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Measures for Priority Robotization of Agriculture in Remote Regions

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Abstract

The implementation of robotics in agriculture is influenced by objective reasons, including a shortage of personnel in the industry, especially during the spread of the COVID-19 epidemic. In Russia, the use of robots in agriculture is very irregular across the federal districts. The largest number of robots is used in agriculture in the Central Federal District - 184 units, the Volga Federal District - 95 units and the Urals Federal District - 68 robots. The study aims to identify the dependence of the use of robotics in agriculture in the federal districts of Russia, considering their socio-economic characteristics. It has been established that in the federal districts with traditionally developed agriculture and a high share of agriculture in GDP, the number of robots is decreasing and there is a technological lag. The highest correlation coefficient of 0.73 is observed between animal productivity and the number of used robots. Thus, agricultural economic entities target to reduce the payback period for robotization projects and thus reduce risks. To make conditions for the implementation of robotics, it is proposed to use agricultural growth corridors (agro-corridors) and agro-clusters.

Discipline: Agriculture & Farming Technology

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1 Introduction

Agricultural organizations are facing a shortage of labor. Primarily, the industry needs workers in mass professions, which include workers for harvesting, animals care. One of the reasons for the current situation in the agricultural sector of the economy is the unfavorable demographic situation in some regions and the growing urbanization of the population [1]. There is an increase in the cost of labor, which forces agricultural producers to introduce labor-saving technologies [2]. Digitalization of agriculture can solve the problem and make it possible to increase the efficiency of the industry in a particular subject of the Russian Federation. Recently, there has been a high rate of introduction of digital technologies into production, including the robotization of agriculture [3].

In recent years, personnel problems in agriculture have become more urgent due to the COVID-19 epidemic. The coronavirus pandemic and the associated restrictions on the movements of labor forces have clearly shown the high dependence of agriculture on labor supply and has become a real challenge for the sustainability of agricultural production [4,5,6]. Restrictions on the movements of workers have led to the shutdown of some industries and the disruption of supply chains in the industry. At the same time, the coronavirus epidemic has encouraged farmers to do online sales and replacement of human labor with various machines and automated means [7], robotics in particular.

2 Materials and Methods

The main hypothesis is that the robotization of agriculture is carried out with regional characteristics and specifics of sectors of agricultural production. So, these issues have not been properly studied, which slows the process of robotization of agriculture in the Russian Federation and is an important national economic problem.

The study aims to identify the correspondence between the use of robotics in agriculture in the federal districts of Russia and their socio-economic characteristics.

A set of methods was used to study the territorial aspects of robotization of agriculture. When solving each problem, appropriate research methods and information bases were used at each stage of the study. To analyze the activities on the introduction of robotics in agriculture, Rosstat data were used, relevant data requests were made to the Ministry of Agriculture of the Russian Federation on the number of robotics units introduced in agricultural organizations (in dynamics), etc. The data for individual regions was clarified in the regional ministries of agriculture and agro-industrial complex. We used the results of our own research, including Internet screening.

The specialization of agricultural organizations has an important role in robotization. The fact is that currently, the most commercially widespread robotics is for animal husbandry. This is due to the fact that relatively stable environmental parameters are created in livestock buildings, including temperature, humidity, illumination, etc., which makes conditions for the use of robots. The use of robotics in crop production is difficult due to the need for robots to move over rough terrain, orient themselves, to work with a large number of uncalibrated objects (fruits, trees, etc.).

In this regard, we assume that with an increase in the share of livestock products in the total volume of agricultural production, the density of robotization should increase, which requires further research.

