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Main Factors of the Spatial Development in Promoting and Hindering Agriculture Robotization in Russia

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Abstract

This research determines the significant differences in the level of robotization of agriculture in Russia. As the processes of robotization of agriculture can be associated with certain socio-economic characteristics of the spatial development of regions, this study aims to analyze the factors of the spatial development of regions that promote and hinder the robotization of agriculture. Having identified and systematized influencing factors makes it possible to reduce the impact of obstacles and intensify the influence of factors contributing to the introduction of robotics. A 2D projection of the characteristics of the expert group (the Phi contingency coefficient) and the results of the expert survey (the Pearson's correlation coefficient) was developed. The most significant factor in the spatial development of regions, which currently hinders the robotization of agriculture, is a share of profitable agricultural organizations in the region. According to the experts, the factors of the spatial development of regions hindering the robotization of agriculture are insufficient volumes of subsidies for the technical renewal of agriculture and investment risks in the region. The most significant factor in the spatial development of regions, contributing to the robotization of agriculture is the availability of a developed network of servicing for robotics. Considering these factors will make it possible to choose the optimal measures of influence in order to intensify the activity in robotizing the production and rural areas.

Disciplinary: Agricultural Technology.

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1 Introduction

In recent years, scientific discussions about the prospects for the development of digital technologies and their impact on the economy have been continuing. According to many scientists, there is a huge potential for increasing the economic efficiency of production and society as a whole, in the process of further robotization of production processes [10]. However, the discussion of further digitalization, including robotization, is shifting towards the risks connected with these processes. According to the International Organization of Robotics, the most robotic countries in the world are (in descending order of robotics density) Singapore, South Korea, Japan, Germany, Sweden, Denmark, Hong Kong, Chinese Taipei, USA, Belgium, and Luxembourg [1]. Disproportions in the robotization level in countries and particular regions necessitate a search for patterns that explain these phenomena. At the same time, agriculture remains one of the least robotic industries, as historically industrial robotics began to be explored earlier than in other industries. It is of great interest to identify the factors that encourage accelerated robotization in some regions and leave the processes of robotization in stagnation in other regions.

2 Materials and Methods

The main hypothesis of the study is that the processes of robotization of agriculture can be associated with certain socio-economic characteristics of the spatial development of regions.

The study aims to analyze the main factors of the spatial development of regions that promote and hinder the robotization of agriculture.

The research objectives are

- to determine the main factors of the spatial development of the regions which impact the robotization of agriculture;
- to assess the factors of the spatial development of regions, in terms of the nature of this impact;
- to carry out a quantitative assessment of the main factors of the spatial development of regions with a group of experts.

To analyze the main factors of the spatial development of the regions, a group of experts from the Sverdlovsk region was involved. These experts were, first of all, skilled people in running a business such as heads of agricultural organizations. Another expert group was the representatives of the executive authorities who manage the industry directly. And, finally, the third group was representatives of the academic community, research institutes, who are respected experts in agriculture. Per the aim and objectives of the study, a questionnaire with two main sections was developed. The first section asked the experts to put personal data, including gender, age, professional activity, and education. The second section suggested assessing various factors of the spatial development of regions in terms of the degree of influence on robotization of agriculture and indicating its nature (positive or negative influence) of this impact. And it was necessary to give a point according to the increasing power of impact from "1" (no influence) to "10" (the greatest influence) on robotization of regional agriculture.

For a more detailed description of the surveyed group, a two-dimensional projection was developed with the Phi contingency coefficient. To calculate this coefficient, all qualitative respondents' details were taken, such as gender, age, education, and professional activity. Correlation coefficients between characteristics were calculated using the software. The final correlation matrix with the Thorgerson method was put on a two-dimensional surface, which allowed visualizing the distance of certain variables from each other (characteristics of the experts) (Figure 1).

