

# Modeling the Social Consequences of Industrial Robotization

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## ABSTRACT

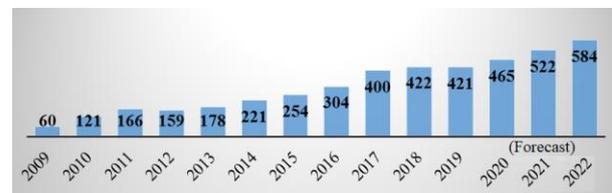
The article examines the issues of predicting the negative consequences of automation of business processes for the population. The author presents the controversial context of the results of robotization, on the one hand, manifested in the aggregate economic and technological growth, on the other hand, in the reduction of employment. As a research methodology, the authors used the author's approach based on modeling socio-economic processes in Russia by extrapolating the average results of robotization across the world to domestic experience. To calculate the indicators, official statistics from Rosstat and the International Federation of Robotics were used. The analysis results were determined pursuant to the pessimistic scenario and have specific quantitative estimates. They show a significant increase in the gender-sensitive unemployment rate. The paper notes as negative the consequences of the further social stratification of the population by income levels, and substantiates its reasons. In the final part of the research, a conclusion is made about the need for government intervention in regulating the consequences of robotization, and the main vectors of such regulation are set. The scientific novelty of the research consists in the development of the author's methodology for modeling the social consequences of the industrial production robotization, as well as assessing such consequences in relation to the Russian Federation.

**Keywords:** robotization, unemployment, labor, business process automation, robotization regulation, average per capita income

## 1. INTRODUCTION

Means of production development and scientific and technological progress are key factors in the transformation of social and labor relations. Robotization of real production is an objective process associated with the development of technology, as well as with the need to enhance production efficiency. Intelligent robots make an important part of the digitalization of industry and agriculture.

The global material production sphere is facing major challenges such as rapidly changing consumer trends, scarcity of resources and skilled workers, an aging population and a growing demand for locally sourced products. Flexible automation based on industrial robots provides a solution to all of these problems. The robotics implementation level is the most important economic indicator, as it reflects the development and progress of the country. Pursuant to Google Analytics, the number of searches in the search engine on the topic "Automation of robotics processes" increased 30 times from 2016 to 2018. It is no coincidence that there is a general trend towards an increase in the number of industrial robots (Figure 1).



**Figure 1:** Annual number of industrial robots deployed, th. units

Source: Compiled by the author based on statista.com data

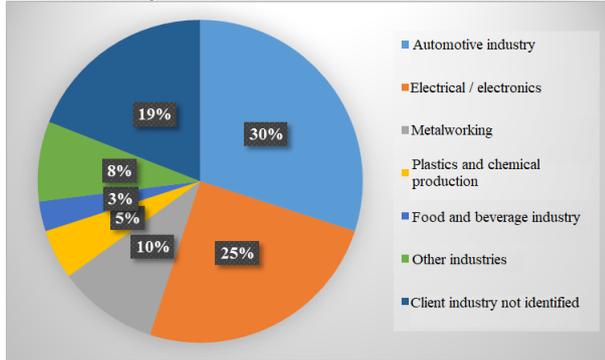
Since 2010, the demand for industrial robots has increased significantly owing to the constant trend towards automation and constant technical innovation in industrial robots. It is important to note that, pursuant to forecasts, the trend will continue, and world shipments of industrial robots will amount to more than 584 th units in 2022, thus ensuring an average 12 percent growth in 2020-2022.

Herewith, the main consumer of robots is Asia, whose 2018 share accounts for 283,000 units out of 422,000 of the total amount. Currently, there are five main markets for industrial robots: China, Japan, the USA, the Republic of Korea, and Germany. These countries account for 74% of global robot installations.

Therefore, the robotization shall be considered as a positive phenomenon contributing to the economic growth. Robotic technologies and the implications of their use

deserve special attention because they are bound to change and transform the existing social and labor relations. Moreover, the effects of such an influence are not extremely ambiguous, in particular, we are talking about the social consequences of robotization.

An assessment of the industry's application of robotics is critical, as it helps determine which industries will be most "socially affected". Pursuant to the Federation's 2018 data, the distribution structure of installed robots by industry is as follows (Figure 2).



**Figure 2:** The structure of the installation of robots by industry, 2018

Source: Compiled by the author based on the data of the International Federation of Robotics, access mode: <https://ifr.org>

In 2018, the average density of robots in the manufacturing industry was 99 robots per 10,000 workers. Herewith, Europe is the region with the highest density of robots, with an average of 114 units. In America, the density is 99 units, while in Asia/Australia it is 91 units. Currently, the Russian Federation observes an extremely low level of robotization density compared to world leaders - 4 units per 10,000 workers. Moreover, it is worth noting that this global average includes only those countries that have a corresponding operational stock of robots. For this reason, this indicator is overestimated, since countries with low robot density are systematically excluded from the estimated population.