3 Results and Discussion.

Currently, the most widespread robots in agriculture are ones for cattle milking. According to some data, their number in the world is more than 50 thousand units [8]. According to the International organization of robotics, this is approximately 1.5% of the total number of robots in use [9]. The cattle milking robot is a box in which the animals are milked directly and a central module with key components that ensure the operation of the device. The main component is a manipulator arm that performs three-dimensional movements. The robot includes a teat and udder cleaning system with cleaning solution and brushes. The automatic milking device also includes fittings for putting on and taking off teat cups, sensor and control devices, and special scales to weigh the cow concentrates and milk. Modern models of milking robots have the ability to control the quality of milk, that is, to determine its color, acidity, temperature, milk flow rate, electrical conductivity, and volume of each udder quarter, this feature allows separating high-quality milk from unsuitable for consumption. This equipment has an animal identification system. Optical, laser, combined, ultrasonic systems (sensors) are used to detect teats, treat the udder, put on and then remove teat cups. Some brands of milking robots have a milk quality system that determines the number of somatic cells.

Table 1: Development indicators of federal districts for 2014-2021 and correlation with the level of robotization in agriculture.

Federal districts of the RF	Robots, units	The density of robotization, robots per 10 thousand employees	Animal productivity, kg	Share of employees in agriculture in the total number of employed, %	Growth rates of agricultural production, %	The share of agriculture in the regional GDP, %	Share of the livestock industry in agriculture %
Russian Federation	495,0	0,75	4944	8,3	104,1	4,8	47,8
Central federal district	184,0	0,32	7031	5,4	104,5	3,3	48,2
North-western federal district	66,0	0,61	7122	4,8	101,8	2,4	65,0
Southern federal district	1,0	0,01	4487	13,5	105,4	11,8	32,0
North Caucasian federal district	0,0	0,00	2895	19,8	105,2	14,9	44,9
Volga federal district	95,0	0,69	5626	9,7	104,2	7,2	50,3
Ural federal district	68,0	2,16	5916	5,0	102,5	11,8	57,7
Siberian Federal District	4,0	0,05	4944	8,9	102,2	6,1	55,0
Far Eastern federal district	17,0	0,67	2395	7,8	108,1	3,4	41,8
Correlation coefficient with the number of robots	-	-	0,73	-0,58	-0,19	-0,46	0,29
Correlation coefficient with robotics density	-	-	0,27	-0,56	-0,25	0,06	0,45

Based on the results of inquiries to regional offices and the Ministry of Agriculture of the Russian Federation, it was possible to get data on the introduction of 435 units of robotics into agriculture, while the density of robotization in Russia as a whole is 0.75 robots per 10 thousand employed in the industry. It should be noted that the average productivity of cows was 4944 kg per head, and a share of livestock production was 47.8% of the total structure of agricultural production. The Russian Federation is a country of an industrial type of development, as the share of agriculture in GDP is only 4.8%, while the share of industry workers is 8.3% of the total number of employees. Recently, the agriculture of the Russian Federation has been developing very dynamically, the average annual growth rate of agricultural production was 4.1% (Table 1).

As Table 1 shows, the largest number of robots is used in agriculture in the Central Federal District - 184 units. The Volga Federal District takes second place - 95 units and the Urals Federal District - 68 robots. However, in terms of robotization density, the Ural Federal District is confidently leading - 2.16 robots per 10,000 people employed in agriculture. At the same time, the two districts have practically zero density of robotization in agriculture, the Far Eastern Federal District is characterized by an average level of robotization density.

The correlation coefficient between the number of robots and the share of workers employed in agriculture is negative and is 0.58. The correlation coefficient with robotics density is 0.56. Thus, the higher the proportion of people employed in agriculture in the federal district of their total number, the fewer robots are used there. A rather similar situation is observed when the number of robots is correlated with the share of agriculture in the region's GDP. As can be seen from the table, it is 0.46 and 0.06, respectively. In other words, the federal districts with traditionally developed agriculture, where the share of agriculture is over 10% in the structure of GDP, have a technological lag.

