual recognition of standards. Establish a cooperative mechanism and platform for fair, just, and scientifically grounded standards recognition based on international standards. Promote mutual recognition of standards following international criteria, facilitating certification for enterprises. Strengthen collaboration in transport, customs, and trade facilitation. Foster ties with think tanks, encouraging policy planning and information exchange to build mutual trust. Provide intellectual support and offer professional legal advice and technical standards training to enterprises.[7] Develop industry-specific standards in areas such as warehousing and logistics, machinery manufacturing, electronic information, biomedicine, fine chemicals, new materials, e-commerce, big data processing, research and development, and social and cultural industries.[8]

**2. Investment Attraction.** Avoid excessive protectionism of existing industries in the China-Belarus Industrial Park and refrain from pursuing high-profile developments without balance. Embrace the notion of independent development and avoid overemphasis solely on high technology, ensuring a conducive environment for a diverse range of sectors like food, light industry, and building materials. To facilitate smooth integration, the International Land Port of Gansu (Lanzhou) should identify high-quality industries aligned with its developmental positioning. Take the initiative to offer preferential policies to attract enterprises in accordance with the development conditions. Focus on nurturing dynamic small and medium-sized enterprises along with local characteristic industries. Strengthen the region's industry competitiveness and proactively engage enterprises that align with the development conditions into Lanzhou. Exploit the strategic location of Lanzhou to establish point-to-point business connections with the China-Belarus Industrial Park. This cooperation will support enterprises in their outbound ventures with the backing of Lanzhou and simultaneously attract high-quality enterprises to invest in the region. Furthermore, attract and develop high-quality projects within Lanzhou, thereby fostering local economic growth.

To address the issue of limited financial services within the China-Belarus Industrial Park, targeted financial preferential policies have been implemented. These policies aim to diversify and broaden the scope of financial cooperation, effectively resolving challenges related to currency exchange and inter-regional investor settlements. In the resource-rich areas of both participating regions, comprehensive "one-stop" services are being offered to streamline and expedite investors' business operations. Additionally, specialized financial and tax regulations have been designed exclusively for enterprises situated within the designated area. These enterprises operate under a distinct framework that is not constrained by the jurisdiction or limitations of the regional governments where they are situated. Instead, they operate directly within the jurisdiction provided by the designated zone, facilitating a more flexible and supportive business environment.

**3. In the Domain of Logistics.** The China-Belarus Industrial Park, positioned in landlocked Belarus, relies on the Lithuanian port of Klaipeda within the European Union's Kaunas Free Trade Zone for sea-based commodity exports. The competitive dynamics between this port and the China-Belarus Industrial Park have resulted in less-than-optimal transportation options for investment activities. The International Land Port of Gansu (Lanzhou) can leverage this situation as an opportunity to robustly develop the Lanzhou-Kazakhstan-Russia-Belarus China-European liner bulk container service trains

[7] Ministry of Commerce: will support the upgrading of a number of new batch of overseas economic and trade cooperation zones. Sina Finance. URL: http://finance.sina.com.cn/china/gncj/2019–03–09/doc-ihrfqzkc2462083.shtml (accessed on 09.03.2019).

[8] Chinese Government's Support Policies and Measures for Overseas Economic and Trade Cooperation Zones. Ministry of Commerce of the People's Republic of China). URL: http://www.mofcom.gov.cn/article/zt_jwjjmyhzq/subjectn/201004/20100406869369.shtml (accessed on 15.04.2010).

[17]. By establishing overseas bases and sub-parks in the China-Belarus Industrial Park, the Lanzhou Land Port can capitalize on the time-efficient land transport advantages, implement strategies to reduce cross-border logistics costs, facilitate two-way point-to-point services, and foster multimodal transport development. This approach would effectively establish the Lanzhou Land Port as a pivotal national logistics hub. The Lanzhou Land Port has already been at the forefront as a national logistics hub. The implementation of point-to-point liner services, fortification of information-oriented service systems, and provision of streamlined customs clearance services through innovative data systems, intelligent order management systems, and sophisticated query and data analysis systems are essential. Establishing an electronic port and collaborative customs clearance platform would significantly enhance customs clearance efficiency.

**4. Advancement of "Sister Park" Construction.** Initiating the establishment of cross-border collaboration parks along the Silk Road Economic Belt is crucial to bolster connectivity, streamline cargo sourcing, catalyze profound industrial collaboration, and foster a climate of international trade development. Dedicated efforts shall be directed towards propelling the expansive growth of enterprises in Lanzhou. This entails nurturing several large-scale international land port enterprises distinguished by elevated service standards and robust global competitiveness. Leveraging overseas initiatives and cross-border industrial cooperation parks, the promotion of Lanzhou's international land port expansion beyond China's borders will be prioritized. This strategic move aligns with the overarching Silk Road Economic Belt construction while concurrently laying the foundation for cross-border collaboration platforms.

Drawing on Lanzhou's industrial, geographical, and land transport advantages, expeditiously realizing the development orientation of the "China-Belarus Industrial Park" is paramount. This endeavor aims to achieve mutual benefits with the China-Belarus Industrial Park. It is noteworthy that the China-Belarus Industrial Park is still in its nascent phase of development and operation, grappling with various policy, managerial, and operational challenges. Lanzhou International Land Port should proactively identify windows of opportunity for its growth and navigate novel developmental pathways amidst the array of challenges it confronts.

**5. Advancing Scientific Research and Innovation.** In addition to robustly fostering forefront industries grounded in contemporary logistics, modern trade, and export processing, Lanzhou Land Port can strategically collaborate with the China-Belarus Industrial Park to foster profound exchanges in scientific and technological innovation. Notably, the China-Belarus Industrial Park, in 2021, achieved the establishment of the China-Belarus Science and Technology Achievement Industrialization Innovation Centre.[9] This hub encompasses international R&D collaboration, science and technology research institutions, and research enterprises within the park. Facilitated by fund support, this center is instrumental in nurturing small and micro enterprises, cultivating the founders of R&D outcomes, as well as fostering innovation and entrepreneurship among young entrepreneurs.

Given that the comprehensive execution of robust scientific and technological endeavors constitutes a pivotal facet in Gansu's acceleration of the "one nucleus and three belts" regional development blueprint, Lanzhou Land Port can leverage the city and province's university and enterprise resources, as well as tap into the existing assets of the China-Belarus Science and Technology Achievement Industrialization Innovation Centre. This concerted effort should accelerate the advancement of innovation platforms, bolster the transformation of scientific and technological achievements, cultivate high-tech industries, and forge novel competitive edges for subsequent industrial growth. The net result will be the cultivation of fresh advantages in industrial progression, thereby nurturing a wealth of premium economic increments for forthcoming development.

China and Belarus have notably ratified an agreement encompassing mutual recognition of academic degrees and certifications, concurrently launching joint university programs. This partnership has resulted in a year-on-year increase in the exchange of foreign students. Mandarin has even been integrated as an optional foreign language in the Belarusian college entrance examination. With

[9] China-Belarus Industrial Park. URL: https://industrialpark.by/ (accessed on 10.08.2023).

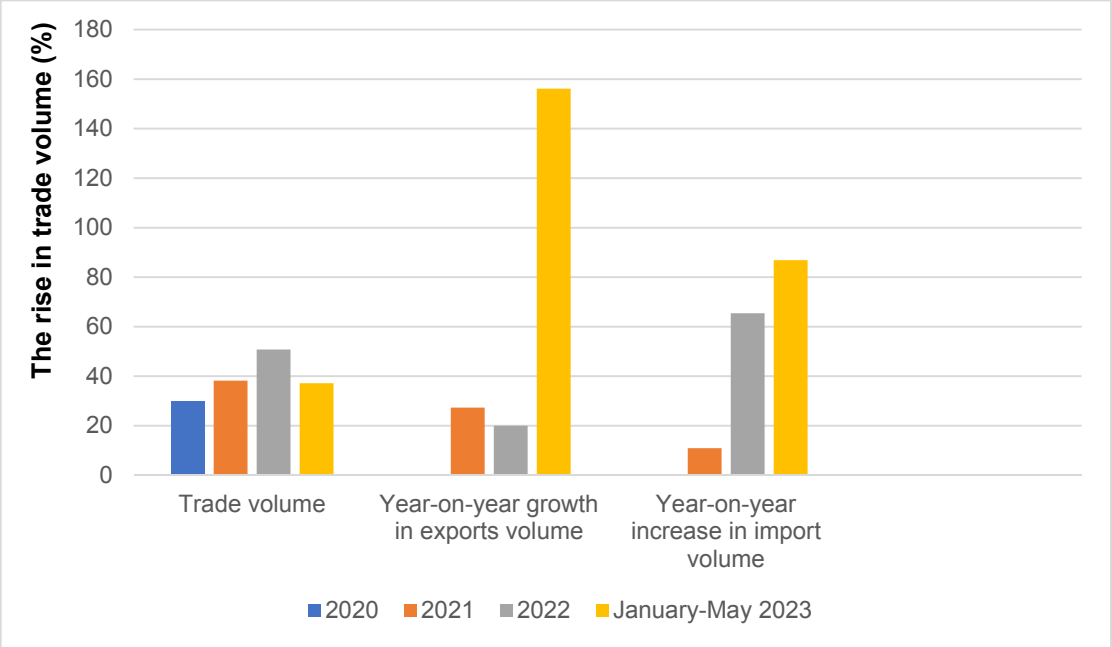


*Fig.* **China-Belarus trade volume from 2020 to 2023**

*Source:* Compiled on the basis of data from Ministry of Foreign Affairs of the People's Republic of China. URL: https://www.mfa.gov.cn/ (accessed on 10.08.2023).

over 7,000 Chinese students presently in Belarus and a corresponding number of Belarusian students in China,[10] a total of six Confucius Institutes have been established in Belarus thus far. In this vein, Lanzhou's higher education institutions should orchestrate tailored educational initiatives, emphasizing the cultivation and dissemination of international talents. This strategic alignment should focus on nurturing interdisciplinary and multifaceted professionals dedicated to fulfilling the developmental requisites of the "Belt and Road" initiative.

## CONCLUSION

Western China is undergoing a transformation, evolving from being an interior region to becoming a pioneering frontier in terms of trade liberalization and foreign trade engagement. This evolution is marked by an amplified involvement in international trade, accompanied by rapid escalations in both import and export volumes. As reported by China's General Administration of Customs, in 2020, the trade volume between China and Belarus exceeded the threshold of US$ 3 billion for the first time.[11] Within this context, China's exports to Belarus amounted to US$ 2,113 billion, while imports from Belarus totaled US$ 889 million.[12] The momentum continued in 2021, witnessing a surge in China-Belarus trade to a value of US$ 3.822 billion, marking a notable year-on-year growth of 27.33%[13] (*see Figure*). During this period, China's exports to Belarus expanded to US$ 2.729 billion, indicating a 29.15% growth, while imports from Belarus amounted to US$ 1.091 billion, registering a year-on-year increase of 22.7%.[14]

The trend of bilateral trade between China and Belarus exhibited even more robust growth in 2022, with the trade volume soaring to US$ 5.079 billion, denoting a remarkable year-on-year expansion of 33%.[15] China's imports from Belarus witnessed an impressive surge of

[10] Embassy of the People's Republic of China in the Republic of Belarus URL: http://by.china-embassy.gov.cn/zbgx/jylx/202301/t20230121_11013915.htm (accessed on 20.01.2023)

[11] Ministry of Foreign Affairs of the People's Republic of China. URL: https://www.mfa.gov.cn/ (accessed on 10.08.2023).

[12] Ibid.

[13] Ibid.

[14] Ibid.

[15] Ministry of Foreign Affairs of the People's Republic of China. URL: https://www.mfa.gov.cn/ (accessed on 10.08.2023).

65.4%, whereas the rise in exports to Belarus reached a commendable 20%.[16] The initial months of 2023 also bear witness to this trend, as the trade volume between China and Belarus from January to May reached an impressive US$ 3.72 billion, signifying an extraordinary year-on-year growth of 127%.[17] Further granularity reveals that China's imports from Belarus escalated by a remarkable 86.9%, while exports to Belarus saw an astonishing leap of 156.2%.[18]

The Belarusian government is equally attuned to the significance of collaboration. This was evident during the state visit of the President of the Republic of Belarus, Alexander Lukashenko, to China, which spanned from February 28 to March 2, 2023. On a national level, a consensus was reached to jointly advance the development of the China-Belarus Industrial Park, transforming it into an internationally oriented cooperative endeavor and a satellite town affiliated with the city of Minsk. China's commitment remains steadfast in supporting the integration of large-scale production enterprises and high-tech companies into the industrial park.[19]

Previous research on the China-Belarus Industrial Park primarily centered around addressing their internal challenges, such as enhancing industrial features and optimizing functional layouts. This paper takes a fresh approach, delving into the potential for cooperation and growth of interregional industrial parks. It examines this potential through the lenses of policy formulation, investment attraction, broadening collaboration in logistics, mutual promotion of "sister parks", and fostering cooperation in scientific research and innovation.

Looking ahead, it is envisioned that the China-Belarus Industrial Park will collaborate with the International Land Port of Gansu (Lanzhou), capitalizing on their respective strengths, sharing experiences, and collectively formulating policies. Such collaboration will facilitate the growth of the logistics industry, fostering diverse cooperation and exchanges. By collectively addressing individual shortcomings and progressing together, they can contribute to mutual advancement while promoting shared development among nations.

Undoubtedly, the imminent inter-regional synergistic development of the International Land Port of Gansu (Lanzhou) and the China-Belarus Industrial Park is poised to propel the economic progress of nations along the "Belt and Road". This cooperative endeavor also holds the promise of establishing an exceptionally efficient logistics network for both Lanzhou and Minsk along the Silk Road Economic Belt. As a result, a flourishing industry and thriving development are on the horizon.

This collaboration aims to propel both the International Land Port of Gansu (Lanzhou) and the China-Belarus Industrial Park to the forefront of global advancement. This joint endeavor is poised to significantly catalyze and contribute to the ongoing prosperity of the global economy.

[16] Ministry of Foreign Affairs of the People's Republic of China. URL: https://www.mfa.gov.cn/ (accessed on 10.08.2023).
[17] Ministry of Foreign Affairs of the People's Republic of China. URL: https://www.mfa.gov.cn/ (accessed on 10.08.2023).
[18] Ministry of Foreign Affairs of the People's Republic of China. URL: https://www.mfa.gov.cn/ (accessed on 10.08.2023).
[19] Joint Declaration of the People's Republic of China and the Republic of Belarus on the Establishment of an All-weather Comprehensive Strategic Partnership. People's Daily. 16.03.2022.

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## REFERENCES

1. Liu W.D., Tian J.C., Ou X.L. Research on "Belt and Road Initiative". Beijing: The Commercial Press; 2017. 584 p. (In Chin.).
2. Jiang L. International Land Port of Gansu (Lanzhou) project drives the development of logistics and warehousing industry. *LanZhou RiBao = Lanzhou Daily*. 01 ed. June 22, 2022. (In Chin.).
3. Jin Y.Q. Research on competitiveness enhancement of International Land Port of Gansu under the perspective of integration field. *WuLiu KeJi = Logistics Science and Technology*. 2022;(3):42–44. (In Chin.)

4. Bräutigam D., Tang X. "Going global in groups": Structural transformation and China's special economic zones overseas. *World Development.* 2014;63:78–91. DOI: 10.1016/j.worlddev.2013.10.010
5. Salmygina E.D. China-Belarus: Multilateral economic cooperation and its prospects. *Vestnik obshchestvennykh i gumanitarnykh nauk = Bulletin of Social Sciences and Humanities.* 2021;2(2)31–38.
6. Liu Z., Dunford M., Liu W. Coupling national geo-political economic strategies and the Belt and Road Initiative: The China-Belarus Great Stone Industrial Park. *Political Geography.* 2021;84:102296. DOI: 10.1016/j.polgeo.2020.102296
7. Song Z. The experience of China-Belarus Industrial Park. Renmin Huabao = China Pictorial. Oct. 16, 2017. URL: http://www.rmhb.com.cn/zt/ydyl/201710/t20171016_800107082.html (accessed on 16.10.2017). (In Chin.).
8. Zhang H. Xi Jinping's summit diplomacy and China-Belarus "Belt and Road" cooperation. *ELuoSi XueKan = Russian Studies.* 2020;(1):5–21. (In Chin.).
9. Haro Sly M.J. Suzhou Industrial Park and its role in the Belt and Road Initiative: The Great Stone Industrial Park in Belarus. *Revista de Gestão.* 2021;28(4):316–334. DOI: 10.1108/REGE-01–2021–0003
10. Xu L.J., Gao H. Challenges and suggestions on tax financing for China-Belarus Industrial Park. *Jinri Caifu = Fortune Today.* 2020;(08):54–55. (In Chin.)
11. Yaroshenko A. Residents of the Great Stone Park will begin to build more actively after the construction of the infrastructure. BELTA. May 31, 2016. URL: http://www.belta.by/interview/view/rezidenty-parka-velikij-kamen-nachnut-stroitsja-aktivnee-posle-vozvedenija-infrastruktury-4859 (accessed on 31.05.2016). (In Russ.).
12. Theses of the speech of the First Deputy Minister of Economy D.N. Krutoy at the International Conference "Eurasian Economic Union: Strategy for further development". Minsk. BSU. Aug. 15, 2018. URL: https://eec.eaeunion.org/upload/iblock/fe8/Doklad-integratsiya.pdf?ysclid=lpkterrg4n296154457 (In Russ.).
13. Zhao H., Zeng G., Hu H. Report on China's Overseas Park Development under the "Belt and Road" Initiative. Beijing: China Social Science Press; 2018. 135 p. (In Chin.).
14. Chen X. Change and continuity in Special Economic Zones: A reassessment and lessons from China. *Transnational Corporations.* 2019;26(2):49–74. DOI: 10.18356/22df74e1-en
15. Fujita M., Krugman P., Venables A.J. The spatial economy — Cities, regions and international trade. Cambridge, MA: The MIT Press; 1999. 382 p.
16. Pereira A.A. The Suzhou Industrial Park experiment: The case of China-Singapore governmental collaboration. *Journal of Contemporary China.* 2004;13(38):173–193. DOI: 10.1080/1067056032000151391
17. Han Y.D. World supermarkets: Resilience in the midst of an epidemic. Central Commission for Discipline Inspection and National Supervision website. URL: https://www.ccdi.gov.cn/yaowenn/202208/t20220820_212607.html (accessed on 20.08.2022). (In Chin.).