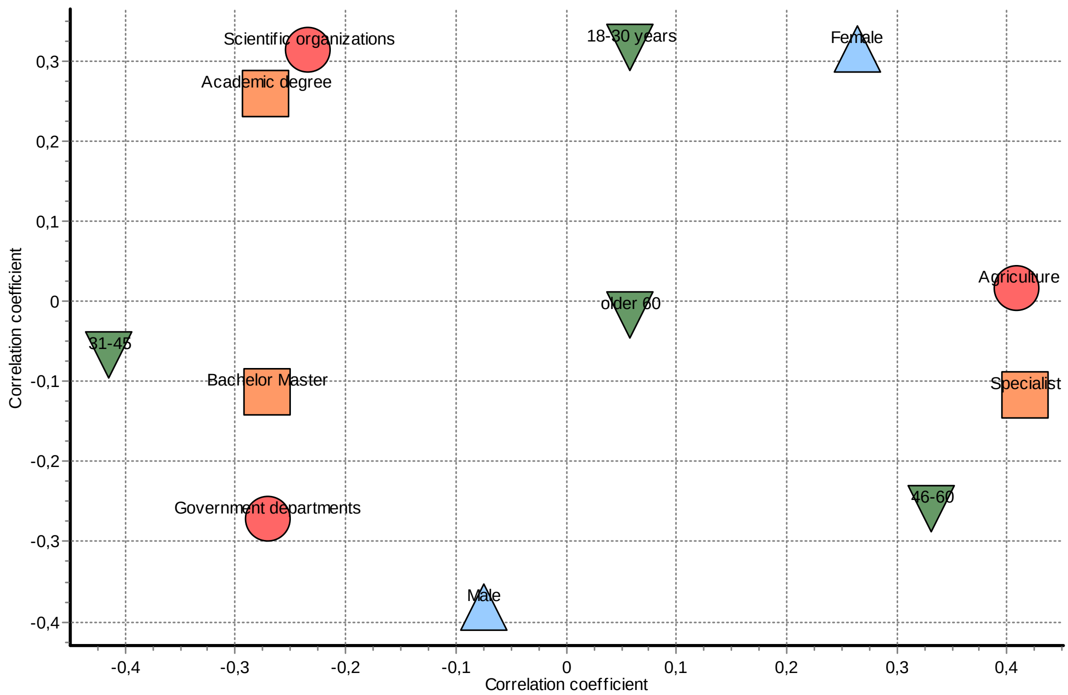


Figure 1: A two-dimensional projection of the surveyed employees (the Phi contingency coefficient), unit fraction.