The growth rate of agricultural production can influence the motivation of farmers to introduce new equipment, including robotics. This allows making a conclusion about a relationship between the growth rates and the introduction of robots in the federal districts. In practice, one can see a negative correlation between the number of robots (-0.19) and the density of robotization (-0.25). The analysis of the robotization rate and the increase in agricultural production shows an inverse relationship between them. On the one hand, the group of regions with a high density of robotization has average growth rates of agricultural production. On the other hand, the regions with no robotics used have the most significant growth rates of agricultural production. The explanation for this may lie in the fact that currently only a small proportion of agricultural products are produced using robotics. Thus, the most common type of robotics used is milking robots. With an average service rate of about 60 heads by one robot, the total number of cows served by milking robots is 26,100 heads or 0.3% of the total number. Thus, currently, the robotization of agriculture does not impact significantly the pace of agricultural production, mainly due to the low rate of robotization in the agricultural sector of the economy. The largest share of livestock products in the volume of production is observed in the Northwestern Federal District, while the density of robotization there is 0.61 robots per 10 thousand employees. The correlation coefficient of the share of livestock in agriculture with the number of robots was 0.29, and the density of robotization was 0.45. It can be noted that almost all used robotics is applied in animal husbandry, which determines the average level of correlation of this indicator with the results of the development of federal districts.

The highest correlation coefficient of development indicators of the federal districts with the number of robots is observed in terms of animal productivity (0.73), while the dependence on the density of robotics is average (0.27). This allows making the conclusion that the greatest motivation of the regional economic entities to introduce robotics is to reduce the payback of farm robotization projects. This allows reducing significantly the risks of investment projects, especially such capital-intensive ones as the introduction of robotics. As the results of our previous studies show [10,11], the payback period for robotization projects depends on the productivity of cows (Figure 1).

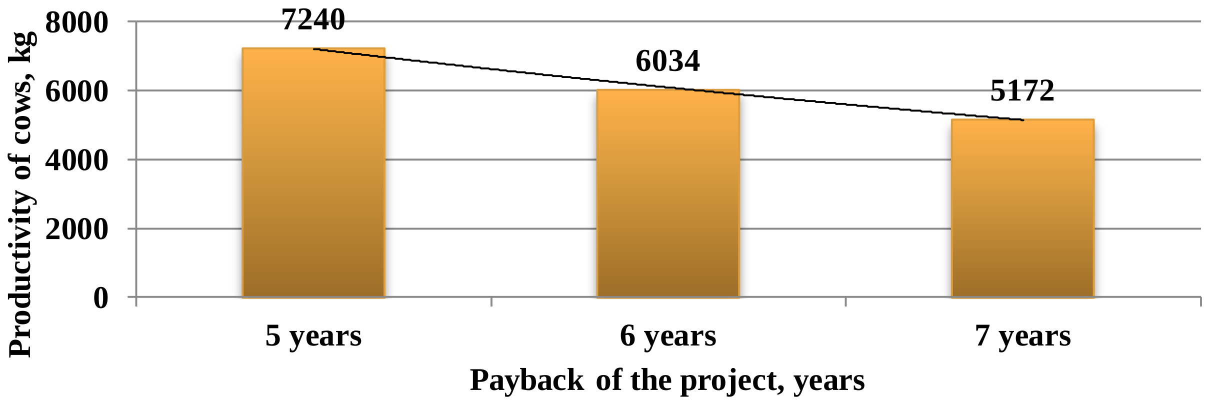

Figure 1: Payback period of milking robots from cattle productivity, years.

Figure 1 shows the payback of robotics is 7 years with the cattle productivity of 5172 kg of milk per year, which makes robotization projects quite long. Under these conditions, not every business entity will make investments with such long payback periods. However, with an increase in cattle productivity up to 7240 kg, the payback of robotization projects is reduced to 5 years, which allows farmers to invest in these projects. In this case, the risks for farmers are much lower.

4 Discussion

It is possible to group regions in terms of animal productivity and the density of agricultural robotization (Figure 2).

From Figure 2, there are 18 regions, while the average annual productivity of cows was 7384.4 kg of milk per head. These regions are characterized by a high density of agricultural robotization - 2.67 robots per 10 thousand employees in the industry. The average number of robots in one region (among this group) was 12.8 units.