## ABOUT THE AUTHOR

***Qu Tao*** — Cand. Sci. (Pedagogy), lecturer of the College of International Cultural Exchange, Northwest Normal University, Lanzhou, Province Gansu, China
http:// orcid.org/0009-0004-5233-0922
qt@nwnu.edu.cn

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# Analysis of Multimodal Data in Project Management: Prospects for Using Machine Learning

**P.A. Mikhnenko**
Bauman State Technical University, Moscow, Russia

## ABSTRACT

The modern project environment is characterized by high complexity, uncertainty, speed and depth of changes that affect the project during its life cycle. However, the project's change management processes do not take into account the need to implement analytical procedures for dynamic processing of multimodal data arrays. The **purpose** of the study is to determine the content of analytical procedures for project management and substantiate the use of machine learning technologies for their effective implementation. The **methodological basis** was project management methods, theory of change, concepts of artificial intelligence and machine learning, as well as analytical approaches. Methods of descriptive modeling of the project management process and expert assessments of the prospects for using machine learning technologies were also used in the work. The information base was made up of scientific materials on the topic under consideration, as well as expert assessments. The **results** of the study allowed us to conclude that for the analysis of multimodal data, natural language processing and intellectual decision support technologies are most in demand, which can serve as the basis for new technological solutions in the field of project management.

***Keywords:*** project management; changes; analytical procedure; multimodal data fusion; machine learning

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## INTRODUCTION

During the implementation of projects, profound changes in their internal and external factors often occur, so today one cannot rely on a predetermined project management methodology — new approaches are needed that not only involve changes, but also allow one to benefit from them [1]. Project teams are forced to identify and analyze changes, continuously evaluate processes and feedback, and maintain dialogue with stakeholders.

Project management faces challenges that arise not only from external factors, but also from errors and changes in team performance. Project managers are forced to consider feedback dynamics to effectively manage change [2], and responsibility for change management often leads to disagreements among project participants [3]. Communication plays an important role in the change management process, facilitating interaction between the project team and stakeholders [4].

In modern theory and practice of project management, more and more attention is paid to digital transformation [5]. The introduction of intelligent tools contributes to the digitalization of project management and the creation of competitive advantages for organizations [6]. The use of artificial intelligence (AI) technologies, in particular machine learning, improves the efficiency of project management, increases productivity and reduces the likelihood of errors in decision making [7].

Thus, in a complex and dynamic external environment, project change management (PCM) processes require multimodal data analysis. To solve this problem, AI technologies, in particular machine learning, can be used.

## SCIENTIFIC DEVELOPMENT OF THE PROBLEM AND FORMULATION OF THE RESEARCH PROBLEM

### Literature review

Since the early 1950s methodology of project management has developed primarily in line with theories and methods of operations research, management decision making, critical path [8], decision graphs [9], program evaluation and analysis [10], work scope management [11], critical chain [12] and other approaches. Today, scientific publications cover a wide range of problems connected with an increase in the efficiency of project management through the use of mathematical and instrumental methods, including those in the context of PCM.

Work [13] presents methods for selecting projects using optimization methods and mathematical programming, as well as management decision support systems to reduce the subjectivity factor. Research on PCM processes confirms the conceptual complexity of this activity, which differs from general project management practices, especially in the context of communications [14]. In this regard, it is worth noting the publication [15], in which project changes are assessed from the point of view of the manager's ability to understand the motivation of participants and take it into account when managing changes. The work [16] describes taxonomies of the causes and effects of project changes, as well as ways to use them in the change management process. The authors of the publication [17] show that the positive effect of high-quality project planning can be reduced by the negative consequences of changing its goals, therefore the success of the project is associated with effective change management.

Work [18] discusses the difference between projects as a "process of change" and projects as the "content of change": the

first approach is that organizational change management is carried out in the form of projects, and the second is that the purpose and content of change is to create project form of management of the organization's activities. The cited authors draw attention to the paradox: organizational changes aimed at introducing a project form of management are often carried out not in the form of a project.

Changes in IT projects are the main source of risk, affecting the time, cost of development and quality of software, which can be increased and successfully completed by effective PCM [19], which consists of identifying and managing multiple sources of uncertainty [20]. The most stringent requirements that drive unique project changes come from clients, end users, and government agencies [21].

Projects with unclear goals or goals that cannot be defined initially (for example, research projects) are managed using an extreme approach in which the team and client are constantly learning and making "discoveries", which allows them to adjust the project boundaries at each stage [1].

Today, an important problem in managing projects in general and their changes in particular is the processing of large volumes of multimodal information and the use of intelligent digital systems for decision making under conditions of uncertainty. Work [22] describes a method of computer support for decision-making and continuous improvement of a company's business processes in the context of PCM. The authors of the article [23] propose a fuzzy production system model for managing IT project tasks using natural language categories for decision making under conditions of uncertainty and change. The use of fuzzy logic allows project managers to work with qualitative categories of variables, which helps improve the quality of decisions.

Most current publications on the research topic focus on the development of systems and procedures using machine learning technologies. It is noteworthy that the first mention of artificial intelligence in relation to project management was in 1987 in an article [24], where it was noted that AI-based software could help managers capture their experience and share it with other project participants.

Modern authors consider the areas of application of visual analytics in flexible IT project management [25], emphasize the importance of situational advisory systems for managing complex technological investment projects [26], explore the use of fuzzy logic and neural networks in intelligent project management information systems [27], discuss the prospects for using artificial neural networks and the cognitive visualization method for managing project portfolios [28], pointing out the possibilities of using machine learning in the management of innovative projects, while noting the limited applicability of this method due to the need to access large amounts of information about previous solutions for model training [29].

### Statement of the research problem

As a review of the literature shows, the most promising tasks in project management are increasing the efficiency of control systems and the use of machine learning technologies in project practice.

The object of study in this article is the project management process. The subject is the analysis of multimodal data[1] in the management of PCM.

The research hypothesis is that the analytical procedures performed in the PCM

[1] The term "multimodal" here refers to the use of multiple modes and means of presenting information within a single analytical context. Multimodal data refers to data of different natures and forms of presentation: text, sounds, images, video, data from technical devices, etc.

require solving the problem of fusion and analyzing multimodal data arrays.

*Multimodal fusion* is a technology for intelligently combining data of different natures, resulting in the synthesis of new information about production, management, economic and other processes and phenomena, as well as increasing the accuracy of analysis and decision-making. For example, to analyze the organizational structure, corporate culture and human resources of a company, the following can be used: texts (job descriptions, staffing, orders and instructions); images (diagrams of organizational structure and business processes, photographs of workplaces); video and audio files (interviews with employees, video minutes of meetings); numerical data (number of employees and wages); information from the media and social networks (employee profiles, comments). Multimodal fusion of such data makes it possible to more accurately and quickly identify errors in job descriptions, analyze the quality of management decisions, draw conclusions about the compliance of employee competencies with job responsibilities, predict structural changes, assess the quality of communications and corporate culture, etc.

To solve these problems, neural networks, big data and machine learning technologies are used.

In accordance with the National Strategy for the Development of Artificial Intelligence in the Russian Federation for the period up to 2030, artificial intelligence is called "a set of technological solutions that allows you to simulate human cognitive functions (including self-learning and searching for solutions without a predetermined algorithm) and when performing specific tasks to obtain results comparable to those of human intellectual activity.[2] "

Technologies based on the use of AI include: computer vision, natural language processing, speech recognition and synthesis, intelligent decision support, advanced artificial intelligence methods.[3]

In the article, machine learning is understood as a scientific and practical discipline and a set of technologies in the field of research and development of algorithms and models capable of synthesizing new knowledge and using it for decision making. The main feature of such algorithms is the ability to learn without explicitly programmed instructions. Machine learning forms the basis of many applications and technologies, such as speech recognition, computer vision, recommendation modeling, natural language processing, etc.[4]

The study is aimed at identifying the content of analytical procedures for processing multimodal data in project management, as well as assessing the potential of machine learning in project change management.

To achieve this goal the following methods were used: 1) analysis of the compliance of modern machine learning technologies with project management processes; 2) descriptive modeling of the PCM process; 3) examination of the prospects for using machine learning technologies in project management.

## METHODS

### AI technologies comparable to PCM tasks

The authors of the review [30] identify groups of machine learning technologies that can be used in project management (*Table 1*).

[2] National strategy for the development of artificial intelligence for the period until 2030. Decree of the President of the Russian Federation dated October 10, 2019 No. 490 "On the development of artificial intelligence in the Russian Federation". URL: http://www.kremlin.ru/acts/bank/44731

[3] "Order of the Ministry of Economic Development of the Russian Federation dated June 29, 2021 No. 392 "On approval of criteria for determining whether projects belong to projects in the field of artificial intelligence." URL: http://publication.pravo.gov.ru

[4] The article does not discuss aspects of deep learning as one of the features of modern machine learning algorithms.

*Table 1*

**Machine learning methods in project management**

| Reference | Machine learning method | English term |
|---|---|---|
| ANN | Artificial neural networks | Artificial neural networks |
| HONNS | Neural networks of high order | Neural networks of high order |
| HNN | Hopfield neural network | Hopfield neural network |
| FL | Fuzzy logic | Fuzzy logic |
| DCM | Fuzzy cognitive maps | Fuzzy cognitive maps |
| GA | Genetic algorithms | Genetic algorithms |
| FMGA | Fast-messy genetic algorithm | Fast-messy genetic algorithm |
| SVM | Support vector machine | Support vector machine |
| BT | Bootstrap technique | Bootstrap technique |
| GB | Gradient Boosting | Gradient Boosting |
| RF | Random Forest | Random Forest |
| KGM | K-grouping means | K-grouping means |
| FNN | Neuro-fuzzy | Neuro-fuzzy |
| NNAB | Neural network-adding bootstrap | Neural network-adding bootstrap |
| NNAR | Neural networks of adaptive reinforcement | Neural networks of adaptive reinforcement |
| FRBS | Fuzzy Rule-Based Systems | Fuzzy Rule-Based Systems |
| GFS | Genetic Fuzzy Systems | Genetic Fuzzy Systems |
| EFSIM | Evolutionary fuzzy support vector machines inference model | Evolutionary fuzzy support vector machines inference model |
| EFNIM | Evolutionary fuzzy neural inference model | Evolutionary fuzzy neural inference model |
| EFHNN | Evolutionary diffuse hybrid neuronal network | Evolutionary diffuse hybrid neuronal network |

*Source:* compiled by the author based on [30].

Analysis of the above methods allows us to assume that their use in PCM will create new approaches to data processing and analysis, automation of decision-making processes, forecasting and optimization. However, for the full application of these methods, more in-depth research is required, as well as their adaptation to this subject area. *Table 2* shows machine learning methods that can be used in PCM.

Today, project management uses many technological solutions based on AI. They can be divided into two classes:

1. Virtual assistants to the project manager (intelligent assistants), which help him in performing various tasks and making decisions.

2. AI technologies integrated into project management systems for process automation, data analysis, event forecasting, etc.

*Table 2*

**Machine learning methods in project change management**

| Project management process | Machine learning method | Machine learning method |
|---|---|---|
| Planning | ANN, GA | ANN, GA |
| Project data analytics, Random Forest, Gradient Boosting | EFNIM, BT, RF, GB | EFNIM, BT, RF, GB |
| Project risk modeling, mitigation and management | GA, SVM | GA, SVM |
| Project mitigation and recovery plans | ANN | ANN |
| Project execution discovery and modeling | GA, EFNIM | GA, EFNIM |
| Real time predictive analytics | GA, EFHNN | GA, EFHNN |
| Automated report generation | GA | GA |
| Stakeholder Management | EFSIM | EFSIM |

*Source:* compiled by the author.

Both classes have potential for development, however, to select and implement a solution, it is necessary to take into account the specifics of the project environment, the needs of the organization and the availability of technology (*Table 3*).

The use of AI technologies in PCM opens up opportunities for increasing the efficiency of management decisions, which requires interdisciplinary research, development of methodologies, and adaptation of AI technologies to the features of PCM.

*Table 4* shows the tasks by type of AI technology, which are comparable in purpose and content with the tasks of the PCM.

## DESCRIPTIVE MODEL OF THE PCM PROCESS

As already noted, PCM requires the use of multimodal analytics methods based on the extraction, fusion and analysis of data, their sentiments, multimodal deep learning, etc. Data mining is the process of identifying meaningful patterns, hidden relationships, regularities and trends in large data sets that can be used for forecasting, identifying opportunities and making decisions.

Data fusion refers to the process of combining data through matching, deduplication, missing values, aggregation and other techniques to help uncover hidden relationships, recognize trends, create new information and develop more reliable models and forecasts.

The fusion of data from different sources, known as multi-source data fusion, is the combination of information from different sources. Multi-modal data fusion is the combination of data from different modalities (text, images, sound, video, etc.) to obtain a more complete or accurate picture of events. The use of this term is justified when it is necessary to emphasize the importance of merging data of different natures and the use of processing and analysis methods to solve technical problems is required.

Sentiment Analysis is the determination of the emotional tone of a text (positive,

*Table 3*

**AI-based technological solutions in project management**

| Technological solutions | Area of application in project management |
|---|---|
| PMOtto.ai | Speech and text recognition and their convertion into commands for information systems. Formation of recommendations for PM |
| Lili.ai | Optimizing the project budget and increasing the efficiency of the management program |
| Autodesk Construction IQ | Identification of work with a high probability of delays and other risks of construction projects |
| Bitrix24 | Creating new project tasks, assigning or replacing executors, updating the status of task execution, etc. |
| Smart Projects | Full cycle support of PM |
| Aurora | Creation of optimal calendar and network schedules for large and complex projects |
| Liquid Planner | Automatic adjustment of expected completion dates for project tasks |
| Infosys Nia Contracts Analysis | Contract management, speeding up contract review and reducing contract risks |
| PsodaVision | Sync physical and digital Kanban boards using machine vision technology |
| Cloverleaf | Formation and development of a project team based on a comparison of the personal qualities and skills of the participants |
| PineStem | Formation of a project team based on existing experience in IT projects |
| TARA.ai | Formation of options for project implementation within the budget, assistance with the selection of project team members |

*Source:* compiled by the author.

negative, neutral) using natural language processing and machine learning. Used to analyze reviews, social media, news and make informed decisions.

Multimodal Deep Learning is the use of neural networks with multiple input layers, each of which processes different types of data, which makes it possible to analyze and extract semantic relationships and dependencies between different modalities, increasing the quality and accuracy of the analysis. In general, the PCM (*Fig. 1*) includes a number of analytical procedures:

A1 — identification of current factors of the external and internal environment relevant to the goal and scope of the project;

A2 — forecasting changes in project results;

A3 — planning project changes;

A4 — distribution of responsibilities and coordination of actions of project participants during the PCM;

A5 — assessing the operational results of project changes;

A6 — assessment and interpretation of the current results of the project;

A7 — defining and updating the goals and scope of the project.

In this study, an analytical procedure is understood as a set of actions aimed at obtaining new information through the merging and intelligent processing of arrays of heterogeneous data, mainly in real time of project management.

*Table 4*

**AI-Technologies comparable to the tasks of the PCM**

| AI Technology Category | Technological task | Task code |
|---|---|---|
| Computer vision | Identification of objects in complex environments | KZ1 |
| | Pattern recognition based on context and signals from multiple sources (data fusion) | KZ2 |
| | Event analysis using video analytics systems | KZ3 |
| | Monitoring the progress of a production or organizational process using video analytics systems | KZ4 |
| | Analysis of data received from spacecraft | KZ5 |
| Natural Language Processing | Classification and clustering of individual statements, short and long texts | OY1 |
| | Search and classify various types of entities in text, including names of organizations and personal names | OY2 |
| | Extraction of facts from texts and their systematization, including automatic training of ontologies | OY3 |
| | Searching for text documents by analogy or meaning, searching for trends and future guidelines for scientific and technological development, searching for hidden content and meanings | OY4 |
| | Isolating the most important information from the context and synthesizing unique texts | OY5 |
| Speech recognition and synthesis | Creating multitasking conversational assistants | RS1 |
| | Sound and speech recognition in challenging environments | RS2 |
| | Recognition of complex semantic structures and slang in speech for use in systems for searching for hidden content and meaning, including for improving current solutions | RS3 |
| Decision support | Predictive and prescriptive analysis, which allows you to predict the development of the situation based on data analysis and automate decision making in real time | PR1 |
| | Preparation of solutions based on open data sources and unstructured information, including for adaptive dynamic control of complex objects | PR2 |
| | Intelligent simulation modeling of the behavior of market participants for goods, works and services | PR3 |
| | Providing decision support based on long-term data, including for calculating standardization in economic sectors | PR4 |
| | Control of equipment and production systems based on data from measurement systems and historical data on the behavior of systems in various situations | PR5 |
| | Ultra-short-term forecasting, real-time data flow analysis and emergency forecasting | PR6 |
| | Identifying anomalies in production processes and searching for their causes | PR7 |

*Source:* compiled by the author.