In assessing the social consequences of robotization, it is extremely important to consider the level of provision of a particular industry with personnel, since for some of them, robotization leads to the release of jobs and an increase in unemployment, while for others, with a lack of labor resources, the use of robots is the way to salvation. For instance, pursuant to experts, the rural population in Russia (considering the migration) will decrease by 10.2% by 2040 (Blinova, Bylina, 2014) [1]. These demographic trends are leading to an increasing shortage of agricultural personnel. Herewith, the state program for the development of agriculture and regulation of markets for agricultural products, raw materials and food for 2013-2020 provides for an increase in agricultural production in farms of all categories in 2020 compared to 2010 by 39%. Achieving these targets requires a competent, technically trained and educated workforce. These circumstances necessitate the use of labor-saving technologies, which

may include digital, intelligent and robotic technologies (Skvortcov, Semin, Skvortsova, 2019) [2].

Robots replacing humans have become one of the most discussed topics in research and business circles. Pursuant to a study by a number of scientists, current work in the field of robotization is mainly focused on modern and advanced technological developments (Paulius, Sun, 2019) [3]. Herewith, an increasing number of studies over the past 2-3 years have been devoted to assessing the social consequences of robotization (Sukhorukov, Eroshkin, Vanyurikhin, Karabahciev, Bogdanova, 2019) [4]. The 2016 World Economic Forum also predicts that the 4th industrial revolution will have a negative impact due to rising unemployment around the world. In particular, it was noted that by 2020, due to the integration of new technologies, 7.1 mln people will lose their jobs, while only 2 mln new jobs will be created in the computer and mathematical, architectural and mechanical engineering industries.

In fact, the scientific community was divided into two camps. Some adhere to the position that robotization carries with it, if not irreversible, then very serious social consequences for states. Gradually, the positive attitude towards technology as a means of creating new jobs is changing by the assumption that this is not the case (Rotman, 2015; Lukina, Slobodskaia, Zilberman NN, 2016) [5, 6]. Pursuant to scientists, about half of the world's jobs can be automated by 2030-2035 (Brynjolfsson, 2014; Manyika, Chui, Miremadi, Bughin, George, Willmott, Dewhurst, 2017) [7, 8]. For instance, Frey and Osborne, evaluating the susceptibility of jobs to technological developments, came to the following conclusions (Frey, Osborne, 2017) [9]. First, about 47 percent of total U.S. employment is in the high-risk robotization category. These are jobs that are more than 70% likely to be automated over the next decade or two. Secondly, most of the transport and logistics professions, as well as the bulk of office and administrative support and workers in manufacturing professions, are at social risk arising due to robotization. Finally, wages and educational attainment show a strong negative relationship with the likelihood of computerization. This finding implies an increased demand for skilled labor, with computerization being largely confined to low-skilled and low-wage occupations.

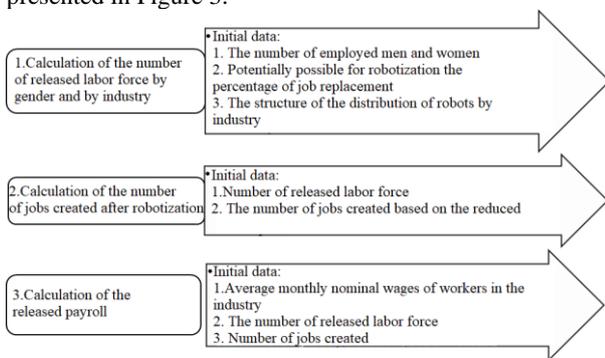
Herewith, other scientists hold the opposite opinion and assess robotization processes exclusively as additional opportunities for national economies (Vishnevsky, Knjazev, 2018; Vishnevsky, 2019) [10, 11]. For instance, Yu.G. Tyurina believes that negative forecasts of job losses are based on a contradictory and unfounded assumption that the number of required workers cannot be changed (Tyurina, Troyanskaya, Kuznetsova, Kremleva, 2019) [12]. In practice, in the history of innovation, labor productivity growth has always led to an increase in the labor market, not a decline. The main problem in this case is that the requirements for personnel are changing. Robots are replacing a routine and low-skilled workforce, while at the same time creating a need for highly skilled service engineers. With due attention to the development of

human capital, developing countries can significantly enhance their economies through robotization. However, this thesis of scientists does not correlate with the official position of the UN expecting the developing countries to suffer the most from automation: about 2/3 of their population may lose their jobs. Moreover, about 80% of workers in Russia are not ready to work in highly competitive, technologically complex markets (Butenko, Polunin, ... Topolskaya, 2017) [13]. A similar situation is observed in many developing countries, where the average worker is engaged in low-skilled work that requires routine actions and does not seek to enhance his/her skills.