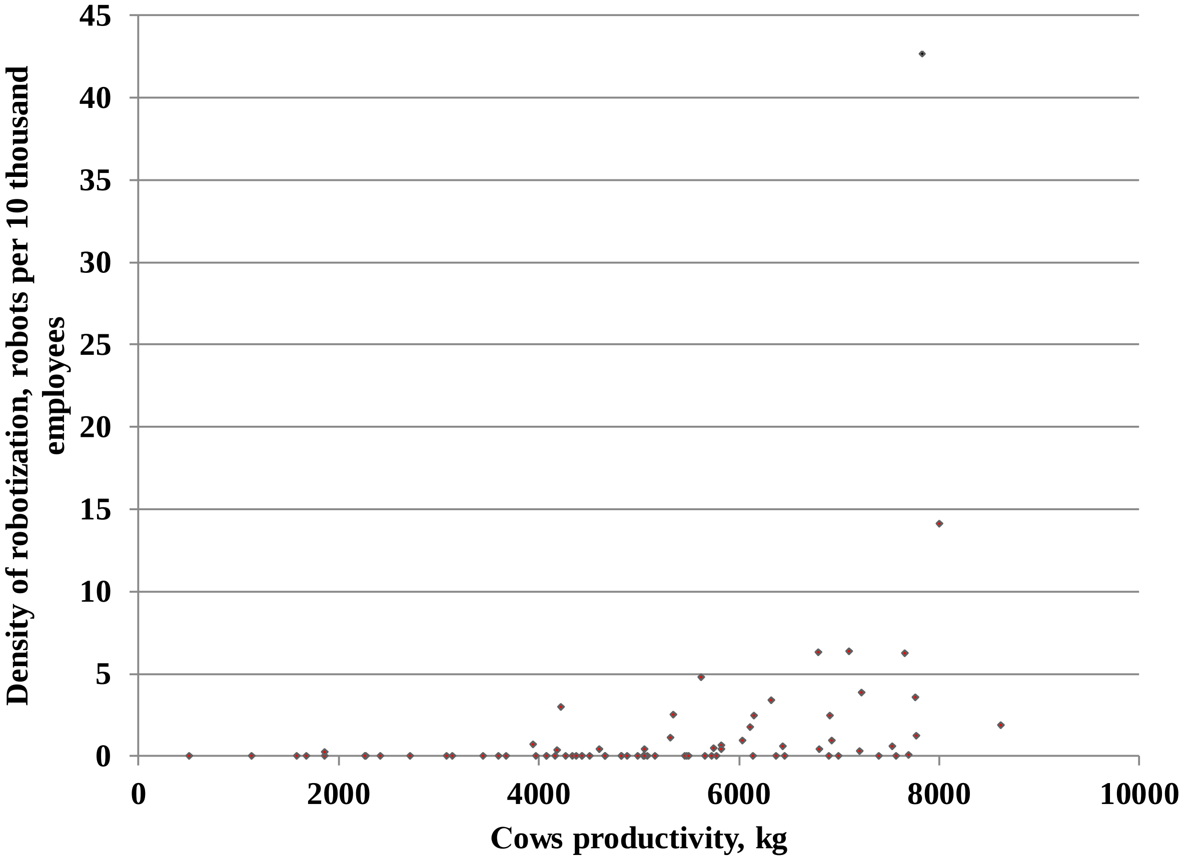

Figure 2: Data on the productivity of cows and the density of robotization of agriculture in the regions of the Russian Federation.

5 Conclusion

The existing world experience in solving the problems of territorial development, including the increasing technological backwardness, allows offering a set of different tools. In particular, agricultural growth corridors (agricultural corridors) are aimed at making conditions for the development of agriculture on the territory connected by transport lines, such as highways, railways, ports or canals [12]. Agro-clusters are a geographic concentration of interconnected producers, agricultural organizations and institutions engaged in one and same agro-industrial subsector, interacting with each other to solve common problems and search for common development opportunities. The development of these structures can contribute to the priority robotization of remote rural areas.

6 Availability of Data and Material

Data can be made available by contacting the corresponding author.

7 Conflict of Interests

The authors confirm that the presented information does not contain a conflict of interest.

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