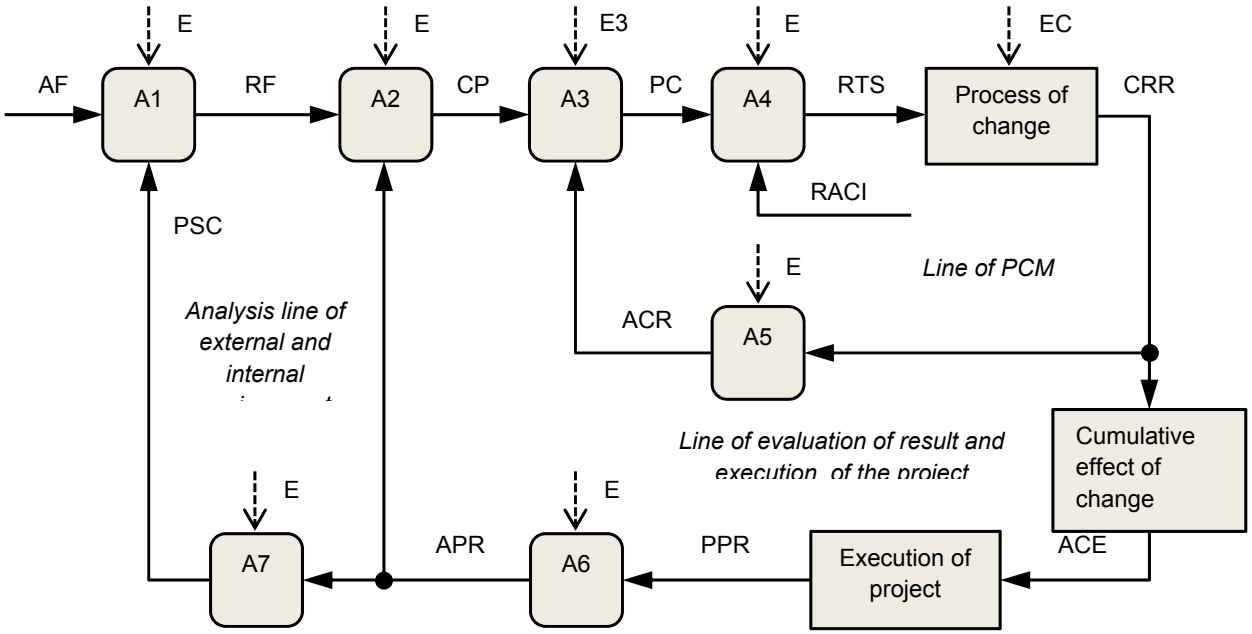


*Fig 1.* **Analytical procedures for project change management**

*Source:* compiled by the author.

*Note:* AF — actual factors of the external and internal environment of the project; RF — relevant factors; CPR — change prediction; PCP — project change plan; RACI matrix; RTS — revised project team structure; CRR — changes-related results; ACR — assessment of changes-related results; ACE — accumulated change effect; PPR project performance results; APR — assessment of project performance results; PSC– project scope; E 1...E 7 — errors; ECP — error of change process.

The set of analytical procedures and processes form three interconnected circuits:

1. Analysis of the external and internal environment of the project.
2. Evaluation of the results of the project.
3. Project change management.

The dynamic nature of the model indicates the continuity of the PCM process, which reflects the most general understanding of the role and content of PCM in project management — it most closely corresponds to the agile project management approaches and extreme project management approaches. At the same time, the model does not contradict the traditional approach based on the Incremental PMLC model of project life cycle management, and within their framework describes the processes of initiating and implementing change requests [1].

The project execution process is influenced by changing external and internal environmental factors (AF). Change data comes from information systems, financial and annual reports, signaling devices, business publications, media reports, social media channels, etc. [31, 32], and their probabilities and strengths of influence are characterized by linguistic and quantitative assessments.

The relevance of external and internal environmental factors (RF) is assessed by a comparison of the array of relevant factors (AF) and information about the current understanding of the goal and scope of the project (PSC). The RF and PSC arrays are represented by data of different modalities and dimensions, which suggests their multimodal fusion and synthesis of new information during the analytical procedure A1.

Forecasting changes in project results (A2) is carried out by a comparison of RF and APR

*Table 5*

**Content of analytical procedures**

| Analytical procedure | Input array | Possible data source and type | Synthesized information |
|---|---|---|---|
| A1 — identification of current external and internal environmental factors relevant to the goal and scope of the project | AF — current factors of the external and internal environment of the project | Reports of analytical agencies: numerical, texts, images, graphs.<br>Laws and orders of executive authorities.<br>Statistical data: numerical, texts, graphs, videos.<br>News publications and social media: texts, images, graphics, audio, video.<br>Market and competitor analysis results: numerical, text, images, graphs, videos.<br>Information about past projects and experience accumulated by the project team: text, communications | RF — current factors of the external and internal environment, relevant to the goals and scope of the project |
| | PSC — goals and scope of the project | Technical task.<br>Charter and other project documents: numerical, texts.<br>Interviews with stakeholders.<br>Strategic documents of the company.<br>Past project experience | |
| A2 — forecasting changes in project results | RF — current factors of the external and internal environment, relevant to the goals and scope of the project | RF — current factors of the external and internal environment, relevant to the goals and scope of the project | CPR — forecast of changes in project results |
| | APR — assessment of current project implementation results | Project documents: numerical, texts, graphics, communications of participants.<br>Signals from devices and sensors, video recording | |
| A3 — planning project changes | CPR — forecast of changes in project results | Project documents: numerical, texts, graphics, participant communications | PCP — Dynamic Project Change Plan |
| | ACR — Assessing the operational results of project changes | Data from information systems: numerical, graphs.<br>Communications of participants.<br>Videos of change management processes | |
| A4 — distribution of responsibilities and coordination of actions of project participants during the PCM | PCP — Dynamic Project Change Plan | Project documents: numerical, texts, graphics, communications of participants.<br>Project manager decisions: text, communications | RTS — updated structure of responsibility and coordination of project participants |
| | RACI matrix — the current structure of distribution of responsibilities of project participants | Expert assessments: numerical, text.<br>Opinions of project participants: text, communications, audio, video.<br>Project documents: matrix of responsibilities of project participants, data on the actual composition of the project team.<br>Results of assessing personal competencies and psychological compatibility of project team members | |

*Table 5 (continued)*

| Analytical procedure | Input array | Possible data source and type | Synthesized information |
|---|---|---|---|
| A5 — Assessing the operational results of project changes | CRR — operational results of project changes | Project documents: numerical, texts, graphics, communications of participants.<br>Video recordings of change management processes.<br>Expert assessments: numerical, text.<br>Opinions of project participants: text, communications, audio, video.<br>Device and sensor data.<br>Expert assessments: numerical, text | ACR — Assessing the operational results of project changes |
| A6 — evaluation and interpretation of current project results | PPR — current results of the project implementation | Project documents: numerical, texts, graphics, communications of participants.<br>Video recordings of project management processes.<br>Opinions of project participants: text, communications, audio, video.<br>Device and sensor data.<br>Expert assessments: numerical, text | APR — assessment of current project implementation results |
| A7 — defining and updating the goals and scope of the project | APR — assessment of current project implementation results | Project documents: numerical, texts, graphics, communications of participants.<br>Opinions of project participants: text, communications, audio, video.<br>Expert assessments: numerical, text | PSC — goals and scope of the project |

*Source:* compiled by the author.

data sets; the second is described by linguistic and quantitative variables that characterize the fact that the next stage of the project has been completed or the product release has acquired new consumer properties. The peculiarity of the analytical procedure A2 is also due to the difference in the content and dimension of the input data arrays and the need to carry out their multimodal fusion and synthesis of new information.

The project change planning process in this study is also represented by the analytical procedure (A3), since it involves the multimodal fusion of heterogeneous CPR and ACR data sets; the second serves as an assessment of the operational results of project changes carried out in the previous cycle of changes, obtained as a result of the implementation of individual operations and activities that do not have a significant impact on the current results.

The process of distributing responsibilities and coordinating the actions of project participants during the PCM ends with the organizational and administrative procedure for making a management decision. However, the need for analysis allows us to classify it as analytical. Procedure A4 involves comparing the content of the dynamic project change plan (PCP) with the current structure of distribution of responsibilities of project participants (RACI matrix), justifying the need to involve relevant mechanisms for coordination and motivation of the latter, as well as updating the structure itself.

The analytical procedure for assessing the operational results of project changes (A5) consists of a multimodal fusion of data obtained from different sources to correctly interpret their compliance with the dynamic change plan.

*Table 6*

**Professional status of experts**

| Professional status | Number, people |
|---|---|
| Project manager | 6 |
| Project team member | 15 |
| Software Developer | 8 |
| Middle manager | 6 |
| Teacher of specialized disciplines | 7 |

*Source:* compiled by the author.

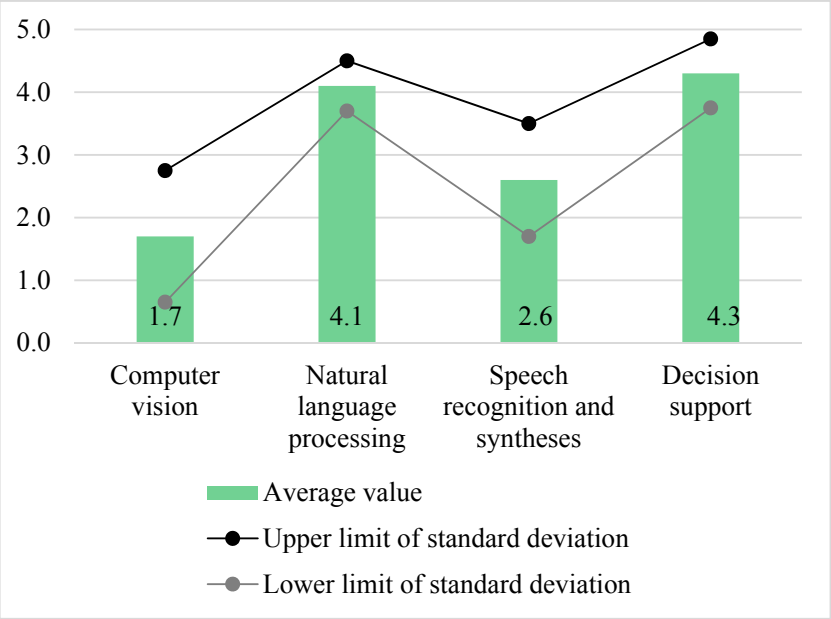


*Fig. 2.* **Expert assessments of the prospects for the use of AI technologies in the PCM**

*Source:* compiled by the author.

The cumulative effect in a broad sense refers to the accumulation and receipt of the cumulative result of all project changes (both positive and negative) made to it throughout the life cycle. The cumulation of the results of project changes has a significant impact on its key indicators: cost, schedule, quality, risks and stakeholder satisfaction.

The analytical procedure for assessing and interpreting the current results of a project (A6) is a systematic and structured study of its current state to determine how successfully it is being implemented. In general, A6 includes:

1. Assessing the current results of the project — analyzing data received from project

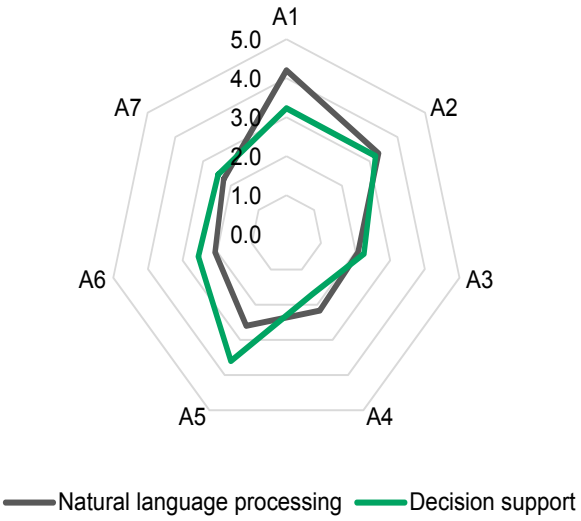


*Fig. 3.* **Diagrams of the distribution of average estimates of the relevance of the two categories of technologies and analytical procedures of the PCM**

*Source:* compiled by the author.

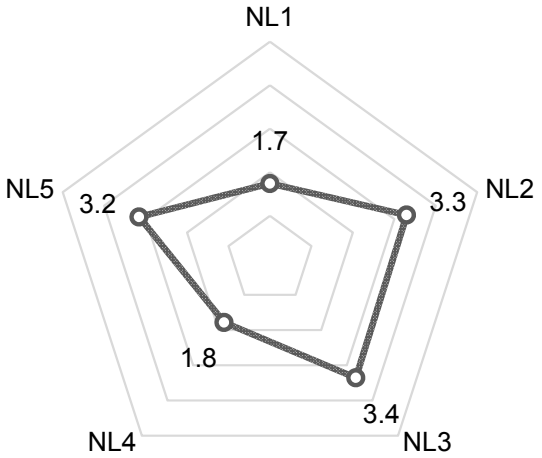


*Fig. 4.* **Diagram of the distribution of average estimates of the relevance of technological tasks in the category "Natural language processing"**

*Source:* compiled by the author.

team members and other stakeholders to determine its current status.

2. Identification of problems and risks — identifying those that may affect the implementation of the project.

3. Performance assessment — its measurement and comparison of actual indicators with planned ones.

4. Development of recommendations — identifying ways to improve productivity and generating proposals for improving project management.

5. Control and feedback — establishing mechanisms for monitoring the implementation of the project and providing feedback to improve the process of its implementation.

The importance of the analytical procedure for determining and updating the goals and scope of the project (A7) is due to the need to make adjustments to it in terms of describing the scale, boundaries, purpose, functional specification, hierarchy of work and conditions for its execution as a result of the changes made [1].

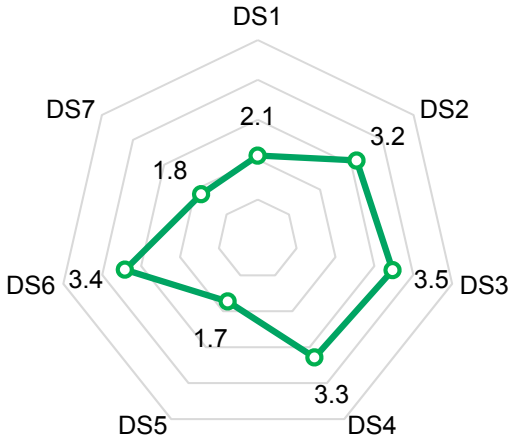


*Fig. 5.* **Diagram of the distribution of average estimates of the relevance of technological tasks in the category of "Decision support"**

*Source:* compiled by the author.

In general, the implementation of all the described analytical procedures is accompanied by errors, which are shown in *Fig. 1* are designated by variables E 1...E 7. The ECP variable indicates the presence of potential errors when implementing project changes as outlined in the dynamic plan.

*Table 7*

**Comparison of technological tasks relevant to the problem of PCM with machine learning methods and existing technological solutions in the field of AI**

| Code | Technological task relevant to the problem of PCM | Machine learning method | Technological solution |
|---|---|---|---|
| NL2 | Search and classification of various types of entities in texts, including names of organizations and names of personalities | ANN, GA, EFNIM, EFHNN | PMOtto.ai, PsodaVision |
| NL3 | Extraction of facts from texts and their systematization, including automatic training of ontologies | ANN, EFNIM, BT | PMOtto.ai, TARA.ai |
| NL5 | Isolating the most important information from the context and synthesizing unique texts | ANN, GA, EFNIM, EFHNN | PMOtto.ai, PsodaVision |
| DM3 | Intelligent simulation modeling of the behavior of market participants for goods, works and services | ANN, GA, EFNIM, GA+SVM | PMOtto.ai, Lili.ai |
| DM4 | Providing decision support based on long-term data, including for calculating standardization in economic sectors | ANN, GA, EFHNN, EFSIM | Lili.ai, Liquid Planner, Cloverleaf, PineStem |
| DM6 | Ultra-short-term forecasting, real-time data flow analysis and emergency forecasting | GA, EFHNN | Autodesk Construction IQ, Битрикс24, Liquid Planner, PsodaVision, Cloverleaf |

*Source:* compiled by the author.

*Table 5* shows the content of the analytical procedures of the PCM and indicates some possible sources and types of data.

## RESULTS

### Evaluation of the prospects for using AI technologies in PCM

To assess the potential of use of AI technologies in PCM, two rounds of online experiment were organized, in which 42 experts[5] took part. In the first round, they were asked to evaluate the prospects for the implementation and use of AI technologies in PCM by 2030 on an individual rating scale from 0 to 5, where 0 means that there is no prospect, and 5 means that it is most likely. The professional status of the experts is given in *Table 6*.

As a result of the first round of examination, assessments were obtained that made it possible to substantiate the prospects of using AI technologies in PCM. Score charts indicate heterogeneity across technology categories (*Fig. 2*).

The assessments of the prospects for the use of natural language processing (NL) and decision support (DS) technologies in PCM turned out to be the highest and most consolidated. The maximum variability of opinions with a minimum average was identified when assessing the prospects for using computer vision (CV) technology.

Since, according to the results of the first round, the NL and DS technologies were

[5] 39 experts took part in the second round.

recognized as the most promising, in the second round the experts determined the degree of relevance of technological tasks in these categories to the analytical procedures of the PCM (*Fig. 3*).

The relationship of the diagrams indicates the possibility of a rational combination of AI technologies to improve the efficiency of analytical procedures of the PCM. The use of natural language processing technologies is most promising in relation to the analytical procedure A1, and decision support technologies are relevant to the A5 procedure.

In the "Natural Language Processing" category, the maximum scores were obtained for technological tasks NL2 — search and classification of various types of entities in the text, including names of organizations and names of personalities; NL3 — extraction of facts from texts and their systematization, including automatic learning of ontologies; NL5 — identifying the most important information from the context and synthesizing unique texts (*Fig. 4*).

In the "Decision Support" category, the most highly rated technological tasks were DS3 — intelligent simulation modeling of the behavior of participants in the market for goods, works and services; DS4 — providing decision support based on long-term data, including for calculating standardization in economic sectors; DS 6 — ultra-short-term forecasting, analysis of data flow in real time and forecasting of emergency situations (*Fig. 5*).

### Comparison of technological tasks of PCM with AI technologies

*Table 7* shows an option for comparing technological problems with machine learning methods and existing AI technological solutions.

It should be noted that this comparison is variable: firstly, solving technological problems is not limited to the use of these machine learning methods; secondly, some of the solutions provided go beyond the technology categories "Natural Language Processing" and "Decision Support" chosen by experts (for example, PsodaVision belongs to the "Computer Vision" category).

Nevertheless, the data in *Table 7* allow us to evaluate the directions for updating existing and developing new technological solutions to improve the efficiency of PCM processes.

## DISCUSSION

An important feature of PCM analytical procedures that involve processing dynamic arrays of multimodal information is the need to merge data of different natures and dimensions, which makes it difficult to form conclusions and decisions using traditional methods and analysis tools.

A promising solution to this problem is the use of AI technologies in the field of:

Natural language processing:

- search and classification of various types of entities in texts, including names of organizations and names of personalities;
- extraction of facts from texts and their systematization, including automatic learning of ontologies;
- selection of the most important information from the context and synthesis of unique texts.