## 2. MATERIALS AND METHODS

Within the framework of this study, the task was set to assess the social consequences of robotization for the Russian Federation. Scientists note that in many studies for this purpose, a simple regression analysis was used with respect to robotization as an independent variable and employment as a dependent variable (Tyurina, Troyanskaya, Kuznetsova, Kremleva, 2019) [12]. Herewith, the presented approach does not provide a high forecast accuracy, since it does not take into account all other factors.

Due to the relative novelty of the problems under consideration, as well as the limited statistical information in the field of production robotization in Russia, the author used a modeling method based on the comparability of national employment and income indicators with global trends. In its most general form, the proposed approach is presented in Figure 3.



**Figure 3:** Methodology for modeling the social consequences of production robotization

Source: compiled by the author

Let us provide some clarifications regarding the proposed methodology.

In the first stage, the percentage of job replacement potentially possible for robotization was determined on the basis of data from a study by Stepan Zemtsov, who, based on internationally comparable methods, calculated that about 44% of workers in Russia can be replaced by robotic labor (Zemtsov, 2017) [14]. Herewith, pursuant to estimates of other rating agencies, this indicator ranges from 40 to 70%.

To assess the structure of the distribution of robots by industry, it is advisable to use national statistics, however, due to the lack of such information in official sources, the author applied the analogy method, pursuant to which the average percentage of the distribution of robots by countries of the world for 2018, presented in Figure 2, was used in the calculations.

The calculation of the number of laid-off workers is performed considering the gender characteristic, which is explained by the nature of the replaced and newly created professions. This is important, first of all, since the indicator is very significantly different in terms of gender criterion - the number of jobs created per job made redundant, which is the basis for the implementation of the second stage. We used the results of earlier studies in this area declaring that during robotization: 1 new job is created for 3 lost male jobs, while 1 new job is created for 5 lost female jobs (Sizova, Khusyainov, 2017) [15]. This fact is essential when assessing the social consequences of robotization of production; it is incorporated into the model in the form of adjustment factors 2/3 for men and 4/5 for women (Formula 1).

Thus, the general mechanism for calculating the number of laid-off workers (x) can be formalized as follows (Formula 1).

$$x = \frac{2/3 \sum_{i=1}^n x^m * d^a * d_i^r + 4/5 \sum_{i=1}^n x^w * d^a * d_i^r}{1}, \quad (1)$$

where n is the number of industries most significantly influenced by robotization;

$x^m$  is the number of men employed in the economy;

$x^w$  is the number of women employed in the economy;

$d^a$  is the share of jobs that can be replaced by robotic labor;

$d_i^r$  is the share of i industry in the total volume of used industrial robots.

As part of the third stage, the data on average accrued wages of employees broken down by gender and industry were used to calculate the available payroll, and therefore the reduced income of citizens. Herewith, considering that, first of all, the professions that are most easily replaced by automated labor will be freed, the amount of wages that is charged to the laid-off workers is corrected by a decreasing correction factor k (formula 2).

$$k = \frac{x_{op}}{x_o}, \quad (2)$$

where  $x_{op}$  is the average 2019 accrued wages of workers in the category "operators of production plants and machines, assemblers and drivers" in manufacturing;

$x_o$  - the average 2019 accrued wages of workers in manufacturing industries.

The amount of wages that will be accrued to newly hired employees is corrected by an increasing correction factor l (formula 3).

$$l = \frac{x_e}{x_o}, \quad (3)$$

where  $x_B$  is the average 2019 accrued wages of workers in the category of "highly qualified specialists" in manufacturing industries;

$x_o$ - the average 2019 accrued wages of employees in the industry.

The cumulative monthly change in the wage fund ( $\Delta S$ ) is determined by formula 4.

$$\Delta S = k \left( \sum_{i=1}^n x_B^m * s_i^m * d_i^r + \sum_{i=1}^n x_B^w * s_i^w * d_i^r \right) - l \left( \frac{1}{2 \sum_{i=1}^n x_B^m * s_i^m * d_i^r} + \frac{1}{4 \sum_{i=1}^n x_B^w * s_i^w * d_i^r} \right), \tag{4}$$

where  $x_B^m$  is the number of men made redundant as a result of robotization processes (determined by formula 1 - the first term);

$x_B^w$  is the number of women made redundant as a result of robotization processes (determined by formula 1 - the second term);

$s_i^m$  is the average 2019 salary of men in the manufacturing sub-sectors;

$s_i^w$  is the average 2019 salary of women in the manufacturing sub-sectors.