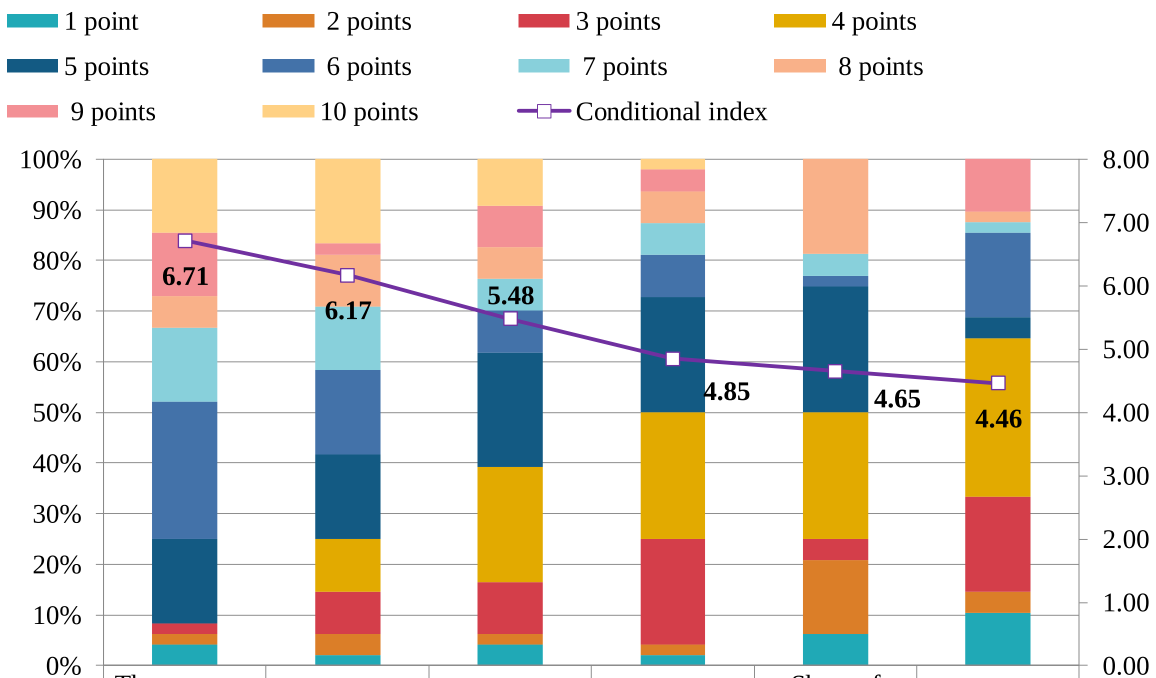
From Figure 1, the professional activities of the experts are in different angles of the two-dimensional projection. So, representatives of the executive authorities take the lower left-hand corner, representatives of research organizations are at the top, and representatives of agricultural organizations are in the middle right. According to the diagram, the representatives of research organizations mainly have an academic degree (the smallest distance to the academic degree icon) at two age categories - from 18-30 years old and 31-45 years old (the smallest distance to the age icon). The representatives of executive bodies are mostly men (the smallest distance to the gender icon), while almost all of them have a bachelor's or master's degree and are over the age of 31-45. It should be noted that the business representatives as heads of agricultural organizations are more correlated with the "specialist" education group, aged 46-60. Moreover, the majority of women (the smallest distance to the gender icon) belong to this group.

3 Results and Discussion

The availability of services for robotics in regions is a significant factor for making a decision on robotization. According to Figure 1, this factor has the greatest impact on the robotization of agriculture. Thus, this factor gets an assessment of 10 points (the greatest influence) among 14.6%

of the respondents, while only 12.5% of the surveyed experts indicated that this factor has a decisive influence (9 points). The conditional index of the significance of this factor was 6.71 points. Leading manufacturers of robotic equipment for agriculture should expand their network in regions.

The assessment of the factors promoting the robotization of agriculture is presented in Figure 2.



	The presence in the region of a developed network of service maintenance for robotics, pcs.	Proximity to regional markets, RUB mln	Share of employed with higher education in the population,%	Share of workers employed in agricultural production	Share of small and micro organizations in the total number of agricultural organizations ,%	Share of agricultural organizations in the region's GDP,%
10 points	14.6	16.7	9.3	2.1	0.0	0.0
9 points	12.5	2.1	8.3	4.2	0.0	10.4
8 points	6.3	10.4	6.3	6.3	18.8	2.1
7 points	14.6	12.5	6.3	6.3	4.2	2.1
6 points	27.1	16.7	8.3	8.3	2.1	16.7
5 points	16.7	16.7	22.9	22.9	25.0	4.2
4 points	0.0	10.4	22.9	25.0	25.0	31.3
3 points	2.1	8.3	10.4	20.8	4.2	18.8
2 points	2.1	4.2	2.1	2.1	14.6	4.2
1 point	4.2	2.1	4.2	2.1	6.3	10.4
Conditional index	6.71	6.17	5.48	4.85	4.65	4.46

Figure 2: The assessment of the factors of the spatial development of regions that impact robotization of agriculture, %.

The proximity to regional markets is determined by the sum of the market volumes of neighboring regions, divided by the square of the distance to them, and is traditionally measured in millions of rubles. As the results of the survey show, this factor is at the second place of importance. The greatest preference for this factor was given by 16.7% of the respondents, and its conditional index was 6.17 points. Thus, the proximity to large consumers of production can be a significant factor for the implementation of projects on the robotization of the industry.