2. Decision support:

- intelligent simulation modeling of the behavior of participants in the market for goods, works and services;
- providing support for decision-making based on long-term data, including for calculating standardization in economic sectors;
- ultra-short-term forecasting, real-time data flow analysis and forecasting of emergency situations.

The use of AI in the listed areas may be most in demand, but other problems can also be solved with its participation. The comparison results make it possible to assess the directions of development of the corresponding solutions and their architectures in the interests of implementation in PCM processes. When using data sources, it is necessary to take into account industry specifics, scale and complexity of projects.

It is important to note that this study does not aim to prove the universality of AI technologies and their priority in the field of project management in relation to traditional approaches. The results obtained by the author make it possible to substantiate the possibilities of using AI in the PCM as an additional tool that expands the capabilities of the project team and increases the efficiency of its work.

The main limitations of the method include:

a) the level of detail used in the model and the composition of analytical procedures (however, the model allows for the description of other processes and analytical procedures of the PCM);

b) variability of expert assessments due to the level of competencies of the group.

The use of neural networks and deep machine learning technologies in project management in the future may lead to the formation of unique risks, the consideration of which will require the adoption of managerial, legal and economic decisions and the creation of appropriate institutions.

The most actively predicted risks these days are:

- reduction in demand for labor of analysts, experts, consultants and junior administrative and managerial personnel;
- reducing the responsibility of project team members who perceive the neural network as a "black box" that generates "correct" recommendations;
- formation by a neural network of non-optimal solutions (or optimal according to criteria that do not coincide with the project's performance indicators).

Specific risks of using AI technologies in managing projects and their changes include:

a) inaccuracy in estimating project deadlines when the neural network does not have data on all its parameters (insufficient training data on task durations under different conditions);

b) prioritization errors leading to suboptimal resource allocation (limitations of machine learning methods in understanding complex interdependencies between tasks);

c) underestimation or incorrect assessment of project risks (the inability of modern AI algorithms to simulate rare "tail" events);

d) failure to take into account the "human factor": AI algorithms are not able to take into account all the emotional aspects of the behavior of project team members (the difficulty of formalizing and taking into account emotional and behavioral factors);

e) lack of creativity: AI technologies are not able to offer innovative and creative solutions (specificity of the current level of technology development).

The most obvious economic effects can be meeting project deadlines, as well as reducing resource overruns by optimizing change management procedures.

The directions for the development of the method are a detailed description of the analytical procedures of the PCM and clarification of the requirements for the architecture and purpose of specific technological solutions in the field of AI.

The priority tasks for further research are:

- identification and systematization of data sources on factors of the internal and external environment of projects;

• formation of ontologies of features of project management situations for deep learning of neural networks;

• development of algorithmic and software for hybrid systems for multimodal fusion and processing of heterogeneous data.

Comparison of the descriptive model of the PCM process with the results of an examination of the prospects for using AI technologies in PCM allows us to develop a normative model of PCM, which is also one of the promising directions for the development of this research.

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## REFERENCES

1. Wysocki R.K. Effective project management: Traditional, agile, extreme. Indianapolis, IN: John Wiley & Sons, Inc.; 2011. 816 p.
2. Ansari R. Dynamic simulation model for project change-management policies: Engineering project case. *Journal of Construction Engineering and Management*. 2019;145(7):05019008. DOI: 10.1061/(ASCE)CO.1943–7862.0001664
3. Ibbs C.W., Chao C. Proactive project change-prediction tool. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*. 2015;7(4):04515003. DOI: 10.1061/(ASCE)LA.1943–4170.0000175
4. Butt A., Naaranoja M., Savolainen J. Project change stakeholder communication. *International Journal of Project Management*. 2016;34(8):1579–1595. DOI: 10.1016/j.ijproman.2016.08.010
5. Luk'yanova A.V. Trends of changes in project management in the context of digitalization. *Ekonomika: vchera, segodnya, zavtra = Economics: Yesterday, Today and Tomorrow*. 2021;11(8–1):198–203. (In Russ.). DOI: 10.34670/AR.2021.17.73.025
6. Mikhailov A.S. Application of artificial intelligence in project management. *Upravlenie proektami i programmami = The Project Management Journal.* 2021;(1):6–12. (In Russ.).
7. Shedko Yu.N., Vlasenko M.N., Humiliaev N.V. Strategic project management based on artificial intelligence. *Ekonomicheskaya bezopasnost' = Economic Security*. 2021;4(3):629–642. (In Russ.). DOI: 10.18334/ecsec.4.3.111949
8. Kelley J.E., Walker M.R., Sayer J.S. The origins of PCM: A personal history. *PM Network*. 1989;3(2):7–22. URL: https://www.pmi.org/learning/library/origins-cpm-personal-history-3762
9. Magee J.F. Decision trees for decision making. *Harvard Business Review*. 1964;(July):1–12. URL: https://hbr.org/1964/07/decision-trees-for-decision-making
10. Malcolm D.G., Roseboom J.H., Clark C.E., Fazar W. Application of a technique for research and development program evaluation. *Operations Research*. 1959;7(5):646–669. DOI: 10.1287/opre.7.5.646
11. Fleming Q.W., Koppelman J.M. Earned value project management. 4th ed. Newtown Square, PA: Project Management Institute; 2010. 232 p.
12. Goldratt E.M. Critical chain. Great Barrington, MA: The North River Press; 1997. 246 p.
13. Shapovalov A.V., Preobrazhenskiy A.P., Choporov O.N. Analysis of approaches used for project management in organizations. *Modelirovanie, optimizatsiya i informatsionnye tekhnologii = Modeling, Optimization and Information Technology*. 2019;7(1):418–429. (In Russ.). DOI: 10.26102/2310–6018/2019.24.1.038

14. Lehmann V. Connecting changes to projects using a historical perspective: Towards some new canvases for researchers. *International Journal of Project Management*. 2010;28(4):328–338. DOI: 10.1016/j.ijproman.2010.01.011
15. Takahashi Y., Yajima H., Dan T., Murata T. Research of motivation management method for project members at dynamic change of project. *IEEJ Transactions on Electronics, Information and Systems*. 2016;136(8):1246–1252.
16. Sun M., Meng X. Taxonomy for change causes and effects in construction projects. *International Journal of Project Management*. 2009;27(6):560–572. DOI: 10.1016/j.ijproman.2008.10.005
17. Dvir D., Lechler T. Plans are nothing, changing plans is everything: The impact of changes on project success. *Research Policy*. 2004;33(1):1–15. DOI: 10.1016/j.respol.2003.04.001
18. Winch G., Meunier M.-Ch., Head J., Russ K. Projects as the content and process of change: The case of the health and safety laboratory. *International Journal of Project Management*. 2012;30(2):141–152. DOI: 10.1016/j.ijproman.2011.06.005
19. Hu E., Liu Y. IT project change management. In: Proc. Int. symp. on computer science and computational technology — SCSCT 2008 (Shanghai, December 20–22, 2008). Piscataway, NJ: IEEE; 2008:417–420. DOI: 10.1109/ISCSCT.2008.224
20. Haskins T.C. Uncertainty, change management the application to risk & safety for infrastructure projects how it happens in Australia. In: Proc. 4th IET Int. conf. on systems safety 2009 (Incorporating the SaRS Annual Conference). (London, October 26–28, 2009). Piscataway, NJ: IEEE; 2009. DOI: 10.1049/cp.2009.1574
21. Karlsen J.T. Project stakeholder management. *Engineering Management Journal*. 2002;14(4):19–24. DOI: 10.1080/10429247.2002.11415180
22. Karvonen S. Computer supported changes in project management. *International Journal of Production Economics*. 1998;54(2):163–171. DOI: 10.1016/S 0925–5273(97)80441–0
23. Diyazitdinova A.R., Limanova N.I. Fuzzy set approach for IT project task management. *Programmnye produkty i sistemy = Software & Systems*. 2019;(1):5–11. (In Russ.).
24. Hosley W.N. The application of artificial intelligence software to project management. *Project Management Journal*. 1987;18(3):73–75.
25. Drogovoz P.A., Korenkova D.A. Modern tools for agile management of IT projects and prospects for its improvement using artificial intelligence technologies. *Ekonomika i predprinimatel'stvo = Journal of Economy and Entrepreneurship*. 2019;(10):829–833. (In Russ.).
26. Melekhin V.B., Aygumov T.G. Fuzzy model of knowledge representation in situational advising subsystem of project management. *Pribory i sistemy. Upravlenie, kontrol', diagnostika = Instruments and Systems: Monitoring, Control, and Diagnostics*. 2020;(6):40–45. (In Russ.). DOI: 10.25791/pribor.06.2020.1185
27. Yusufova O.M., Nevredinov A.R. Intelligent systems based on fuzzy computing and neural networks in project management. *Ekonomika i predprinimatel'stvo = Journal of Economy and Entrepreneurship*. 2019;(8):828–833. (In Russ.).
28. Drogovoz P.A., Shiboldenkov V.A., Korenkova D.A. An approach to creating a hybrid recommendation system to support decision-making on project management based on neural network mapping and cognitive visualization of earned value indicators. *Ekonomika i predprinimatel'stvo = Journal of Economy and Entrepreneurship*. 2019;(9):1212–1217. (In Russ.).
29. Kultin N.B. Artificial intelligence in the management of innovation projects. *Innovatsii = Innovations*. 2019;(12):99–103. (In Russ.). DOI: 10.26310/2071–3010.2020.254.12.014
30. Gil Ruiz J., Martínez Torres J., González Crespo R. The application of artificial intelligence in project management research: A review. *International Journal of Interactive Multimedia and Artificial Intelligence*. 2020;6(6):54–66. DOI: 10.9781/ijimai.2020.12.003

31. Shiriaev I.M., Kurysheva A.A., Volchik V.V. Narrative institutional analysis and the national innovation system in Russia. *Journal of Institutional Studies*. 2021;13(3):81–101. (In Russ.). DOI: 10.17835/2076–6297.2021.13.3.081–101
32. Fedorova E.A., Pyltsin I.V., Kovalchuk Yu.A., Drogovoz P.A. News and social networks of Russian companies: Degree of influence on the securities market. *Zhurnal Novoi ekonomicheskoi assotsiatsii = Journal of the New Economic Association.* 2022;(1):32–52. (In Russ.). DOI: 10.31737/2221–2264–2022–53–1–2

## ABOUT THE AUTHOR

***Pavel A. Mikhnenko*** — Dr. Sci. (Econ.), Associate Professor, Professor of the Department of Business Informatics, Bauman Moscow State Technical University, Moscow, Russia
https://orcid.org/0000-0002-1766-8029
mpa69@yandex.ru

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# Managing the Digital Transformation of Enterprises: Assessing its Level in Woodworking Industry Companies

**Yu.S. Konovalova, D.S. Burtsev**
ITMO University, Saint Petersburg, Russia

**ABSTRACT**

The research is devoted to analysing the woodworking industry from the point of view of using modern digital technologies at its enterprises. The **relevance** of this work is due to the fact that the timber industry is an important sector of the Russian economy, and the solution of such a **task** as determining the level of digital transformation (DT) of one of its industries will help identify problem areas and potential opportunities for improving production processes and introducing innovations. The methodological basis was the use of private and universal scientific **methods** such as analysis, synthesis, comparison, observation, ranking, and expert judgement. The authors of the study studied the activities of foreign and domestic timber processing companies, presented two options for calculating the level of their DT — both by quantifying the level of digitalisation of business processes and the scale of the company, and by analysing the effect of project implementation and the complexity of the technologies used, and found that the results obtained in both cases coincide. In the course of the work, three approaches to digital transformation were considered and it was concluded that its level not only in Russian, but also in foreign companies in the woodworking industry is average. The practical **significance** of the research consists in the development of recommendations and creation of a methodology for assessing the digital transformation of woodworking industry enterprises, which the latter can use when preparing for changes in the business model and the introduction of new technologies.

***Keywords:*** digital transformation; industrial enterprises; digital technologies; timber industry; woodworking industry; innovation; practice analysis; digitalization

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## INTRODUCTION

The forestry industry is an important sector of the Russian economy, combining industries related to the harvesting and processing of wood, and playing a significant role in the creation of biological resource potential.

To ensure its effective functioning, high-quality, accessible and complete information about available resources is necessary, which is why the introduction and development of digital technologies at forestry enterprises is such an important and relevant topic [1]. Currently, an increasing number of large companies are increasing investments in IT startups, as they understand the importance of these projects [2].

The branches of the timber industry complex can be provisionally divided into four groups: logging, wood processing, wood chemical and pulp and paper industries. As part of this study, it was decided to analyze the activities of enterprises in the wood processing industry (as a narrow segment of the forest industry).

Digital transformation (DT) provides a business with a competitive advantage, and companies that have mastered new technologies become market leaders [3, 4]. This is due to improved efficiency of business processes, improved customer experience, the emergence of resilience to change and the emergence of more accurate data analytics.

Experts distinguish 3 approaches to DT: process, industry and technology. In the first case, the organization seeks to optimize and automate its business processes through the use of digital technology tools. With a technology approach, it focuses on the development and use of digital technologies to optimize its own business models, processes, products or services. . In the case of an industry approach, a company considers change and innovation within the entire industry, and not just in the context of its own organization [5]. One more approach can be distinguished — an integrated one, which combines those previously listed and includes all changes in business models, business processes, technologies and culture of the organization.

The terms automation, digitalization and digital transformation refer to the implementation of technology in various aspects of a business.

*Automation* involves the use of computers, increases the efficiency and accuracy of procedures and reduces the cost of managing repetitive operations. *Digitalization* is associated with the use of various kinds of electronic devices for storing and processing information; it helps to increase the efficiency of work processes, facilitate access to data and improve communication within the company. A digitalized business process involves the use of digital technologies and solutions for its automation and optimization [6]. *Digital transformation* covers a broader spectrum of transformations, affecting not only processes, but also the structure and culture of the company as a whole, and also involves modern technologies, organizational and cultural changes to improve business processes and meet the needs of stakeholders. As a result, the company becomes more competitive in the long term [7–9].

Both automation and digital transformation projects can have the same effect if they complement each other and they use similar technologies and tools (for example, if automation is one of the tools for implementing digital transformation). Improving business processes through automation can be the first step of DT, which will set the stage for larger changes. Once this is done, the company will be able to move on to more complex projects using complex technologies — say, such as artificial intelligence, the Internet of things and

blockchain. Digital transformation opens up new avenues for automation and increases its efficiency.

## RESEARCH METHODS

During the work, general scientific methods of cognition were used — analysis, synthesis, comparison, observation, ranking, expert assessments. Scientific journals and Internet resources became the information base. The level of digital transformation of six wood processing enterprises was determined by analyzing data (including performance indicators) obtained from open sources. The calculations were based on such quantitative indicators as the efficiency of project implementation, the number of digitalized business processes (i.e. those that use at least one digital solution) and the scale of the company. The evaluation criteria were the effect of project implementation and the level of technology complexity.

The companies selected for comparison are fairly representative of the industry, and their practices and experiences may reflect general trends and characteristics of the wood products industry.

## FORMULATION OF RESEARCH PROBLEM

This study selected three Russian and three foreign companies in the wood processing industry for analysis:

1. Segezha Group (Russia) is the largest manufacturer and supplier of wood construction materials: rounded and edged, as well as laminated veneer lumber, etc.[1]

2. Ilim Group (Russia) is one of the largest producers of pulp and paper on the world market; actively works on environmental projects and socio-economic development of the regions of its presence. The company is also a timber manufacturer.[2]

3. Sveza company (Russia) is engaged in the production and export of wood panels and materials for construction and transport; In its activities, it adheres to a policy of environmental responsibility and uses only environmentally friendly materials.[3]

4. West Fraser (Canada) is a company specializing in the production of a wide range of wood products. West Fraser manages its resources sustainably while maintaining high environmental standards.[4]

5. Weyerhaeuser Company (USA) is a company that is the largest manufacturer of laminated laminated wood and one of the leaders in the production of particle boards. Weyerhaeuser has a strong focus on sustainable forestry practices and environmental stewardship and has significant logging and land management assets.[5]

6. Canfor Corporation (Canada) is one of the world leaders in wood processing. The company actively works to reduce the environmental impact of its production processes.[6]

All of the above organizations are international and have enterprises and subsidiaries around the world, have extensive experience in the production of wood, wooden products, specialize in the production of pulp, paper, plywood, OSB boards and other building materials and have advanced technologies and highly qualified personnel, which allows them to produce high quality products.

