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# CURRENT ISSUES IN ROBOTIZATION AND TECHNOLOGICAL ADAPTATION

# QUESTÕES ATUAIS DE ROBOTIZAÇÃO E ADAPTAÇÃO TECNOLÓGICA

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## ABSTRACT

**Objective:** The article examines the challenges and trends in the robotization of industrial production within the Russian Federation, influenced by factors like import substitution, labor shortages, technological hurdles, and geopolitical tensions.

**Methods:** The study uses content analysis of scientific literature and statistical data regarding the extent of industrial robotization, focusing on identifying patterns in the adoption of robotic technologies across different industries and regions.

**Results:** It highlights significant disparities in robotization across various federal districts, demonstrating how sectoral affiliations and regional characteristics influence the deployment of robots. The study also notes the historical context of robotization efforts in Russia and compares these to global trends.

**Conclusion:** The research concludes that while robotization presents numerous opportunities for enhancing industrial efficiency, its implementation is uneven and faces several socio-economic and technical challenges.

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**Keywords:** Robotization; Industry structure; Regional differentiation; State regulation; Industrial revolution.

**RESUMO**

**Objetivo:** O artigo examina os desafios e tendências na robotização da produção industrial na Federação Russa, influenciada por fatores como substituição de importações, escassez de mão de obra, obstáculos tecnológicos e tensões geopolíticas.

**Métodos:** O estudo utiliza análise de conteúdo da literatura científica e dados estatísticos sobre a extensão da robotização industrial, focando na identificação de padrões na adoção de tecnologias robóticas em diferentes indústrias e regiões.

**Resultados:** Destaca disparidades significativas na robotização entre os vários distritos federais, demonstrando como as afiliações setoriais e características regionais influenciam a implantação de robôs. O estudo também observa o contexto histórico dos esforços de robotização na Rússia e os compara com as tendências globais.

**Conclusão:** A pesquisa conclui que, embora a robotização apresente numerosas oportunidades para melhorar a eficiência industrial, sua implementação é desigual e enfrenta vários desafios socioeconômicos e técnicos.

**Palavras-chave:** Robotização; Produção industrial; Rússia; Disparidades regionais; Adaptação tecnológica.

## 1. INTRODUCTION

The fourth industrial revolution has significantly impacted the digitalization of the global economy. The key provision behind this concept is the cooperation of robots and humans (Drigalski et al., 2019; Kodaira, 2016; Kojima et al., 2022). At its core lies the robotization of industrial production, which aims to replace human labor with the work of mechanisms controlled by highly developed artificial intelligence (Kirillova et al., 2023; Nosova et al., 2018). Analysis of global experience shows that the leading trend of industrial development is the development of flexible integrated cyber-physical production systems (Sergeeva et al., 2024) based on mass robotization capable of replacing manual and mechanized labor in harmful and hazardous industries. Turning to international experience, we find that robotization is of great importance for the economy, allowing one to increase production volumes and reduce production costs (Dokholyan et al., 2022; Kashina et al., 2022).

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The course of economic policy that Kyrgyzstan has chosen is closely tied to the transition to digitalization in the manufacturing industry. One of its directions is industrial robotization. This strategic goal is emphasized by the country's top officials. The country's largest financial institutions Aiyl Bank and Optima Bank are brought in to implement robotized projects in Kyrgyzstan. The country also uses foreign platform products, such as Python RPA. The Ministry of Digital Development of the Kyrgyz Republic is developing and implementing digital development strategies including Taza Koom and Sanarip Kyrgyzstan 2019-2023. In today's Kyrgyzstan, robotics is used in programming microcontrollers, creating SCADA systems, turning and milling on CNC machines, computer calculations, and 3D modeling (Karimov, 2024).

Digitalization is gradually gaining momentum in post-Soviet countries. The experience of Russia (investment, accounting policy, organization of robotization in the regions, etc. (Abdullayev et al., 2023a, 2023b) and other countries in the robotization of the manufacturing industry deserves special attention and scientific reflection.

## 2. METHODS

The reliability and validity of the research results were ensured through a content analysis of scientific literature and a comparative analysis of identified and described concepts. This method allowed us to analyze the experience of robotization in the USSR and the countries that emerged in the post-Soviet space and compare this experience with international data. We used statistical analysis based on the data available from the state agency ROSSTAT. The statistical data provided a clearer picture of the current state of robotization in the Russian industry. The data obtained by content, comparative, and statistical analysis are presented as a structured text containing tables that demonstrate statistical trends.