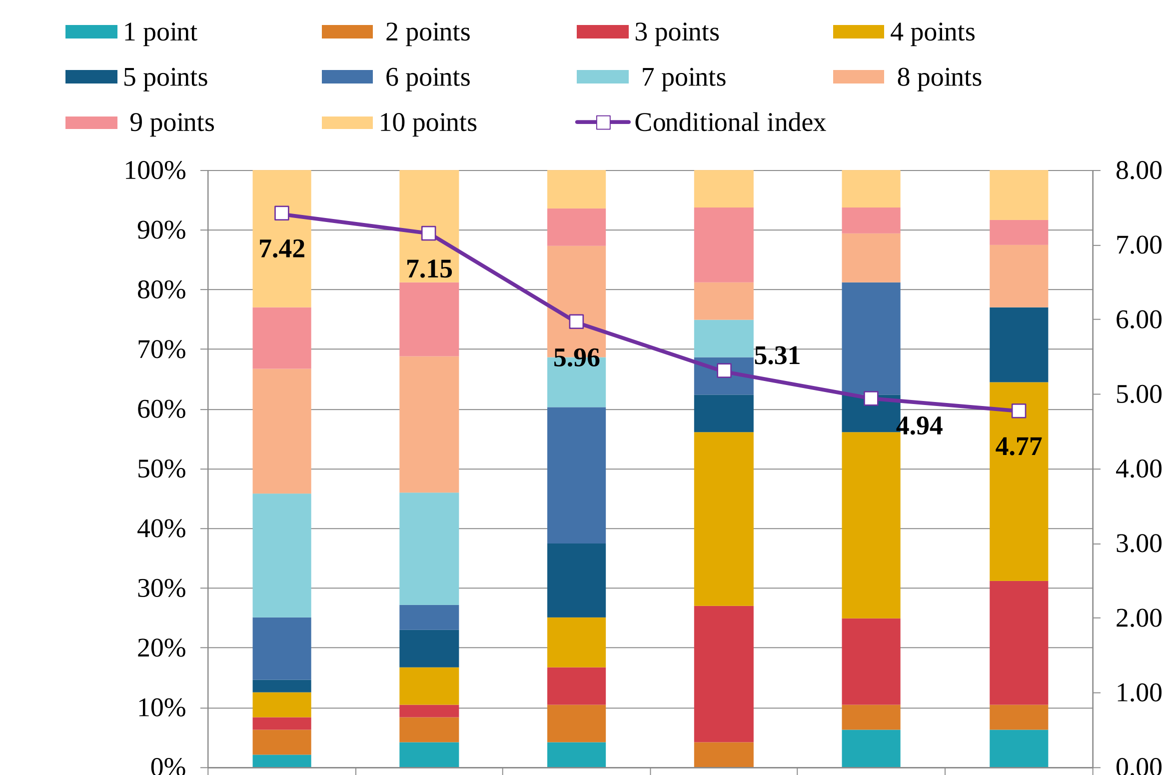
Having a higher education can help to increase the organization's capacity to master innovations, which include digital technologies and robotics. The experts highly appreciated the share of workers with higher education in the regional population. This factor received an assessment of 10 points (the greatest influence) from 9.3%, while a significant part (22.9%) indicated the average value of this factor. At the same time, the average index of employees with higher education in the regional population was 5.48 points.

One of the characteristics of the status of the human capital in the regions is the share of workers employed in agricultural production. Agriculture occupies a relatively small share in the structure of gross production. According to the World Bank, only 2.8% of the world's gross income came from agriculture, hunting, forestry, and fishing [2]. At the same time, about 1.3 billion people (19% of the world population) were directly employed in agriculture or received income from activities related to this industry. The factor of the spatial development of regions, reflecting the share of workers employed in agricultural production, according to the experts, has an average impact on the robotization of the industry. In total, two-thirds of the assessments (68.7%) are in the range of 3-5 points, and the conditional index was 4.85 points.