Let's analyze the state of digital transformation in these 6 companies (*Table 1*)

[1] Company Segezha Group (official website). URL: https://segezha-group.com/

[2] Ilim group (official website). URL: https://www.ilimgroup.ru/

[3] Sveza (official website). URL: https://www.sveza.ru/

[4] West Fraser (official website). URL: https://www.westfraser.com/

[5] Weyerhaeuser (official website). URL: https://investor.weyerhaeuser.com/quarterly-and-annual-results

[6] Canfor Corporation (official website). URL: https://www.canfor.com/

*Table 1*

**Analysis of digital transformation practice**

| Company name | Country | Name of the approach to digital transformation | Type of digital solutions | Project | Received effect |
|---|---|---|---|---|---|
| Segezha Group | Russia | Process | Universal | 1. Automated dispatch system "SegezhaLes". 2. Hardware and software complex for raw material accounting. 3. Digital inventory. 4. Project of a unified enterprise management system | – Reducing the number of routine processes; – increase in measurement accuracy; — simplification of document flow; – saving time; – increasing data reliability; – increased efficiency; – planning accuracy; – cost optimization |
| Ilim Group | Russia | Process | Local | 1. Digital twin of the organization. 2. Project to optimize the supply of raw materials. 3. Operational dispatch control system | – Cost optimization; – planning accuracy; – optimization of logistics; – simplification of logging and cargo transportation; – reduction in the number of errors; – increased efficiency; – increased safety |
| Sveza | Russia | Process | Universal | 1. Robotization of logistics. 2. Digitalization of the recruitment procedure. 3. Digital educational project for staff. 4. Automated process analysis | – Time saving; – increasing the digital literacy of staff; – reduction in the number of errors |
| West Fraser | Canada | Sectorial | Universal | 1. Order tracking application. 2. Zero approach to IT security | – Simplification of the process of tracking and managing orders; – online order tracking; — increased data security |
| Weyerhaeuser Company | USA | Complex | Mixed | 1. Project for digital transformation of the logging process. 2. Cloud storage | – Increase in the efficiency of interaction within the company; – high-quality production process management |
| Canfor Corporation | Canada | Complex | Mixed | Project "Enterprise Design for Global Enterprise" (cloud platform) | – Increase in the efficiency of interaction within the company; – improvement of the quality of information; — increasing planning accuracy; – risk reduction; – cost optimization; – increasing the efficiency of production activities |

*Source:* compiled by the authors based on Segezha Group Sustainability Report. URL: https://www.akm.ru/upload/akmrating/SEGEZHA_sustainability_report_2020.pdf; Ilimgroup.ru portal. URL: https://www.ilimgroup.ru/press-tsentr/detail/gruppa-ilim-vystupila-generalnym-partnerom-foruma-smart-forest/; Sveza Sustainability Report. URL: https://www.sveza.ru/upload/iblock/4b7/%D0%9E%D1%82%D1%87%D0%B5%D1%82%20%D0%BE%D0%B1%20%D1%83%D1%81%D1%82%D0%BE%D0%B9%D1%87%D0%B8%D0%B2%D0%BE%D0%BC%20%D1%80%D0%B0%D0%B7%D0%B2%D0%B8%D1%82%D0%B8%D0%B8%202020.pdf; Westfraser.com portal. URL: https://www.westfraser.com/; Weyerhaeuser.com portal. URL: https://investor.weyerhaeuser.com/quarterly-and-annual-results; Questoraclecommunity.org portal. URL: https://questoraclecommunity.org/learn/customer-stories/canfor-transforms-its-business-from-a-legacy-system-to-a-cloud-hosted-erp-platform/

Weyerhaeuser Company and Canfor Corporation use local and universal solutions in their activities. Basically, companies in the woodworking industry introduce ready-made technologies that are used by other organizations.

The effect of projects within the DH framework may be similar to the result obtained from automation and digitalization, despite the fact that these concepts are not identical. This is due to the close interaction of these processes and the synergy resulting from the use of similar technologies.

Based on the data in *Table 1*, the implementation of projects has led to cost reduction, improved quality and increased efficiency of existing business processes.

Wood products companies often take a process approach to digital transformation; sectoral and technology approaches can be useful complements, but are more likely to be focused on specific areas of activity, such as innovation in production technologies or improved forest management.

Taking an integrated approach can help industry organizations achieve greater efficiency.

**Calculating the level of digital transformation by assessing the level of digitalization of business processes and assessing the scale of the company**

The priority areas of digital transformation are working with data and digitalization of business processes [10] — *Table 2* shows quantitative and qualitative assessments of the level of the latter: the number and type of business processes are determined, and the maturity levels of the digital technologies implemented in the companies under consideration are classified [10, 11]. All data necessary for the calculation was obtained from open sources.

The "+" sign indicates processes that have been digitalized in the company — in general, these are the majority of all organizations under consideration. A high level of digitalization is indicated in green, an average level in yellow, and a low level in red. Ilim Group and Canfor Corporation received the highest scores. The quantitative assessment of the remaining companies is two points (which corresponds to the average level of digitalization).

The number of top-level business processes (aimed at achieving the company's strategic goals) at forest industry enterprises may vary depending on the size and organizational structure of the latter. On average, from 10 to 16 such processes can be distinguished. They may be related to production, logistics, personnel management, etc. [12].

The timber industry complex is currently actively introducing new digital technologies, but generally the level of digitalization of business processes remains average [13, 14]. For further assessment, it is necessary to analyze such an indicator as the number of employees of the organization (*Table 3*).

All listed companies belong to large businesses, which are rated with the highest score. To determine the level of digital transformation, we will indicate the standard values of this indicator for each type of business (*Table 4*).

Since, as mentioned above, the organizations in question belong to large businesses, to confirm a high level of DT they need to score nine points; the average will be for companies that received six points; and low — for those who scored 3 points. Let's calculate the level of digital transformation (*Table 5*) using the data in *Table 2, 3 and 4*.

Based on the results obtained, we can conclude that two companies have a high level of DT: Ilim Group and Canfor; the rest are characterized by an average level of this indicator.

A *high level* of digital transformation means that an organization has introduced

*Table 2*

**The level of digitalization of business processes**

| Type of business process | Name of the business process | | Company name | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Segezha Group* | Ilim Group | Sveza | West Fraser* | Weyerhaeuser Company* | Canfor Corporation* |
| Main | Transportation | | + | + | + | + | + | + |
| Main | Production processes | | + | + | + | + | + | + |
| Providing | IT support | | + | + | + | + | + | + |
| Administartive | Personnel m | | + | + | + | + | + | + |
| Administartive | Financial management | | + | + | + | + | + | + |
| Administartive | Quality control | | + | + | + | | | + |
| Administartive | Sales management | | + | + | + | + | + | |
| Administartive | Supply and inventory management | | + | + | + | + | | + |
| Administartive | Project management | | | + | + | | | + |
| Administartive | Marketing management | | | + | | + | + | + |
| Administartive | Warehouse management | | | + | | + | | |
| Administartive | Resource management | | | + | | | + | + |
| Administartive | Sales planning | | | + | | | | + |
| **Total:** | | | **8** | **All digital twin** | **9** | **9** | **8** | **11** |
| More than 10 business processes have been digitalized — 3 points (high level of digitalization).<br>From 6 to 10 business processes have been digitalized — 2 points (average level of digitalization).<br>Less than 5 business processes are digitalized — 1 point (low level of digitalization) | | Quantative evaluation | 2 | 3 | 2 | 2 | 2 | 3 |
| | | Quality evaluation | Middle | High | Middle | Middle | Middle | High |

*Source:* compiled by the authors.

*Note:* * — Apps run the world company (official website). URL: https://www.appsruntheworld.com/customers-database/

the maximum amount of digital technologies into its activities, allowing it to achieve maximum operational efficiency, automate most processes and quickly respond to changes in the business environment. The *average level* indicates that the organization is using digital technologies, but some business processes are still performed

*Table 3*

**Estimating the scale of companies**

| Name of indicator | | Company name | | | | | |
|---|---|---|---|---|---|---|---|
| | | Segezha Group | Ilim Group | Sveza | West Fraser | Weyerhaeuser Company | Canfor Corporation |
| Number of employees, people | | 14600 | 14845 | 6712 | 9000 | 9200 | 8000 |
| A company with up to 50 employees — small business — 1 point. The company has from 50 to 250 employees — medium business — 2 points. The company has more than 250 employees — large business — 3 points | Quantative evaluation | 3 | 3 | 3 | 3 | 3 | 3 |
| | Quality evaluation | Large | Large | Large | Large | Large | Large |

*Source:* compiled by the authors based on data from [15].

*Table 4*

**Normative values of digital transformation level for the first calculation method**

| Company scale | | | | | |
|---|---|---|---|---|---|
| Large business | | Mid-sized business | | Small business | |
| Quantitative assessment of the level of digital transformation, points. | Qualitative assessment of the level of digital transformation | Quantitative assessment of the level of digital transformation, points | Qualitative assessment of the level of digital transformation | Quantitative assessment of the level of digital transformation, points | Qualitative assessment of the level of digital transformation |
| 9 | High | 6 | High | 3 | High |
| 6 | Middle | 4 | Middle | 2 | Middle |
| 3 | Low | 2 | Low | 1 | Low |

*Source:* compiled by the authors.

*Table 5*

**The first way to assess the level of digital transformation**

| Company name | Name of indicator | | | Explanation |
|---|---|---|---|---|
| | Assessment of the company's scale, points | Assessment of the level of digitalization of business processes, points | Level of digital transformation points | |
| | S | BP | L1 = BP*S | |
| Segezha Group | 3 | 2 | 6 | Middle |
| Ilim Group | 3 | 3 | 9 | High |
| Sveza | 3 | 2 | 6 | Middle |
| West Fraser | 3 | 2 | 6 | Middle |
| Weyerhaeuser Company | 3 | 2 | 6 | Middle |
| Canfor Corporation | 3 | 3 | 9 | High |

*Source:* compiled by the authors.

*Table 6*

**Technology complexity assessment**

| Complexity of technologies | | Company name | | | | | |
|---|---|---|---|---|---|---|---|
| | | Segezha Group | Ilim Group | Sveza | West Fraser | Weyerhaeuser Company | Canfor Corporation |
| From 1 to 3 points, where 3 points — high difficulty, 2 points — average difficulty, 1 point — low difficulty | Quantative evaluation | 3 | 3 | 3 | 3 | 3 | 3 |
| | Quality evaluation | High | High | High | High | High | High |

*Source:* compiled by the authors.

*Table 7*

**Evaluation of the effect of implemented projects**

| Name of effect from implemented projects | Company name | | | | | |
|---|---|---|---|---|---|---|
| | Segezha Group | Ilim Group | Sveza | West Fraser | Weyerhaeuser Company | Canfor Corporation |
| 1. Increase in the speed and accuracy of decision making | + | + | + | + | + | + |
| 2. Reduction of labor and resource costs | + | + | | | | + |
| 3. Improvement in the quality of customer service | | + | + | + | | + |
| 4. Creation of new opportunities for business growth and market expansion | + | + | | | + | + |
| 5. Increased security and data protection | | + | | + | | + |
| 6. Reduced environmental impact | | + | + | + | + | + |
| 7. Increase in the efficiency of interaction within the organization and between its divisions | + | + | + | | + | + |
| Total: | 4 | 7 | 4 | 4 | 4 | 7 |

*Source:* compiled by the authors based on data from [17, 18].

*Table 8*

**Digital transformation level values for the second calculation method**

| Name of indicator | |
|---|---|
| Quantitative assessment of the level of digital transformation, points | Qualitative assessment of the level of digital transformation |
| from 15 to 21 | High |
| from 8 to 14 | Middle |
| from 1 to 7 | Low |

*Source:* compiled by the authors.

manually or using outdated methods. A *low level* of digital transformation is an indicator that the company does not use modern digital technologies and does not implement digitalization; its business processes may be inefficient, slow, and unable to adapt to a rapidly changing market. Each level of DT has its own advantages and disadvantages, and its choice depends on the specific needs and capabilities of the organization. However, companies seeking to take a leading position in the market must use modern digital

*Table 9*

**The second way to assess the level of digital transformation**

| Company name | Name of indicator | | | Explanation |
|---|---|---|---|---|
| | Assessment of technology complexity, points | Evaluation of the effect of implemented projects, points | Level of digital transformation, points | |
| | T | E | $L_2 = E*T$ | |
| Segezha Group | 3 | 4 | 12 | Middle |
| Ilim Group | 3 | 7 | 21 | High |
| Sveza | 3 | 4 | 12 | Middle |
| West Fraser | 3 | 4 | 12 | Middle |
| Weyerhaeuser Company | 3 | 4 | 12 | Middle |
| Canfor Corporation | 3 | 7 | 21 | High |

*Source:* compiled by the authors.

*Table 10*

**Comparison of the results of calculating the level of digital transformation**

| Company name | Name of indicator | |
|---|---|---|
| | Qualitative assessment obtained by the first method of assessing the level of digital transformation | Qualitative assessment obtained by the second method of assessing the level of digital transformation |
| Segezha Group | Middle level | Middle level |
| Ilim Group | High level | High level |
| Sveza | Middle level | Middle level |
| West Fraser | Middle level | Middle level |
| Weyerhaeuser Company | Middle level | Middle level |
| Canfor Corporation | High level | High level |

*Source:* compiled by the authors.

technologies and processes to their full potential.

### Calculation of the level of digital transformation by assessing the effect of project implementation and assessing the complexity of technologies

Let's calculate the level of digital transformation in the second way. To do this, we will analyze the effect of projects implemented as part of digital transformation and the complexity of the technologies that were used [22].

When assessing technologies, we will be guided by the following: low complexity is characterized by the use of standard solutions for process automation; medium involves the development of mobile and web applications; high is associated with the use of

advanced and innovative solutions. Assessing the complexity of technologies within the framework of digital transformation depends on how much they influence the company's current business processes and the extent to which their implementation and use are complex (*Table 6*).

All the companies examined used high complexity technologies in their projects based on digital transformation [16] *Table 7* shows estimates of the obtained effect.

The "+" sign indicates the effect achieved by the company when implementing projects as part of digital transformation. Ilim Group and Canfor Corporation received the maximum number of points. The remaining companies have four points out of seven possible. *Table 8* presents the standard values of the DT level necessary for interpreting the results of the calculation performed by the second method.

Let's calculate the level of digital transformation in the second way (*Table 9),* using the data in *Table 6, 7 and 8*.

Thus, Ilim Group and Canfor Corporation have a high level of DT; for other companies it is average.

## COMPARISON OF THE OBTAINED RESULTS OF CALCULATION OF DT LEVEL

The high level of digital transformation of forest industry enterprises plays an important role in ensuring their efficient and sustainable operation. However, according to this indicator, the industry lags behind other sectors of the economy for reasons (related to its specifics) such as the complexity of its automation, the low level of qualifications of workers and insufficient funding. Let's compare the data (*Table 10*) obtained using the first and second calculation methods (*Tables 5 and 9*).

Obviously, the calculation results coincide (and this confirms their reliability). However, it is worth considering that the DT level is not an absolute value, but a relative indicator that can be assessed differently depending on what criteria and methods were used for this. Therefore, even if the results obtained by using different calculation methods are identical, they should be analyzed and the possibility of improving business processes using DT should not be neglected.

Based on the results of the study, we can conclude that, in general, enterprises in the woodworking industry are characterized by an average level of DT, which is confirmed by numerous foreign studies [19–21]. Most companies have not reached a high level of digital maturity and need further development.

According to scientists, the forest industry is moving towards digital transformation and it has enormous opportunities for further growth and development [22, 23].

## INTERPRETATION

The study made it possible to identify the main projects that woodworking industry enterprises are implementing as part of digital transformation — for example, most companies use universal options for their business. This article does not provide clear recommendations on the choice of digital solutions, but its authors will continue to work in this direction.

Open sources on the research topic emphasize the importance of introducing innovations related to digital technologies. Thus, in the work of Yu. S. Polozhentseva, O. V. Sogacheva and A. S. Byankin says that the forestry, woodworking and pulp and paper industries, in terms of the degree of implementation of digital technologies, rank 7th out of 9 possible in the ranking of Russian industrial sectors, which is an average indicator [24]. H. Le believes that Vietnam's wood processing industry occupies a fairly important place in the world. However,

the contribution of digital transformation and high technology to the industry's performance is still modest, and more efforts should be made in this direction to change the situation. It is noteworthy that many wood processing enterprises are hesitant to speed up this process for various reasons, including high costs [25]. Digital development in the Slovenian forest industry, including wood processing, is at a relatively low level compared to other countries, but judging by the latest strategic guidelines adopted at both the state and business levels, this situation should improve in the near future [26].

The digital transformation of the woodworking industry is estimated at 6 or 7 points on a scale from 1 to 10 (10 points is the highest level of digital transformation), and the metalworking industry — at 10 [27]. A study by M. Makkonen revealed a connection between the digitalization of the wood processing industry and the consumer value of products, but at the same time emphasized that companies in the industry have not fully appreciated the importance of DT, so its indicator is at an average level [28].

## CONCLUSION

As mentioned above, the level of DT in the woodworking industry is average, since companies, when implementing projects, mainly adhere to a process or integrated approach and use ready-made digital solutions.

The authors reviewed 6 large companies (3 domestic and 3 foreign); a high level of digital transformation was noted by the Ilim Group (Russia) and Canfor Corporation (Canada); the activities of other organizations in the field of digital technologies are at an average level. These conclusions were made through the use of two different methods for calculating the DT indicator: the first is based on assessing the level of digitalization of business processes and the scale of the company, and the second is based on determining the effect of implementing digital transformation projects and the complexity of the technologies used in them.

Further work in this direction will make it possible to classify digital technologies in the woodworking industry, analyze the factors of the effectiveness of using digital solutions and formulate recommendations for DT of industry enterprises not only in Russia, but also in friendly countries.

The use of digital technologies can help optimize logging and timber production processes, improve product quality, reduce waste, reduce costs, increase the efficiency of production processes and reduce the negative impact on the environment. The presented research complements those previously carried out on this topic and can become a starting point for more in-depth research aimed at studying the specifics of digital transformation in specific industries.

The methods used to calculate the level of digital transformation can be useful in analyzing other companies and industries, and the results obtained can contribute to the exchange of experience and a better understanding of the digital transformation process in different sectors of the economy.