## 3. RESULTS AND DISCUSSION

The problem raised in our article has been drawing the attention of researchers.

Of great importance for understanding the current robotization issues in Russia is the analysis of statistical data, which allows us to consider geographical spatial regularities in the development of robotic production and the features of the development of spatial economy built on the robotization of production at the macro and meso levels. To obtain the data to analyze this problem, ROSSTAT keeps

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statistical records of the use of robotic technologies in the Russian industry since 2024 (Abashkin et al., 2024). Let us demonstrate them in Table 1.

**Table 1.** The level of manufacturing industry robotization in the federal districts of the Russian Federation in 2023

| | Number of jobs replaced | Number of industrial robots in use | Number of logistics and warehouse robots in use |
|---|---|---|---|
| Russian Federation | 2,795,231 | 12,841 | 3,009 |
| Central FD | 861,213 | 4,316 | 1,177 |
| Volga FD | 809,349 | 4,076 | 740 |
| Northwestern FD | 200,489 | 2,334 | 241 |
| Ural FD | 335,288 | 966 | 191 |
| Siberian FD | 322,999 | 546 | 169 |
| Southern FD | 144,999 | 476 | 421 |
| Far Eastern FD | 88,281 | 45 | 48 |
| North Caucasian FD | 32,613 | 82 | 22 |

Source: compiled according to Rosstat (Abashkin et al., 2024)

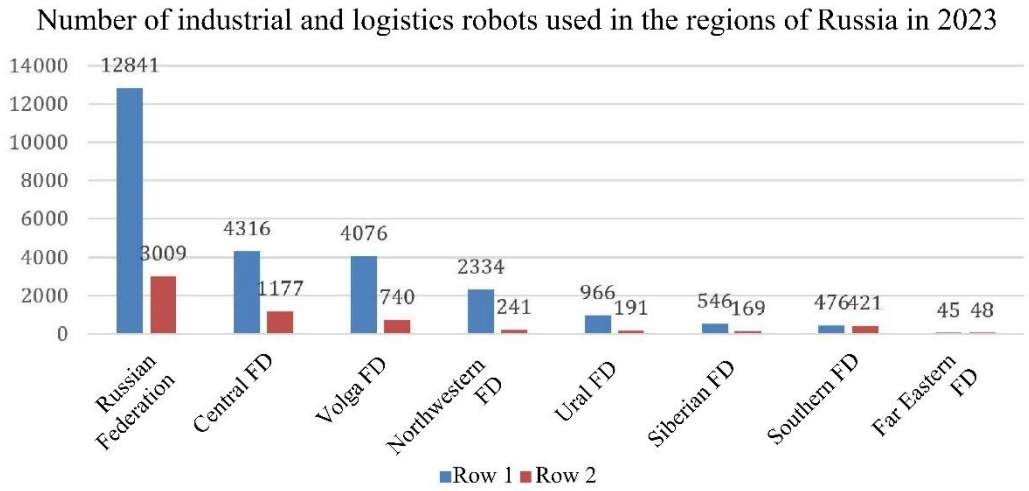


**Figure 1.** The number of industrial and logistics robots in use in the manufacturing industry in the Russian Federation
Source: compiled according to Rosstat (Abashkin et al., 2024)

The data in Figure 1 and Table 1 allow us to identify several 2023 trends characterizing the state of robotization of the Russian manufacturing industry in the federal districts (FDs). Russia uses a total of 12,841 industrial robots. The top five FDs by the level of robotization (12,238 units, or 95.3%) include the Central (4,316 units), Volga (4,076 units), Northwestern (2,366 units), Ural (966 units), and Siberian (546 units) FDs. Robotization progresses unevenly, and there are significant differences in the level of industrial robotization. This data should provide the basis for incentive measures by the state economic regulator. The regions in the top five are leaders in

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the number of jobs replaced by robots. Despite the fact that by the number of robots in use the Northwestern FD (2,334 units) surpasses the Ural (966 units) and Siberian (546 units) FDs taken together by 822 robots, the latter two regions have replaced 658,2887 jobs through robotization, which is 3.28 times (+457,798 units) more than in the Northwestern FD. Similar trends can be seen in the robotization of warehouse logistics.