The research of the UK scientists shows, robotic production allows even medium-sized farms to reduce costs to a minimum level per unit of production, which makes it possible to increase competitiveness [3]. Several studies have shown that small firms are more innovative than large organizations. The factor characterizing the share of small and micro organizations in the total number of agricultural organizations, according to the experts, has an average level of impact on the industry's robotization. Thus, half of the experts assessed this factor as four and five points, and its conditional index was 4.65 points.

One of the indicators characterizing the socio-economic development of agriculture is a share of the agricultural sector of the economy in the region's GDP. It was found that the group of regions with a share of agriculture of less than 5% in the regions' GDP has the average density of robotization of the industry was 1.35 robots per 10 thousand employees; with a share of 5 to 10% - the density of robotization was 2.33, with a share of agriculture over 10% - 0.21 robots per 10 thousand people working in the industry [4]. Thus, the higher the share of agriculture in the region's GDP, the lower the dynamics of the introduction of robots. Nevertheless, the experts noted the positive impact of this factor of the spatial development of regions on the robotization of agriculture. As the results show, 31.3% of experts believe that its impact is limited and is below the average one (4 points), and the conditional index is 4.46 points.

The factors of the spatial development of regions with negative (hindering) impact on robotization of agriculture are presented in Figure 3.



	Share of agricultural organizations in the region working with profit,%	Amount of subsidies for technical renewal of agriculture in the region, thousand rubles	Weighted average adjusted investment risk index of the region, RAEX	Availability of access to communication services (including broadband Internet),%	Availability and length of public roads, km	Average wages of agricultural workers, thousand rubles
10 points	22.9	18.8	6.3	6.3	6.3	8.3
9 points	10.4	12.5	6.3	12.5	4.2	4.2
8 points	20.8	22.9	18.8	6.3	8.3	10.4
7 points	20.8	18.8	8.3	6.3	0.0	0.0
6 points	10.4	4.2	22.9	6.3	18.8	0.0
5 points	2.1	6.3	12.5	6.3	6.3	12.5
4 points	4.2	6.3	8.3	29.2	31.3	33.3
3 points	2.1	2.1	6.3	22.9	14.6	20.8
2 points	4.2	4.2	6.3	4.2	4.2	4.2
1 point	2.1	4.2	4.2	0.0	6.3	6.3
Conditional index	7.42	7.15	5.96	5.31	4.94	4.77

Figure 3: The factors of the spatial development of regions with a negative impact on robotization of agriculture, %.

The financial condition of agricultural organizations has a significant impact on the possibility of updating the material and technical base. Meanwhile, only a quarter of large and medium-sized agricultural organizations in many regions of the Russian Federation can be characterized as financially stable organizations [5]. When the share of profitable agricultural organizations remains low, the robotization of the industry can be carried out at a slow pace. This explains negative assessments of this factor of the spatial development of regions by the experts.

Thus, 22.9% of assessments have 10 points, and 52% of expert assessments have high values (7-9 points), while the conditional index is 7.42 points.

State authorities annually allocate significant funds to support agriculture. So, compensating subsidies for the purchase of new equipment in 2020 in the Russian Federation were 34 billion rubles, and incentive subsidies - 27 billion rubles [6]. Nevertheless, the level of state support for agriculture remains at an insufficient level. In terms of the amount of state support per 1000 km^2 of agricultural land, Russia is inferior to the EU countries in more than 10 times [7]. Therefore, the assessments of the factor that characterizes the negative impact of the number of subsidies on agriculture in the regions are quite expected. Thus, over 18.8% of the respondents indicated the greatest influence (10 points) of this factor on robotization of agriculture, and more than half of them defined this factor as high (7-9 points). The conditional index of this factor is 7.15 points.