## REFERENCES

1. Bareiko S.N., Kravchenko S.K. The role of informatization and digitalization of the forest complex in providing the economic security of Russia. Nauka Krasnoyar'ya = Krasnoyarsk Science. 2021;10(4):92–105. (In Russ.). DOI: 10.12731/2070–7568–2021–10–4–92–105
2. Ksenofontova T. Yu., Mardas A.N., Gulyaeva O.A., Mardas D.A. In search of technological breakthroughs: why are there few successful startups in Russia? In: Smart technologies in the modern world. Proc. Anniver. All-

Russ. sci.-pract. conf. dedicated to the 75th anniversary of South Ural State University (Chelyabinsk, November 20–23, 2018). Vol. 2. Chelyabinsk: South Ural State University; 2018:132–138. (In Russ.).
3. Averina T., Barkalov S., Fedorova I., Poryadina V. Impact of digital technologies on the company's business model. E 3S Web of Conferences. 2021;244:10002. DOI: 10.1051/e3sconf/202124410002
4. Verhoef P. C., Broekhuizen T., Bart Y., Bhattacharya A., Qi Dong J., Fabian N., Haenlein M. Digital transformation: A multidisciplinary reflection and research agenda. Journal of Business Research. 2021;122:889–901. DOI: 10.1016/j.jbusres.2019.09.022
5. Murashova N.V. Main approaches to the digital transformation of rural areas. In: Economics and management in the 21st century: New challenges and opportunities. Proc. 2nd All-Russ. sci.-pract. conf. (Saransk, June 10–11, 2021). Saransk: V.S. Afanas'ev Publ.; 2021:107–112. (In Russ.).
6. Agafonova T.V., Pirogova S.V. Digitalization of business processes. Ekonomika i biznes: teoriya i praktika = Economy and Business: Theory and Practice. 2020;(12–1):26–29. (In Russ.). DOI: 10.24411/2411–0450–2020–11009
7. Verbakh G.G. Digitalization of production. In: Problems of enterprise development: Theory and practice. Proc. 6th Int. sci.-pract. conf. (Penza, April 11–12, 2019). Penza: Penza State Agrarian University; 2019:46–49. (In Russ.).
8. Schumacher A., Sihn W., Erol S. Automation, digitization and digitalization and their implications for manufacturing processes. In: Proc. Int. sci. conf. "Innovation and sustainability 2016" (Bucharest, October 28–29, 2016). Bucharest: University Politehnica of Bucharest; 2016:1–5. URL: https://www.researchgate.net/publication/318877006_Automation_digitization_and_digitalization_and_their_implications_for_manufacturing_processes
9. Lallaoui Y. Digitalization, digitization and automation and their implications for manufacturing processes. In: Scientific initiative of foreign students and graduate students. Proc. 1st Int. sci.-pract. conf. (Tomsk, April 27–29, 2021). (In 2 vols.). Vol. 2. Tomsk: Tomsk Polytechnic University; 2021:398–402.
10. Ermakova S. Digitalization vs digital transformation: Market overview and industry case. E-xecutive.ru. Dec. 15, 2022. URL: https://www.e-xecutive.ru/management/itforbusiness/1995732-tsifrovizatsiya-vs-tsifrovaya-transformatsiya-obzor-rynka-i-keis-iz-promyshlennosti (accessed on 01.05.2023). (In Russ.).
11. Rakhlis T.P. Isaeva M.M. Assessment of the digital mature of an industrial enterprise: A methodological aspect. In: Proc. 16th Int. conf. "Russian regions in the focus of change" (Ekaterinburg, November 18–20, 2021). (In 2 vols.). Vol. 1. Ekaterinburg: Ural Federal University; 2022:480–484. URL: https://elar.urfu.ru/bitstream/10995/108747/1/978–5–91256–542–7_1_093.pdf (accessed on 01.05.2023). (In Russ.).
12. Chuvaeva A.I., Apukhtin A.N. Business processes at the enterprises of the timber industry complex. Nauka i sovremennost'. 2011;(14):304–309. URL: https://cyberleninka.ru/article/n/biznes-protsessy-na-predpriyatiyah-lesopromyshlennogo-kompleksa (accessed on 02.05.2023). (In Russ.).
13. On the index of the level of use of digital technologies. Based on materials from the Institute of Statistical Research and Economics of Knowledge, NRU HSE. ID Expert.ru. Oct. 19, 2022. URL: https://www.idexpert.ru/reviews/Ob-indekse-urovnya-ispolzovaniya-tsifrovykh-tekhnologiy/ (accessed on 02.05.2023). (In Russ.).
14. Digitalization of business processes. ISSEK. Aug. 22, 2018. URL: https://issek.hse.ru/news/222541867.html (accessed on 02.05.2023). (In Russ.).
15. Pletnev D.A., Barkhatov V.I., Naumova K.A. SME's criteria in national economies and its scale: A comparative study. Vestnik Chelyabinskogo gosudarstvennogo universiteta = Bulletin of Chelyabinsk State University. 2021;(6):147–161. (In Russ.). DOI: 10.47475/1994–2796–2021–10617
16. Kravchenko P.P., Burtsev D.S. Business process management at forest industry enterprises within the framework of modern approaches to the implementation of sustainable development projects. Ekonomika,

predprinimatel'stvo i pravo = Journal of Economics, Entrepreneurship and Law. 2022;12(12):3269–3282. (In Russ.). DOI: 10.18334/epp.12.12.116974

17. Masoud R., Basahel S. The effects of digital transformation on firm performance: The role of customer experience and IT innovation. Digital. 2023;3(2):109–126. DOI: 10.3390/digital3020008
18. Plotnikov A.V., Kursat D., Hiroko K., Mikhailova S.D. The impact of digital transformation on the economy. Moskovskii ekonomicheskii zhurnal = Moscow Economic Journal. 2020;(7):163–173. DOI: 10.24411/2413–046X-2020–10518
19. Kankaanhuhta V., Packalen T., Väätäinen K. Digital transformation of forest services in Finland — a case study for improving business processes. Forests. 2021;12(6):781. DOI: 10.3390/f12060781
20. Holmström J. Digital transformation of the Swedish forestry value chain: Key bottlenecks and pathways forward. Stockholm: Skogsindustrierna; 2020. 24 p. URL: http://jonnyholmstrom.com/wp-content/uploads/2020/05/Holmstrom_2020.pdf (accessed on 01.05.2023).
21. Georgieva D., Popova R. Digitisation in forest industry in Bulgaria — state and perspectives. Munich Personal RePEc Archive. MPRA Paper. 2019;(96848). URL: https://mpra.ub.uni-muenchen.de/96848/1/MPRA_paper_96848.pdf (дата обращения: 01.05.2023).
22. Watanabe C., Naveed N. Digital solutions in the forest-based bioeconomy. In: Biernat K. Elements of bioeconomy. London: IntechOpen; 2019. DOI: 10.5772/intechopen.84828
23. Koukouvinou P., Simbi N., Holmström J. Managing unbounded digital transformation: Exploring the role of tensions in a digital transformation initiative in the forestry industry. Information Technology & People. 2023;36(8):43–68. DOI: 10.1108/ITP-03–2020–0106
24. Polozhentseva Yu.S., Sogacheva O.V., Byankin A.S. Monitoring development trends of digital transformation of the industrial complex. Vestnik Akademii znanii = Bulletin of the Academy of Knowledge. 2021;(46):263–269. (In Russ.). DOI: 10.24412/2304–6139–2021–5–263–269
25. Le Hoang. Many woodworking businesses hesitant about digital transformation. The Saigon Times. Jan. 02, 2022. URL: https://english.thesaigontimes.vn/many-woodworking-businesses-hesitant-about-digital-transformation/ (accessed on 02.05.2023).
26. Kropivšek J., Grošelj P. Digital development of Slovenian wood industry. Drvna Industrija. 2020;71(2):139–148. DOI: 10.5552/drvind.2020.1961
27. Christianson R. Industry 4.0 in the wood industry: Beyond the buzz. Association of Woodworking & Furnishings Suppliers. Apr. 19, 2019. URL: https://www.awfsfair.org/2019/04/19/industry-4–0-in-the-wood-industry-beyond-the-buzz/ (accessed on 02.05.2023).
28. Makkonen M. Stakeholder perspectives on the business potential of digitalization in the wood products industry. BioProducts Business. 2018;3(6):63–80. DOI: 10.22382/bpb-2018–006

## ABOUT THE AUTHORS

***Yulia S. Konovalova*** — master student, Department of Technological Management, and Innovations, ITMO University, Saint Petersburg, Russia
https://orcid.org/0000-0001-5238-7620
*Corresponding author:*
YK_brunette98@mail.ru

***Daniil S. Burtsev*** — Cand. Sci. (Agriculture), Associate Professor of the Department of Technological Management and Innovations, ITMO University, Saint Petersburg, Russia
https://orcid.org/0000-0002-4825-1162
dsburtcev@itmo.ru

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# Analysis of the Construction Market in Russia and Abroad in Order to Curb the Growth of Construction Costs and Ensure the Competitiveness of Enterprises by Increasing the Efficiency of the Cost Accounting and Control System

**A.E. Lebedeva, I.V. Karakozova**
MGSU, Moscow, Russia

**ABSTRACT**

The purpose of the study is to analyze the Russian construction market and the prospects for its development in the context of large contracting companies, as well as to determine contractor competitiveness and the place of the largest domestic construction companies in the world ranking. Comparison, analysis, as well as graphical, tabular methods of data presentation and visualization were used as research methods. The paper presents an analysis and characteristics of the Russian and world construction market, its dynamics, structure and key players. The main trends and drivers of the construction industry are described. The volume of construction is growing every year, despite the economic and political crises of past five years. This fact indicates a high demand for construction products. The article considers the main players in the Russian and foreign markets. The leading positions in terms of construction volumes are occupied by such countries as China, the USA, Japan and the EU, while the Russian Federation lags behind in terms of construction production volume. Only four construction companies in the world have a turnover of more than $ 100 billion, while maintaining a significant lead over other players. Whereas the development of the global construction market is associated with population dynamics, an influx of investments in the Asian region is expected, which in turn will contribute to the development of technologies and the introduction of innovations in the field of construction management. The study revealed a direct correlation and relationship between the competitiveness of construction companies and internationalization. Despite the increasing interest of Russian developers in foreign projects, at the moment the expansion trend of Russian construction companies is just beginning to take shape. It is concluded that in order to increase the competitiveness of Russian construction companies in the world market, the efficiency of project management and cost optimization, it is necessary to introduce an effective system of projects cost accounting and control.

***Keywords:*** analysis of the construction market; Russian construction market; global construction market; transnational construction companies; competitiveness of construction companies; cost accounting and control system

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## INTRODUCTION

Despite the active development of the global construction industry, there are both external and internal factors limiting it. Mainly due to increased budget investments and government support, the construction market survived the 2020 pandemic while maintaining key indicators at an acceptable level. However, its consequences and crisis, although with a slight delay, were reflected in the indicators in 2021 [1, 2]. The delayed reaction is due to the fact that construction companies usually have stocks of materials; Thus, rising prices for resources, fluctuations in exchange rates and increasing fuel costs will affect the cost of construction products only in the long term. In this regard, studying the state and patterns that have developed in this area, as well as the reasons for the decline in growth rates, is an urgent task to improve the efficiency of the cost accounting and control system.

Published studies widely cover the development of national construction markets abroad, while Russia's place in global construction production is not fully reflected in the scientific literature, which determines relevance of the research.

In this study, the authors identified and solved the following problems:

1. Analysis of the dynamics and structure of the Russian construction market, as well as the reaction of its participants to the political and economic crises of recent years.

2. Study of the global construction market and its key players, description of modern directions of its development.

3. Determining the place in rank of companies — market leaders in the global construction industry.

4. Finding ways to improve the efficiency of the cost accounting and control system at Russian enterprises in the industry.

The methodology of the research is based on the analysis of the following information:

- Statistical data published by the federal state statistics service Rosstat.
- Forecasts for the development of the global construction market Global Construction 2030 prepared by experts Global Construction Perspective and Oxford Economics
- ENR ratings of the world's largest construction companies.
- Ratings of Russian construction companies from such publications as RBC, Forbes and annual published reports of construction companies.

## RUSSIAN CONSTRUCTION MARKET: DYNAMICS AND STRUCTURE

Construction is one of the largest and most capital-intensive sectors of the economy. Its share in Russia's GDP is about 5% [3]. According to Rosstat, the volume of work performed in the "Construction" type of activity in our country in 2022 amounted to 12,865.5 billion rubles. ($ 188.2 billion), and at the beginning of 2023 increased by 5.2% compared to the previous period. Despite the economic and political crises of recent years, this figure is growing every year, which indicates a high demand for construction products. During 2022, 160,189.6 thousand m2 of space were put into operation; of which 79% (or 126,675.5 thousand m2) were residential buildings; commercial buildings accounted for only 5%, and the shares of industrial, agricultural and educational buildings each amounted to 3% (*Fig. 1*). Thus, the basis of the Russian construction market is residential construction (which corresponds to world indicators).

From the point of view of forms of ownership, the structure of the market in question has undergone significant changes over the past 20 years. Thus, currently most of it is occupied by private companies (*Fig. 2*), and the share of state-owned companies in 2019 accounted for only 1.4%. This indicates

the transition of the Russian construction industry from a planned economy to a free market [3].

It is worth noting that despite the annual increase in the volume of construction work in each category of property, it is private property that is developing most dynamically: its share in the total volume has increased by 6.8% over the past five years. Private companies are the main driver of the construction market in our country. The share of foreign enterprises and organizations with mixed ownership has decreased by 3% and 2.6%, respectively, since 2018 due to the economic and political crises of recent years.

In connection with the decisions of large American and European companies to leave the Russian market, some experts predict the arrival of Asian players, which primarily include Chinese companies [4].

## WORLD CONSTRUCTION MARKET

Housing construction is the backbone of the industry and plays an important role in the development of the global economy. Its main trends and prospects are researched and analyzed by well-known consulting companies such as The Business Research Company, Global Construction, Global Data and PWC (Oxford Economics).

According to Global Construction 2030[1] forecasts, the value of global construction production volumes will increase to approximately $ 14.8 trillion by 2030 (*Fig. 3*); the growth rate will average 2.5% per year.

The world leaders in the industry are countries such as China, the USA, Japan, as well as the states of the European Union, while the Russian Federation, as of 2022, occupies about 2% of the world volume. Since the prospects for the development of the construction market are related to population dynamics [3], active construction, corresponding improvement in technology and the introduction of innovations in management will be observed, according to forecasts, in the countries of Africa and Asia, where the main population growth is expected.

In the coming years, an inflow of investment is predicted in the rapidly growing construction business of Southeast Asia and other developing economies; They are characterized by high rates of urbanization and economic growth; they will become the main drivers of both local and global construction production markets.

The Asian region, with its large young population, is projected to see an increase in infrastructure, residential and educational projects, while Europe, with its rising average age, will need health and cultural facilities.

According to experts, China will retain its leading position in the global construction industry, but its share in the global volume will decrease from 32% (2020) to 29.2% (by 2030). According to Oxford Economics experts, India will overtake Japan and become the third largest construction market.

The international trend towards globalization leads to an increase in the number of multinational construction companies. If previously local contracting enterprises were involved in the implementation of projects in this area, now the contractor is determined through international tenders, in which both large local companies and transnational contracting organizations participate, which involves labor migration of labor and management personnel [5]. Thus, due to the participation of foreign contractors, national construction technologies are integrated and standardized not only within a single state, but also at the global level. The largest players in the

[1] Global Construction 2030 by Global Construction Perspective and Oxford Economics. URL: https://www.gihub.org/resources/publications/global-construction-2030

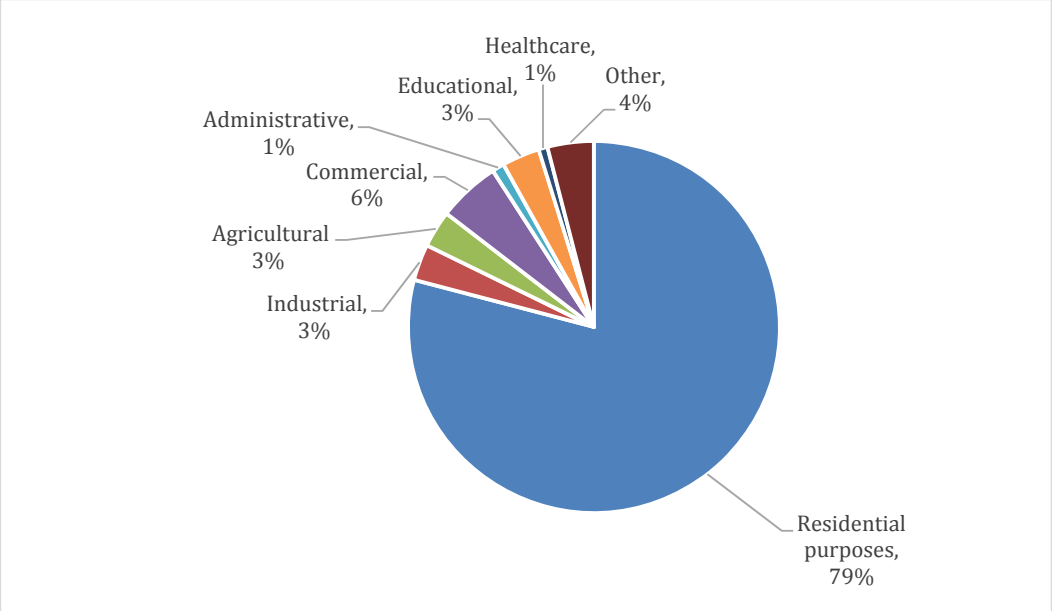


*Fig. 1.* **Commissioning of residential and non-residential buildings in the Russian Federation for 2022**

*Source:* compiled by the authors based on Rosstat data. URL: https://rosstat.gov.ru/

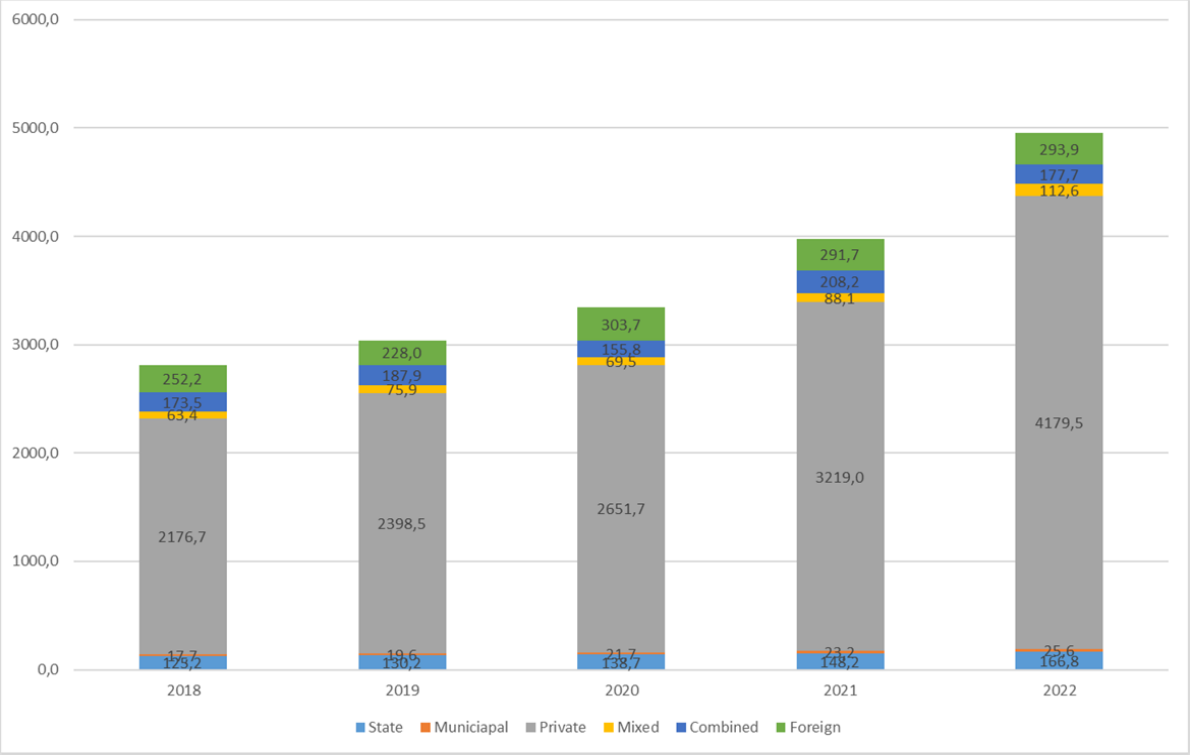


*Fig. 2.* **Dynamics of the distribution of the volume of work performed by the type of economic activity "Construction" by organizations of various forms of ownership (excluding small businesses), million rubles**