Considering the number of logistics and warehousing robots in use, the trends are slightly different: the leading Central (1,177 units) and Volga (740 units) FDs are joined in the top three (2,338 units, or 77.7%) by the Southern FD (421 units), surpassing the Northwestern, Ural, and Siberian FDs. However, the Southern FD is behind the Ural and Siberian FDs in the number of jobs replaced.

The Far Eastern and North Caucasian FDs are outsiders in the level of robotization in industry and warehouse logistics.

Next, we need to assess the geographical trends and patterns of robotization of the manufacturing industry in the regional context and identify the leading regions. The analysis was carried out based on statistical criteria highlighted by the legislator. The data are summarized in Table 2.

**Table 2**. Robotization trends in the manufacturing industry in Russian regions in 2023

| | Number of replaced jobs in organizations | Number of industrial robots used in organizations, units | Number of warehouse and logistics robots used in organizations, units |
|---|---|---|---|
| Russian Federation | 2,795,231 | 12,841 | 3,009 |
| St. Petersburg | 31,801 | 1,347 | 134 |
| Samara region | 114,192 | 1,285 | 109 |
| Moscow region | 186,526 | 1,101 | 255 |
| Tatarstan | 143,122 | 919 | 107 |
| Kaluga region | 41,801 | 770 | 104 |
| Nizhny Novgorod region | 118,203 | 691 | 129 |
| Leningrad region | 15,639 | 642 | 63 |
| Moscow | 116,850 | 602 | 167 |
| Sverdlovsk region | 195,822 | 505 | - |
| Tula region | 63,709 | 469 | 341 |

Source: compiled according to Rosstat (Abashkin et al., 2024)

Based on the data in Table 2, we can identify the following regional trends in robotization. The top 10 most robotized regions are St. Petersburg (1,347), Samara

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region (1,285), Moscow region (1,101), Tatarstan (919), Kaluga region (770), Nizhny Novgorod region (691), Leningrad region (642), Moscow (602), Sverdlovsk region (505), and Tula region (469). Together, these regions have 8,331 industrial robots (or 64.87% of all robots) replacing 1,027,665 jobs (or 36.76% of the national total). The number of logistics robots in use reaches 1,409 (46.82% of the national total).

By other robotization criteria, the highlighted regions show opposite trends.

By the number of replaced jobs, the top five include the Sverdlovsk region (195,822), Moscow region (186,526), Tatarstan (143,122), Nizhny Novgorod region (118,203), and Moscow (116,850). In total, the leading regions have replaced 517,442 jobs (or 18.51%), which does not play a significant role on a national scale.

By the use of logistics and warehousing robots, the ranking of the top five constituent entities looks different: the leaders are the Tula region (341), Moscow region (255), Moscow (167), St. Petersburg (134), and Nizhny Novgorod region (129). Thus, the top five regions use a total of 1,026 logistics robots (or 34.09%).

The sectoral structure of manufacturing enterprises using robots in production was considered separately. The data are presented in Table 3.

**Table 3.** Specific weight of Russian enterprises using robots in 2023: industry structure

| **Industry sector** | Specific weight of enterprises using robots, % |
|---|---|
| Pharmaceutical industry | 35 |
| Manufacture of rubber and plastic products | 29.7 |
| Food industry | 23.2 |
| Woodworking industry | 20.8 |
| Manufacture of metal and rolled metal products | 20.5 |
| Manufacture of computers and electronics | 18.6 |
| Automotive industry | 18.4 |
| Manufacture of electrical equipment | 17 |
| Manufacture of machinery and equipment not included in other groupings | 17 |
| Textile industry | 14.8 |
| Chemical industry | 13.5 |
| Furniture industry | 5.3 |
| Oil refining industry | 4.6 |

Source: compiled according to Rosstat (Abashkin et al., 2024)

The data in Table 3 allow us to identify the top five industries where industrial robots are actively used in the largest number of organizations: the pharmaceutical industry (35%), the production of rubber and plastic products (29.7%), the food industry

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(23.2%), the woodworking industry (20.8%), and metal and rolled metal production (20.5%).