The average adjusted investment risk index of a region reflects the impact of certain factors on investment safety and is calculated based on social, economic, environmental, criminal, and other components. The lowest investment risks are in the Moscow, Belgorod, and Lipetsk regions, and the greatest risks are in the republics of the North Caucasus [8]. According to the experts, the impact of this factor on robotization of agriculture can be assessed as high (31.4% of assessments of 8-10 points), the conditional index is 5.96 points.

An indicator characterizing the availability of the necessary infrastructure for robotization is the availability of hard-surface roads and access to communication services, including broadband Internet. It was found that there is low dependence between the density of robotization of agriculture and the availability of hard-surface roads (correlation coefficient -0.21) and the density of highways (correlation coefficient 0.04). At the same time, the availability of a developed road network is a necessary condition for ensuring timely servicing of such complex equipment as robotics. The correlation between the density of agricultural robotization and the share of organizations using the Internet is 0.10, and the correlation coefficient is 0.04 between the density of robotization of the industry and organizations using broadband Internet access [9]. Using the Internet, the robotics on the farm can be controlled remotely, it becomes possible to update the software remotely, etc. Despite the absence of a visible correlation between the density of robotization of agriculture and the development of regional infrastructure, it is still difficult to imagine the use of robotics in production without a worldwide network and a developed road network. The impact of these factors of regional development on the robotization of the industry has average marks (5.31 and 4.94 conventional points, respectively).

Figure 4 shows the factors of the spatial development of regions that affect the robotization of agriculture with the use of the Pearson correlation coefficient in calculations.

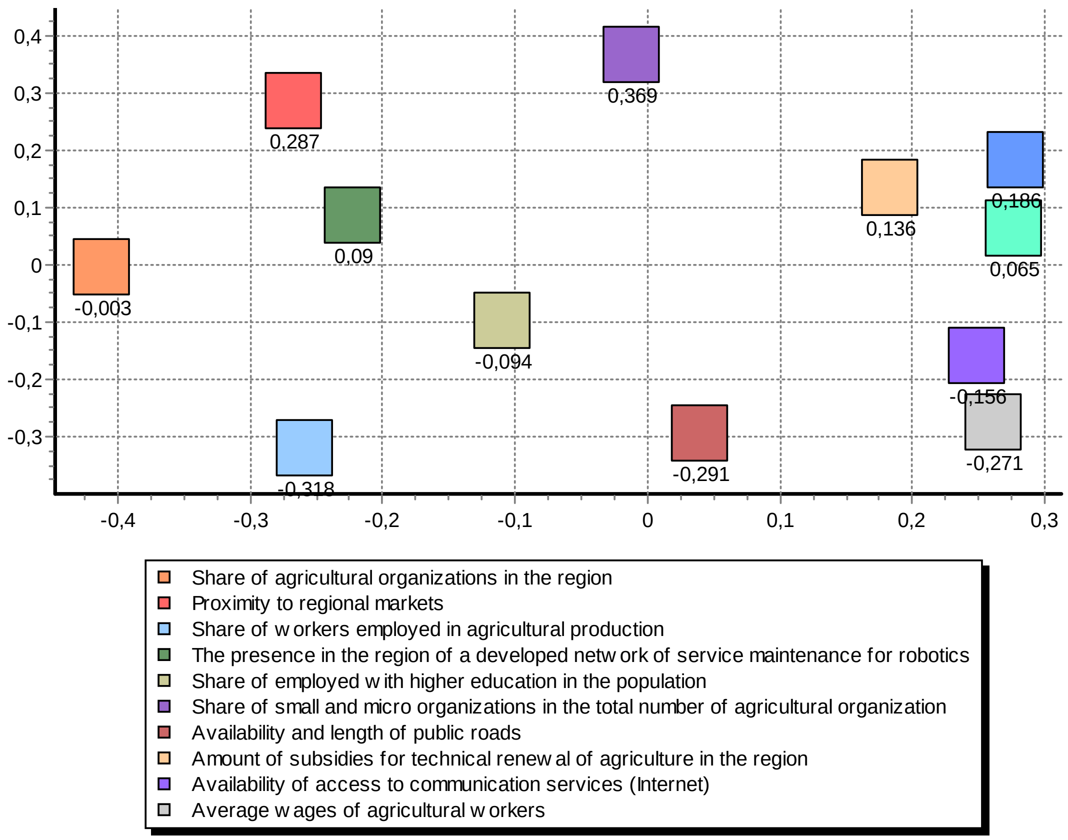


Figure 4: A two-dimensional projection of the correlation of factors of the spatial development of regions that affect the robotization of agriculture (the Pearson correlation coefficient), unit fraction.