*Source:* compiled by the authors based on Rosstat data. URL: https://rosstat.gov.ru/

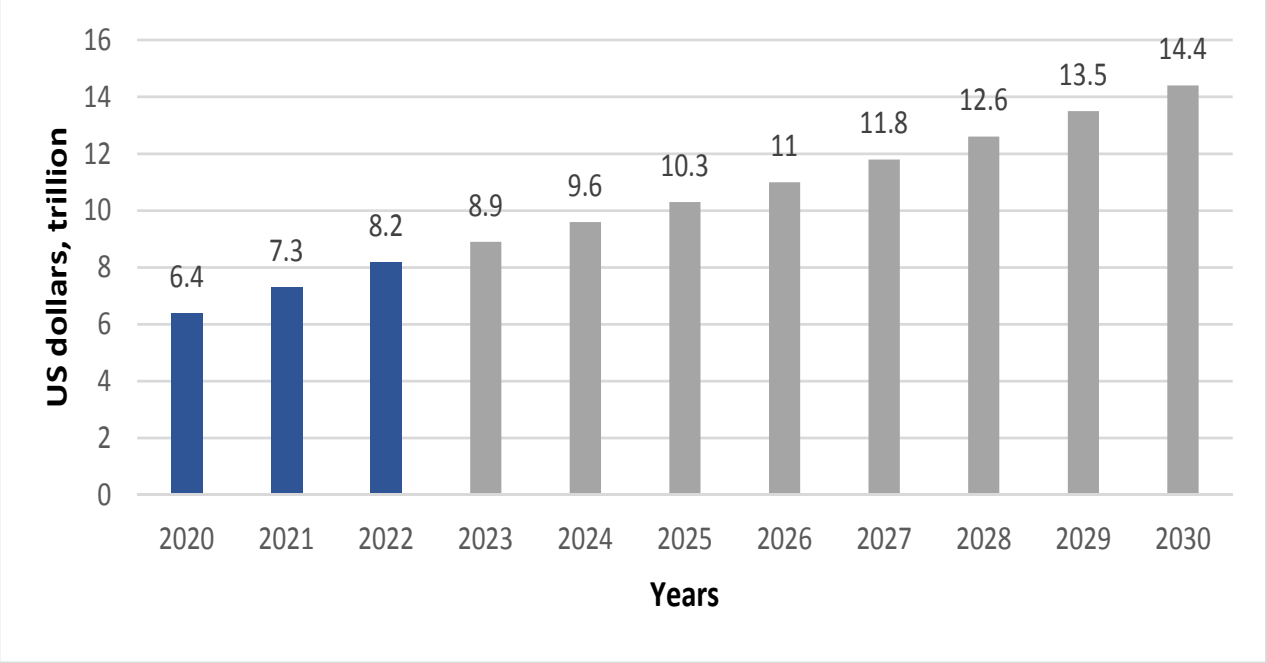


*Fig. 3.* **Global Construction Market Size Actual for 2020–2022 and Forecast for 2023–2030 in trillions of US dollars in 2020 prices**

*Source:* compiled by the authors based on Oxford Economics data. URL: https://www.gihub.org/resources/publications/global-construction-2030

construction market have their representative offices in most countries, and the number of employees of these companies is comparable to the population of a small city.

The top five largest construction companies in the world in 2022 by revenue included China State Construction Engineering Corp Ltd, China Railway Group Ltd, China Railway Construction Corp Ltd, China Communications Construction Co Ltd and Metallurgical Corporation of China Ltd; The world's 10 largest construction companies collectively generated revenue of $ 1,067,926 million, with average revenue growth of 13.8%[2] In terms of geographical distribution, 8 of them are based in Asia, and only 2 in Europe.

The total number of employees of the top ten as of 2021 was 1,810,330 people. It should also be noted that only 4 organizations in the world have a turnover of more than $ 100 billion (*Fig. 4*).

As can be seen from the *Fig. 5* of the diagram, the top three have a significant gap from other market players in terms of annual turnover. Analyzing the revenue data of global construction companies, the following groups can be distinguished:

• turnover from 100 to 300 billion dollars; This group includes only 4 companies, and all of them are from China;

• turnover from 30 to 70 billion dollars; This group includes 9 companies, and the leading place is occupied by the French VINCI Construction;

• turnover from 10 to 30 billion dollars for 21 companies, mainly from the USA;

• turnover from 5 to 10 billion dollars — 25 companies from Asia, Europe and the USA;

• turnover not exceeding 10 billion dollars; This is the largest group — about 40% of the

[2] 2022 Top 250 Global Contractors. ENR. (official site). URL: https://www.enr.com/toplists/2022-Top-250-Global-Contractors-Preview

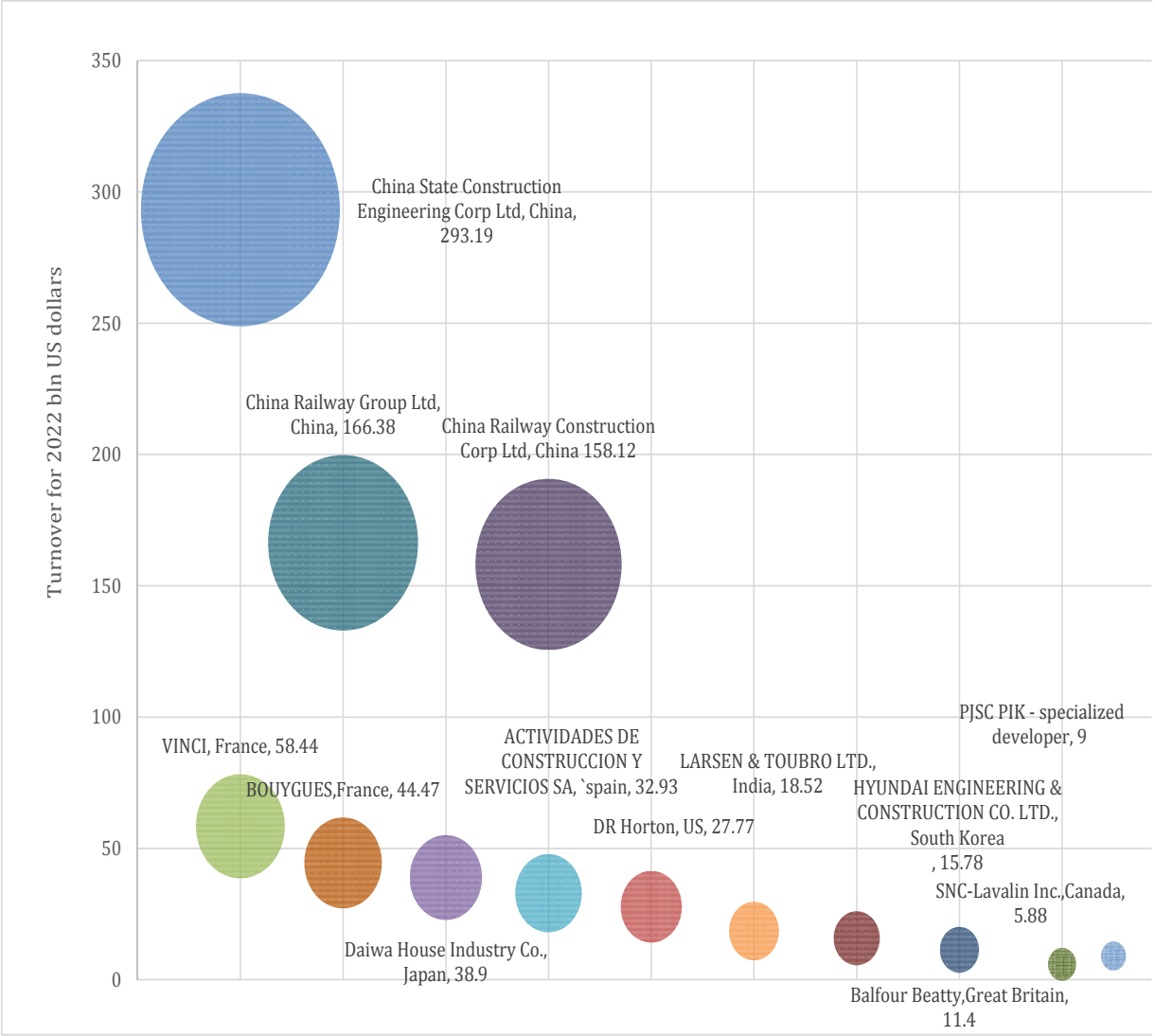


*Fig. 4.* **Comparison of construction company sizes by turnover for 2022**

*Source:* compiled by the authors based on ENR data. URL: https://www.enr.com/toplists/2022-Top-250-Global-Contractors-Preview

companies in the rating, which also includes the largest Russian enterprises.

Thus, we can conclude that Russian companies lag significantly behind the world leaders in the construction industry in terms of turnover and growth rates.

## KEY PLAYERS OF THE RUSSIAN CONSTRUCTION MARKET

The construction industry in Russia is sensitive to any crisis. The geopolitical situation, as well as new economic conditions, significantly affected companies in this sector of the economy, which had to develop new strategies to achieve sustainability and further development in the current conditions. According to the results of a survey of representatives of thousands of construction and design organizations conducted by the inter-industry association of self-regulators "Synergy"[3]:

[3] The interindustry association of self-regulators "Synergy" found out how the current economic situation affected the work of construction companies. URL: https://s-nrg.ru/novosti-sro/

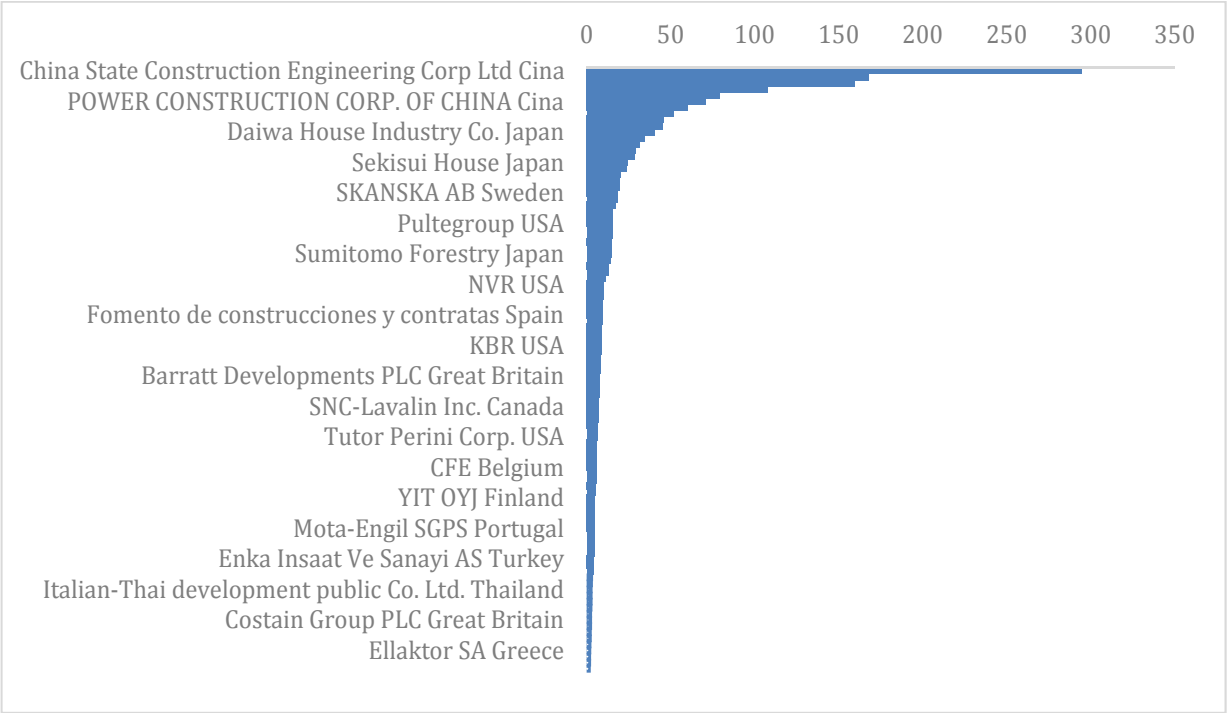


*Fig. 5.* **Comparison of the annual turnover of the construction companies in the world according to 2022 data**

*Source:* compiled by the authors based on ENR data. URL: https://www.enr.com/toplists/2022-Top-250-Global-Contractors-Preview

• 40% of respondents were forced to suspend the construction of some projects due to difficulties in supplying construction materials;

• about 29% of companies decided to freeze the construction of projects with a low level of readiness and directed all resources to complete those whose level of readiness was considered high;

• 25% of respondents stated that the new economic conditions did not in any way affect the activities of their companies and did not affect the production program.

The remaining respondents noted a decrease in the number of design orders (3%), and also reported the termination of contracts for the supply of equipment due to a significant increase in its cost (more than 4%).

Despite the unfavorable market situation, the prospects for the Russian construction industry look encouraging. It is expected that its further growth will be ensured by government support, a reduction in the key rate and an increase in the volume of mortgage lending [4].

The presence of super-large companies in the local construction market creates enough production capacity necessary for large capital-intensive projects, which, in turn, contribute to the growth and development of the industry; the absence of a constant flow of megaprojects slows down its development. It is worth noting that among Russian construction companies, only six have revenues of more than 100 billion rubles. For comparison, in China there have been about 160 such organizations for decades, and in the United States — 12.

The rating of Russian enterprises in the construction industry for 2022, according

mezhotraslevaya-assocziacziya-samoregulyatorov-sinergiya-vyyasnila-kak-skazalas-tekushhaya-ekonomicheskaya-situacziya-na-rabote-stroitelnyh-kompanij/

*Table*

**Rating of Russian construction companies by revenue**

| Rating | Company (group) | Revenue dynamics, % | Net revenue, billion rubles | Reporting form | Region |
|---|---|---|---|---|---|
| 1 | PJSC "PIK-specialized developer" | 35.5 | 380.0 | IFRS | Moscow |
| 2 | Tashir Group | 2.8 | 186.0 | managerial | Moscow |
| 3 | FSK Group | 14.6 | 129.7 | managerial | Moscow |
| 4 | Don Stroy Invest | 40.2 | 129.4 | IFRS | Moscow |
| 5 | LSR Group | 6.9 | 118.0 | IFRS | St. Petersburg |
| 6 | Setl Group | 18.8 | 116.5 | IFRS | Moscow |
| 7 | Etalon Group | –6.7 | 78.6 | IFRS | Moscow |
| 8 | Ingrad | 24.3 | 70.6 | IFRS | Moscow |
| 9 | Samolet Group | 17.7 | 60.1 | IFRS | St. Petersburg |
| 10 | GVSU № 4 | 210.6 | 47.6 | RAS | Moscow |
| 11 | Pioner Group | 16 | 46.4 | IFRS | Moscow |
| 12 | A101 Group | 5.1 | 39.9 | IFRS | Moscow |
| 13 | Cortos Group | 27.9 | 33.8 | IFRS | Moscow |
| 14 | Mospromstroy | –5.8 | 27.3 | RAS/ IFRS | Moscow |
| 15 | Brusnika Construction and Development | 26.3 | 24.4 | IFRS | Ekaterenburgr |
| 16 | MITS Group | –0.3 | 23.9 | IFRS | Moscow |

*Source:* compiled by the authors based on RBK 500 data. URL: https://www.rbc.ru/story/57d825179a79476061252094