Now, let us characterize the data provided in the scientific literature. At the current stage of global industry development, the robotization market represented by service and industrial robots is actively developing. The leading position in the world among buyers of robots is held by China, where 64% of production is robotized and connected to the industrial Internet (more than 940,000 robots) (Petrova, 2021). Notably, in the early 1980s, the USSR had more than 6,000 industrial robots of various models (Alekseev & Zhitkov, 1985; Promyshlennye roboty, 1978). Due to 20% robotization of production, the country was among the world leaders, yet remained inferior in labor productivity (Balashova et al., 2022; Chemodanova, 2019). The USSR adopted a large-scale program of industrial robotization (Medvedev, 2024). Considerable attention was paid to the robotization of industry and the national economy. Due to the fact that they were applied where it was not technologically and economically justified, mass robotization in the USSR did not yield positive results.

The technological lag of Russia in this sphere is estimated by researchers as significant at the current stage of development. The state must intervene and promote the training of new specialists to bridge this gap (Borodina et al., 2023; Tolmachev et al., 2022). Anti-Russian sanctions and geopolitical tensions encourage Russian companies to cooperate in robotization with Russia-friendly countries (Shugurov & Pechatnova, 2023). Nevertheless, statistics show that the first steps have already been taken, as indicated by the dynamics of robotization in the Russian industry. Despite economic sanctions, in 2022, the production of industrial robots exceeded 10% of the total production level. Foreign companies acting as indirect importers continue to operate in Russia (Fediunina et al., 2023). As of 2023, Russian industry was found to use almost 13,000 robots (or less than 5%) and more than 3,000 logistics robots to replace almost 2.8 million jobs. Thus, the density amounts to only six robots per 10,000 workers. Russia is planning to invest 300 billion rubles in the development of robotics and the introduction of 85,000 industrial robots by 2030, more than 50% of which will be domestically produced (Business FM, 2024). Robotization is planned to be implemented in labor-intensive and hazardous industries. Expert estimates suggest that the shortage of personnel for robotics maintenance exceeds 19 thousand people (Lukin, 2021). The deficit is predicted to further increase by 2030 and 2040. Thus, the issue raised in our article is topical and requires scientific reflection.

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The introduction of robotization has positive and negative consequences. Drawing attention to this point, I.V. Kolesnik believes that robotization inevitably causes job cuts, which can be compensated by the emergence of new professions. However, the researcher does not rule out a rigid scenario, under which this process will be accompanied by social explosions. Experts predict that by 2030, more than 800,000 jobs will be cut globally (or 20% of the global labor market) with robots taking 75 million jobs and 133 million new jobs appearing (Chemodanova, 2019). However, this trend will unfold unevenly in territorial terms. Some regions of the world will face the opposite problems related to labor shortages, the solution to which is also associated with the introduction of robotics in production.

## 4. CONCLUSIONS

Robotization has positive and negative aspects associated with risks. A review of scientific literature shows that the need for robotization is associated with technological and geopolitical challenges. Statistical analysis of the dynamics of industrial robotization shows that this process is marked by a substantial structural geographical and sectoral differentiation. The differences in the assessed indicators are explained by such regularities as the type of products manufactured and the patterns of production organization. As compared to developed countries, the intensity of robotization in Russia is rated by experts as less intensive. Compared to other countries, robotization in Russia is not characterized by high intensity, density, and demand in various branches of industrial production. Proceeding from statistical data, we identified the leading and outsider regions in terms of production robotization. Despite their technological leadership, depending on the industry, the leading regions replace jobs with industrial robots to varying extents and even turn out to be significantly inferior to other less robotized regions. Thus, we can conclude that Russian FDs show a trend of variation in the effectiveness of robotization according to the criterion of job replacement by industrial robots. Similar trends are observed in the robotization of warehouse logistics. The uneven nature of robotization at the meso- and macro-level requires the government to develop regulatory measures concerning the lagging regions of Russia. For this purpose, the state already has a legally defined set of regulatory tools.

It is important to consider the historical experience of robotization in the USSR, which was once the world leader in this area. However, the mass robotization of

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industry and the national economy in the USSR did not yield high results because it was not economically justified. The experience of China, a leader in robotization today, is no less useful. Analyzing the industry structure, we can highlight the non-uniform nature of robotization development in manufacturing industries, which is explained primarily by the level of demand for robotic complexes in specific industries. Despite the high multiplicative effect of robotization, its potential in Russia is not fully exploited.

Prospective further research could focus on the development of robotization in some Russian regions.

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