As the analysis of the results of the expert survey shows (the Pearson correlation coefficient), the highest correlation (0.369) of the expert assessments relates to the factor "The availability of access to communication services (including broadband Internet)", and the lowest correlation (-0.318) to the "The share of workers employed in agricultural production".

Table 1 presents the relative and average assessments of the factors of the spatial development of regions.

Table 1: Relative and average assessments of the factors of the spatial development of regions, points.

Factor (indicators) of the spatial development of regions	Average factor assessment	Relative factor assessment	Factor rank
A share of regional profitable agricultural organizations, %	-7,6	-0,109	1
The volume of subsidies for technical renewal of regional agriculture, thousand rubs.	-7,3	-0,105	2
The availability of a developed network of servicing of robotics in the region, pcs	6,9	0,099	3
The proximity to regional markets, mln rub.	6,3	0,091	4
A weighted average adjusted investment risk index of the region, RAEX	-6,1	-0,088	5
A share of employees with higher education in the population, %	5,6	0,081	6
The availability of access to communication services (including broadband Internet), %	-5,4	-0,078	7
The availability and length of public roads, km	-5,0	-0,073	8
A share of workers employed in agricultural production	5,0	0,072	9
The average wages of agricultural workers, thousand rub	-4,9	-0,070	10
A share of small and micro organizations in the total number of agricultural organizations, %	4,7	0,069	11
A share of agricultural organizations in regional GDP, %	4,5	0,065	12

From Table 1, the most significant factors in the development of regions that hinder the robotization of agriculture are a share of agricultural profitable organizations in the region and the number of subsidies for the technical updating of regional agriculture. These factors have the highest average (7.6 and 7.3 points, respectively) and relative (0.109 and 0.105) assessments. The average level of negative impact may be caused by investment risks in the region (relative assessment is 0.088 points). The factors of regional development promoting robotization include the availability of a developed network of servicing of robotics in the region (relative assessment is 0.099 points) and the proximity to regional markets (relative assessment is 0.091 points). The average level of positive impact can be given with a share of workers with higher education in the population (relative assessment is 0.081 points). As the assessments show, at present, the factors of the spatial development of the regions, which hinder the robotization of agriculture, have received a higher assessment in comparison with the favorable factors.

4 Conclusion

The availability of access to communication services, including broadband Internet, is a necessary condition for the use of robotics in production. This study also allows highlighting the factors that promote and hinder the robotization of agriculture and related rural areas. Taking them into consideration will make it possible to choose the optimal measures of influence on them in order to intensify the robotization of production and rural areas. In particular, in order to intensify activities on the robotization of agriculture, it is necessary to reduce the impact of negative factors in regional development. Thus, it is necessary to pay attention to the financial recovery of organizations in the agrarian sector of the economy, to increase subsidies for the purchase of robotics, to develop measures on reduction of investment risks, in particular, preferential insurance of projects for farm robotization. It is necessary to increase the impact of positive factors of regional development. In particular, it is necessary to promote the development of a dealer network for servicing robotics, to develop and implement measures for state support for the development of market infrastructure for trading of agricultural products, and to carry out systematic training of personnel capable of mastering robotics in agriculture.

The analysis data can be used to make a spatial model of robotization of agriculture in dependence on various socio-economic characteristics of the regions and zoning of rural areas according to the practicability of robotization of the industry.

5 Availability of Data and Material

Data can be made available by contacting the corresponding authors.

6 Acknowledgement

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