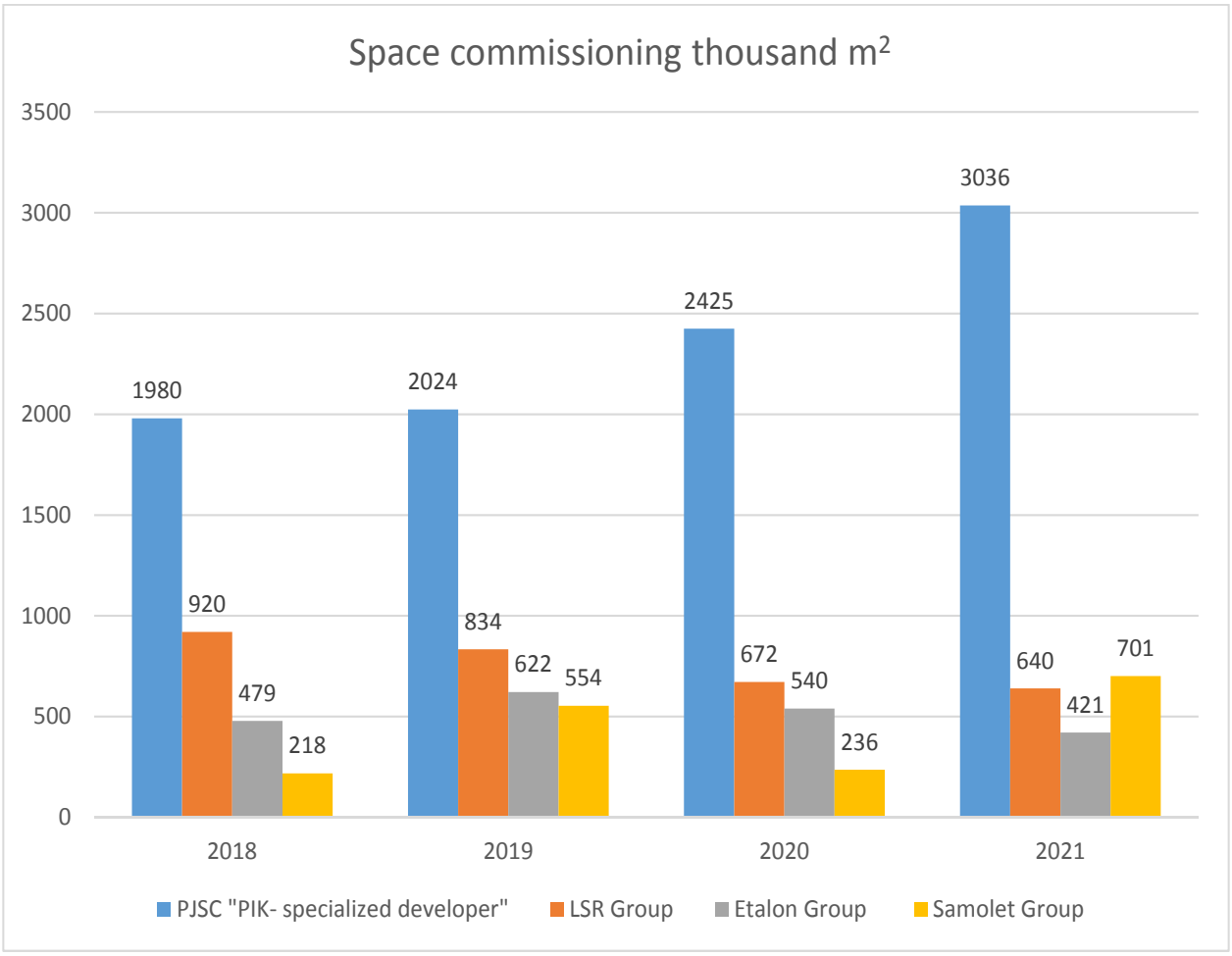


*Fig. 6.* **Dynamics of space commissioning by Russian developers, thousand m²**

*Source:* compiled by the authors based on ENR data. URL: https://www.enr.com/toplists/2022-Top-250-Global-Contractors-Preview

to RBC,[4] was headed by development companies *(see Table)*. First line with revenue of 380.2 billion rubles. for 2020 was occupied by PJSC PIK-Specialized Developer, the largest developer in Russia. Next with revenue of 186 billion rubles. there was a diversified Russian industrial and construction group "Tashir". It was followed by Moscow developers GC FSK and Don-Stroy Invest, three companies from St. Petersburg: LSR Group, Setl Group, GC Etalon. The top 10 also included Ingrad, Samolet Group of Companies, and the state company GVSU No. 4 closed the list. It should be noted that 8 out of 10 listed enterprises specialized in the construction of residential buildings.

The dynamics of space commissioning by Russian developers is shown in *Fig. 6:* PJSC PIK-Specialized Developer showed annual growth and had a significant lead over its closest competitors, while the indicators of LSR Group and Etalon Group decreased significantly over the past two years.

In terms of geographical distribution, the majority of large companies are concentrated

[4] RBC 500. URL: https://www.rbc.ru/story/57d825179a79476061252094 (date of request: 1.05.2023).

in the capital. In terms of the number of projects being implemented, the leader is the Central Federal District; it is followed by Privolzhsky and the Ural Federal District closes the top three.

It is important to note that most of the Russian market leaders, whose head offices are located in Moscow, use International Financial Reporting Standards (IFRS). IFRS are used to increase investment attractiveness, as well as increase the international involvement of large Russian companies in the construction complex [6]. However, only a few contracting organizations publish their reports, and these are mainly large enterprises. The non-publicity of the Russian construction industry indicates that companies are not ready to expand their capabilities in the financial market (through the placement of securities: shares or bonds) and attract investors, including foreign ones.

To track industry dynamics, the Moscow Exchange began calculating the industry construction index in 2020. It includes securities of four public companies: Etalon Group of Companies, LSR Group, PJSC PIK-Specialized Developer and Samolet Group of Companies [7]. It should be emphasized that the largest organizations in the Russian construction complex are focused exclusively on the domestic market, while foreign ones, on the contrary, are more interested in export contracts.

In modern conditions, in the global economy, the importance of exporting services provided to construction companies (in particular, in the field of project management) has increased significantly [9]. Among the advantages of entering the global market are:

- creation of a stable volume of orders and production capacity utilization,
- diversification of income and risks,
- increase in efficiency,
- creation of a competitive advantage and increase in the company's rating,
- stimulation of the development and implementation of innovations,
- the opportunity to exchange experience with foreign companies,
- increase in turnover and growth of the company [8].

Transnational construction firms, as a rule, are multi-industry holdings [10], the business model of which contains a complex of works at all stages of the project life cycle, starting with its creation and including construction, formation of infrastructure and management, as well as operation of the facility until its demolition and carrying out dismantling work.

A number of Russian companies are already operating in the territories of the former USSR countries, as well as in European markets with attractive low interest rates on loans and high demand for real estate. These are organizations such as Dekra Construction, Inteko Group of Companies, Mirax Group, Zarubezhstroy OJSC, etc.

Despite the increasing interest of Russian developers in foreign projects, MR Group experts do not believe that this phenomenon will become widespread [11], because entering a foreign market is associated with a number of difficulties: a large amount of investment, searching and selecting personnel for foreign projects, creating infrastructure and opening an organization office in a new country.

On the one hand, this is a risk, and on the other hand, it is an opportunity to increase profits and increase competitiveness [12], as well as ensure international recognition of Russian companies, subject to effective project management. Only large enterprises have the resources to overcome the risks associated with entering new markets, so at the moment the trend towards expansion of Russian construction companies is just beginning to take shape [9].

The domestic construction market is characterized by an opaque business environment [9] along with the presence of both outdated and conservative and modern management systems. However, it is worth noting that there is a direct relationship between internationalization and the competitiveness of a construction organization. Excess capacity intensifies competition and forces companies to expand beyond the national market. According to Rosstat, production capacity utilization in the construction sector is 66%, which creates the preconditions for the formation of transnational construction companies.

With the development of communication technologies, large contracting organizations have received unique opportunities for further growth, which has shaped modern development vectors. To ensure the coordinated operation of such a structure, it is currently impossible to do without a clearly structured system of cost accounting and control. In the context of digitalization, a modern construction company must formulate special principles and processes for project management, as well as organize appropriate interaction between their participants and predict possible risks. Creating an effective cost control system for project implementation will provide companies with competitive advantages both in the domestic and global markets.

## CONCLUSIONS

The global construction industry will continue to grow due to the development and urbanization of the Asian region, where the leaders of the world ranking of construction companies and the main volumes of international construction production are concentrated, which is determined by the dynamics of population growth. For many years, the leading countries in the construction market have been China, the USA, Japan and the European Union, while the Russian Federation lags behind in terms of construction production volumes.

The key players shaping the dynamics of the domestic construction market are development companies, since housing construction remains the driver of the industry.

The scale of Russian construction organizations is still noticeably smaller than foreign ones, which is determined by the characteristics of the national market and factors inhibiting its development. These include the lack of a sufficient number of large capital-intensive projects that could maintain a high level of revenue for several years, as well as a focus on activities within the country. Large foreign companies, on the contrary, generate a significant portion of their revenue through the implementation of export contracts.

At the moment, the trend towards expansion among Russian construction companies is just beginning to take shape. The condition for their competitiveness in the global market is internationalization and an effective project management system, including control of costs and project deadlines.

In conditions of economic and political crises, the leaders of the global construction complex are paying more and more attention to achieving the main goals of the project: meeting deadlines, quality requirements, as well as the budget and contractual cost. But with supply chains still recovering from the pandemic, effective cost accounting and control systems are needed to contain rising project costs and ensure companies remain competitive.

## REFERENCES


1. Semenenko V. Yu. Global construction market in the context of the COVID-19 pandemic: Trends and factors of influence. *Azimut nauchnykh issledovanii: ekonomika i upravlenie = ASR: Economics and Management (Azimuth of Scientific Research).* 2020;9(3):313–316. (In Russ.). DOI: 10.26140/anie-2020–0903–0075
2. Sanni-Anibire M.O., Zin R. M., Olatunji S. O. Causes of delay in the global construction industry: A meta analytical review. *International Journal of Construction Management.* 2022;22(8):1395–1407. DOI: 10.1080/15623599.2020.1716132
3. Dalakov A.M. Statistical analysis of the construction industry in Russia. *Mezhdunarodnyi nauchno-issledovatel'skii zhurnal = International Research Journal.* 2021;(4–4):95–100. (In Russ.). DOI: 10.23670/IRJ.2021.106.4.122
4. Tarasova I., Trudov V. Yu. The construction industry during the international political crisis of 2022. *Skif. Voprosy studencheskoi nauki = Sciff. Issues of Students' Science.* 2022;(6):378–381. (In Russ.).
5. Sayfullina F. M. et al. Foreign experience in the development of modern construction in the segment of innovative technologies. *Regional'nye problemy preobrazovaniya ekonomiki = Regional Problems of Economic Transformation.* 2020;(12):46–53. (In Russ.). DOI: 10.26726/1812–7096–2020–12–46–53
6. Olatalo O. A., Makarcova T. N., Tsvirenko S. V. Economic development trends of the construction industry: World experience and Russian innovations. *Kant.* 2017;(4):231–234. (In Russ.).
7. Overview of the construction industry in Russia 2020–2022: Past successes and new challenges. Otkrytyi zhurnal. Jun. 24, 2022. URL: https://journal.open-broker.ru/analitika/obzor-stroitelnoj-otrasli-v-rossii/ (accessed on 01.05.2023). (In Russ.).
8. Naidenkov V. I., Dzhamalyan A. A. On the issue of competitiveness factors of construction industry enterprises in Russia. *Ekspert: teoriya i praktika = Expert: Theory and Practice.* 2019;(1):29–34. (In Russ.). DOI: 10.24411/2686–7818–2019–00015
9. Panibratov A. Yu. Strategies for the internationalization of construction companies: Prerequisites, directions and prospects. *Vestnik Sankt-Peterburgskogo universiteta. Menedzhment = Vestnik of Saint Petersburg University. Management Series.* 2010;(1):61–86. (In Russ.).
10. Andersen O. Internationalization and market entry mode: A review of theories and conceptual frameworks. *MIR: Management International Review.* 1997;37(2):27–42.
11. Malina R. MR Group will build housing in Berlin: Why Russian developers are going abroad. Forbes. Oct. 13, 2021. URL: https://www.forbes.ru/biznes/442613-mr-group-postroit-zil-e-v-berline-pocemu-rossijskie-developery-idut-za-granicu (In Russ.).
12. Whitelock J. Theories of internationalization and their impact on market entry. *International Marketing Review.* 2002;19(4):342–347. DOI: 10.1108/02651330210435654

## ABOUT THE AUTHORS

***Alexandra E. Lebedeva*** — Postgraduate student of the Department of Management and Innovation, Moscow State University of Civil Engineering, Moscow, Russia
https://orcid.org/0009-0007-0843-9703
*Corresponding author:*
uncea@yandex.ru

***Irina V. Karakozova*** — Cand. Sci. (Technical Sciences), Associate Professor of the Department of Management and Innovation, Moscow State University of Civil Engineering, Moscow, Russia
https://orcid.org/0000-0002-7913-919X
i.kar@inbox.ru

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# XXIV International Conference on the History of Management Thought and Business "Russia's economic management models: creators, their creations, clash of views"

It has become a tradition for Russian and foreign management experts to gather at the Lomonosov Moscow University at international conferences on the History of Management Thought and Business (HMT&B) to discuss topical management issues.

Since 1996, 23 events have been organized on the following themes:

- "Development of management concepts" (1996).
- "Restructuring of Enterprises in Transition Economy: Theory and Practice" (1998).
- "The State and Entrepreneurship" (2000).
- "Development of management personnel" (2001).
- "Problems of metrics in organization management" (2002, 2003).
- "Scientific concepts and real management" (2004, 2005).
- "Russian model of management" (2008).
- "National models of management" (2009).
- "Business models: yesterday, today, tomorrow" (2010).
- "Social Responsibility of Business and Management Ethics" (2011).
- "Business and management ethics: comparative analysis of national models" (2012).
- "From Stratagems to Strategies, from Strategic Planning to Strategic Thinking and Insight" (2013).
- "Problems of training managers: yesterday-today-tomorrow" (2014).
- "National models of management personnel training" (2015).
- "Scenario management and leadership" (2016).
- "Scenario management: origins, problems, solutions" (2017).
- "Management and the roles of managers: past, present, future" (2018).
- "Managerial labor and the roles of managers: yesterday, today, tomorrow" (2019).
- "Measurement problems in social management: yesterday, today, tomorrow" (2021).
- "Development of views on regional economic management in the countries of the world: history, modernity" (2022).
- "Doctrines of management of organizations: past, present, problems" (2023).

On June 27–29, 2024 the Department of Economics of MSU is planning to hold the next, which is already 24th international conference on the History of Managerial Thought and Business. It has been a long time since we discussed the issues that were raised in 2008–2009. We are talking about national aspects of management. More than 15 years have passed since that time, and it is time to make an inventory of what has been achieved, to evaluate and define the tasks of historical and managerial research, the subject of which has been and continues to be the model of management of Russia's economy. That is why the theme of the 24th conference is **"Russia's economic management models: creators, their creations, clash of views"**. We would like to hear the answers to the following questions: what factors gave rise to the concepts and models of management? Who and thanks to what was the "hero" of scientific and practical creations? What methodological problems relating to *the three components* of Historical and Management Studies (HMS) are facing us today?:

- to the History of Management Thought (HMT);
- to the History of Management (HM);
- to the Historiography of Historical and Management Studies (HHMS)?

As always, the **objects** of historical and managerial research and our conferences will be various kinds of materials and/or documents — monographs, articles, collections of works and legislative acts, letters, memoirs, diaries, archival documents, etc. In the case of our conference, these are materials that present points of view, ideas, views, thoughts, concepts, theories, scientific schools, reflecting the emergence, development, struggle and change of ideas and scientific and applied views on economic management in Russia in different specific-historical periods. The time period is not limited — from the manuscripts of the representatives of ancient Russia to the treatises of our contemporaries.

Moreover, the views and ideas themselves can relate both to the management of Russia's economy as a whole and to the management of its individual aspects and elements — economy, politics, demography, legislation, socio-cultural relations, science, technology, international relations of the country, as well as individual industries, businesses, organizations and functionalities of organizations (personnel, marketing, finance, procurement, production, sales, etc.).

It is also obvious that *the subjects of management* of Russia's economy in different specific historical periods were (as management actors) the state and its institutions of all forms of government, public organisations, the church, the army, and representatives of the private economy.

Hence, there are several questions to which we expect answers at the forthcoming HMT&B-2024 conference:

1. When and in connection with what was the origin of economic management of Russia and managerial thought in Russia?
2. What is the "inheritance" and "heritage" in the science and practice of economic management in Russia?
3. What are the origins and sources of Russian managerial thought: notes of foreigners, chronicles, sets of legal acts, princely statutes, "the Household Management Code" (the patriarchal rules of family life), etc.?
4. What are the factors and reasons for changes in the management systems of economy, organisations, and business in Russia in different specific historical periods?
5. What are the factors of origin, establishment, and development of HMT in Russia?
6. How did the clash of interests of famous creators of models of economic management in Russia arise and manifest itself, for example, such as:

6. 1. Yu. Krizhanich and A. Ordin-Nashchshokin;

6. 1. 1. I. Pososhkov and the noble ideologists of "enlightened absolutism";

6. 2. L. Beria and N. Voznesensky;

6. 3. O.V. Kozlova and G.H. Popov.

7. How and why did the ideas and concepts of systemic (elemental) and complex (aspectual) approaches in economic management in Russia emerge and develop?

8. How were the aspect characteristics of Russia's economic management (economic, political, legal, demographic, etc.) manifested and taken into account?

9. Why and how did the views on personnel support of the processes of economic management of Russia change?

10. What was the "driving force" of management and managerial thought in Russia — the real economy or the logic and intuition of the creator of ideas?

11. How to teach historical and managerial disciplines in the context of economic management in Russia?

12. What problems are faced by HM, HMT and HHMS researchers?

**ORGANISERS OF THE HMT&B-2024 CONFERENCE:**

- Lomonosov Moscow State University.
- Department of Economics of Moscow State University.
- International journal "Problems of Theory and Practice of Management".
- Journal "Management Sciences".
- Laboratory of Historical and Managerial Studies of the Department of Economics of MSU.

**THE ORGANISING COMMITTEE:**

- A.A. Auzan (Co-Chairman) — Doctor of Economics, Professor, Dean of MSU Department of Economics.
- V.P. Kolesov (Co-Chairman) — Doctor of Economics, Professor, President of MSU Department of Economics.
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- Yu.M. Osipov — Doctor of Economics, Professor, Head of the Laboratory of Philosophy of Economy, Department of Economics, MSU.
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- S.E. Chernov — Cand. Sci. (Economics), Associate Professor, Engineer of the Department of Organisation Management, MSU Department of Economics.
- I.V. Dvoluchansky — Senior Lecturer of the Department of Organisation Management of MSU Department of Economics.
- K.A. Stashchshuk — postgraduate student of the Department of Organisation Management of MSU Department of Economics.
- S.A. Genina — laboratory assistant of the Department of Organisation Management of MSU Department of Economics.

**Organising Committee:** tel. 8–495–9392917, 8–495–9392887, 8–916–6735422, 8–985–7277578, 8–905–5156955, 8–926–5572744

E-mails: vmarshev@mail.ru; dvoluchansky@gmail.com; genina.sofia@yandex.ru

The HMT&B-2024 Conference will be held both in offline and online formats.

The Organising Committee will provide all participants with necessary links in zoom.

Acceptance of papers (up to 20 pages) and abstracts (up to 5 pages) — until 15 May 2024 to the specified email addresses.

Requirements for the design of the article:

Font: size — 12.

Font type — Times New Roman.

Alignment — width.

Line spacing — one and a half.

Surname, first name, patronymic name, title of the article, abstract and keywords should be written in Russian and English.

Registration is required for participation in the conference!