Based on the assessment of the reduction in the wage bill, it is possible to calculate the average reduction in per capita income ( $\Delta d$ ) pursuant to formula 5.

$$\Delta d = \frac{\Delta S}{N} \tag{5}$$

where N is the population of the Russian Federation.

### 3. RESULTS

The above approach to assessing the social consequences of robotization was tested and extrapolated to the current economic situation in Russia. The results of mathematical calculations are presented in table 1.

**Table 1** Results of modeling the social consequences of robotization

Indicator	Value
The number of men made redundant as a result of robotization processes, ths. people	7,933
The number of women made redundant as a result of robotization processes, ths. people	8,972
The total number of people made redundant as a result of robotization, RUR ths.	17,945
Cumulative monthly change in the wage fund (decrease), RUR bln	191.5
The average reduction in per capita income, RUR	1,305
Average per capita monetary income of the population, RUR	35,115
Percentage of reduction in average per capita money income of the population, %	4

The robotization of five areas of industrial production (automotive, food and beverage, plastics and chemicals, metallurgy, electronics and electrical engineering) will lead to the release of almost 18 mln people (all calculations are extrapolated based on 2019 data). Let us note that this indicator was obtained on the condition that the calculations neglect the potential 20% of the number of industrial robots, the use of which is not identified by industry. The indicated amount of the released labor force in the manufacturing industry alone will lead to an increase in the unemployment rate to 27% (from 4.4% officially registered in 2019) in the absence of any social regulators. This will cause a decrease in the average per capita money income of the population by 4% (it is advisable to indicate relative changes in the study, since absolute changes are subject to inflationary changes).

We believe that another important and significant consequence of robotization is the growing gap between the income of the rich and poor citizens. This is due to the nature of the labor replaced in the process of robotization. In particular, the calculated adjustment factors allow to estimate the current situation, pursuant to which the minimum wage gap for newly created and laid-off workers

will be 1.5-2 times. It shall be noted that the aforementioned reduction in the average per capita income of citizens will affect mainly the poor, which further enhances the social polarization of society.

### 4. DISCUSSION

The estimates presented in this study are determined pursuant to a pessimistic scenario, however, they generally do not contradict a number of analytical forecasts. Pursuant to the recruiting portal SuperJob, by 2024, about 20% of employed people will lose their jobs as a result of digitalization in Russia, and the unemployment rate may rise to 20-25% by 2022.

Modeling the social consequences of digitalization drew attention to the need for government intervention in regulating the consequences of robotization (Grundel, Nazarova, Zhuravleva, Kostin, Suleymanov, 2019) [16]. The developed economies of the world are already paying attention to this (Agafonova, Sidorova, Polezharova, Ryakhovsky, Kostina, 2020) [17]. The goals of public administration shall include support for retraining

programs and job creation, which is one of the most important conditions for leveling the negative consequences of production automation.

Some states use tax mechanisms, establishing additional fiscal encumbrance of robots for the purpose of financial support to unskilled workers and restrictions of inequality between types of workers whom automation has influenced absolutely differently (Daubanes, Yanni, 2019) [18]. For instance, South Korea in 2018 has reduced the tax deduction on corporate tax by investments of business into automation (Tikhonova, 2020) [19]. Other countries prefer the use of budgetary regulatory instruments (this method is of higher priority). Thus, in 2017, the European Parliament rejected a draft resolution on legal issues, which recommended considering the introduction of a tax on robot owners, declaring instead the payment of compensation to workers dismissed as a result of robotization.

## 5. CONCLUSION

The robotization is certainly an objectively necessary phenomenon that contributes to the economic growth of the national economy. However, the uncontrolled course

## ACKNOWLEDGMENT

The research was supported by the Russian State Agrarian University – Moscow Timiryazev Agricultural Academy, theme № 1.1.6.

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of this phenomenon can lead to global negative social effects. In this part, we absolutely agree with Stepan Zemtsov's (Zemtsov, 2020) conclusion that many social risks do not come from digitalization and automation processes as such, but they arise due to the inability and impossibility of adapting to the digitalization and automation processes [20]. This can be manifested in the possible reluctance of workers to enhance their qualifications, and in the state's unwillingness to manage these processes, and in the absence of the necessary infrastructure. In particular, within Industry 4.0, it is quite possible that the acceleration of technological change and automation in the long term will not match the pace of job creation. For the sake of fairness, we note that the author's expectations in this regard are less negative, since the speed of automation of business processes in Russia is lower than in most developed and developing countries. Moreover, total robotization is a long process, and therefore the Governments of all countries of the world have time to develop effective regulatory tools to smooth out the negative social consequences of the automation of production processes.

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