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FACTORS OF SPATIAL LOCATION OF AGRICULTURE: DATA FROM RUSSIA

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Abstract

The severity of the problem of food supply for the population and the complexity of its solution at the present stage of the development of the society sets the task for agriculture to increase the productivity of production. One of the central places belongs to the rational distribution of agriculture; it indicates the need to identify factors that have a decisive influence on the productivity of production in the external environment. The purpose of the research was to identify the strength of the influence of individual climatic and socio-economic factors on the effectiveness of activities of agriculture in the regions of the Central Federal District of Russia. When carrying out the research, the methods of logical and comparative analysis were used as general scientific methods using a review of information and statistical data. The quantitative assessment of the factors that determine the effectiveness of placement was carried out by the method of multivariate correlation - regression analysis. The constructed models of the formation of performance made it possible to identify the strength of the influence of individual factors. Among the natural and climatic factors, the soil bonitet score and temperature regime have the greatest influence on the production volume. Among the socio-economic factors, the availability of skilled labour and the density of roads and railways have the greatest influence on the production volume.

Keywords: Agriculture, development of the territory, natural and climatic factors, region

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1. Introduction

Despite many significant advances in agriculture in recent years, it is still not possible to provide a solution to the food problem. According to the Food and Agriculture Organization (FAO), there are more than 815 million malnourished people in the world and two billion people suffer from malnutrition diet (The State of Food Security…, 2017). Normal dietary patterns are violated even in many seemingly prosperous countries, for example, the USA (Household Food Security in the United States in 2013, 2014). A similar situation is observed in Russia, where the consumption of many types of food is below rational norms, which indicates the insufficient economic and physical availability of food.

The severity of the problem of food supply for the population and the complexity of its solution at the present stage of the development of society poses a challenge for the agriculture of many countries to improve production efficiency (Paz et al., 2020). The traditional view of the growth of production in agriculture is given to increasing crop yields and animal productivity through the use of effective technologies for agricultural production (Semin, 2019), automation and robotization of agricultural production (Butorin, 2020). Often, research on this issue focuses on the agro-ecological justification of efficient production based on maintaining soil fertility and biologization techniques (Dubovitski et al., 2019, 2020; Gliessman, 2020).

Many researchers assign an important role in the formation of efficient agricultural production that can solve the problem of food security to an increase in the specialization of farms (Alpatov, 2019), the enlargement of production, the development of integrated structures such as agricultural holdings engaged in the production, processing and sale of agricultural products, as well as the formation of cluster-cooperative projects (Rastvortseva, 2017; Zhidkov, 2019). At the same time, it is often concluded that it is necessary to expand government influence and subsidize certain programs (Ivanova & Merkulova, 2018).

The opposite point of view is the opinion about the need to ensure the self-sufficiency of the regions - to achieve complete financial independence from budget subsidies through the effective use of available factors of production (Karpunina et al., 2020) and labour (Novak & Kozlova, 2020), and often the potential of informatization and digitalization (Karpunina et al., 2019; Kuchnarenko & Pudeiyan, 2020).

The situation with food supply is exacerbating in many regions due to the high degree of differentiation of regions in terms of socio-economic development. According to a World Bank report, Russia is among the top three in terms of regional inequality within the country among the states of Europe and Central Asia (Maurizio et al., 2018). Therefore, the balanced development of regions is considered as an element of the mechanism of active development (Kok et al., 2021), and one of the central places here belongs to the rational distribution of agriculture (Alpatov, 2019; Animitsa et al., 2014). In Russia a Spatial Development Strategy (Spatial development Strategy of the Russian Federation…, 2019) has been developed, which emphasizes the level of interregional socio-economic inequality and formulates the main directions of state policy aimed at improving spatial development. However, insufficient attention is paid to the issues of optimal placement of agriculture in order to increase the efficiency of the agricultural sector and maximize the satisfaction of the needs of the population.

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2. Problem Statement

The presence of difficulties in managing the placement of an agricultural enterprise to achieve sustainable development indicates the need to identify factors that have a decisive influence on the performance of production in the external environment. Disclosure of these factors can become the basis for improving the state policy for the placement of regional agriculture in order to overcome the socio-economic differentiation of regions.

3. Research Questions

The questions to which this work directly follow from the hypothesis of the research, which is that the effectiveness of agricultural production has a significant impact on the location of an agricultural holding. In accordance with this, in our opinion, it is advisable to consider the following issues:

- to identify the relationship between exogenous factors of the external environment, formed in the regions, and the results of the agricultural sector;
- to assess the impact of the system of natural and climatic factors and factors of socio-economic development of the territory on the productivity of the agricultural sector;
- to substantiate possible directions for improving the location of regional agriculture.

4. Purpose of the Study

The purpose of this study was to identify the strength of the influence of individual climatic and socio-economic factors on the performance of agriculture in the regions of the central federal district of Russia.

5. Research Methods

When conducting the research, the methods of logical and comparative analysis were used as general scientific methods using a review of information and statistical data. The quantitative assessment of the factors that determine the effectiveness of placement was carried out by the method of multivariate correlation analysis based on the calculation of paired correlation coefficients, point correlation and their subsequent interpretation, as well as through regression statistics based on the calculation of regression coefficients, confidence intervals and building a regression model. The statistical significance of the calculated coefficients is checked by finding the critical values of the Student and Fisher, and then comparing them with the table values.

Considering the set of indicators that have the greatest impact on the performance of the agricultural sector, we stopped at three groups of indicators: natural and climatic conditions, security and qualifications of the workforce, transport accessibility.

To assess the natural and climatic background of the regions, we used data on land fertility, the average of the sums of annual temperatures and the amount of precipitation in the regions. When assessing the quality of the land, the soil quality will be used - a quantitative indicator reflecting the real or potential soil fertility. This indicator is based on a point system, where 30-60 points belong to incompletely

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developed soils, 60-80 points - to grey soils, 80-100 points fall on the types of soils that are the most fertile. When identifying the strength of the relationship between the variables, it was decided to take the gross harvest of cereals and legumes for 2019 as an indicator of performance. This is justified by the fact that the amount of harvested grain directly depends on natural and climatic factors, and does not in any way depend on price factors, which greatly simplifies the future analysis of the relationship.

In addition to the natural and climatic aspects that must be taken into account when locating agriculture, we touch upon the issue of labor force availability, which also has a direct impact on the performance of the agricultural sector and the efficiency of doing business in this sector. In this group of factors, we analyze the influence of the availability of skilled and low-skilled workers, the level of remuneration of workers in the agricultural sector of the region on the total agricultural production (TAP).

Transport accessibility is assessed by us in terms of the density of railways and highways (the length of roads per unit area of the region), as well as an assessment of the quality of roads. Quality points are distributed in the range from 1 to 10, where 10 - the condition of the roads in the region is extremely satisfactory. We assess the impact of transport accessibility indicators on the Gross regional product (GRP). The research was carried out according to the data of the Central Federal District (CFD) of Russia.

6. Findings

The territory of the CFD is 650 thousand km^2 or 4% of the territory of the Russian Federation and includes 17 regions, including the Moscow region. The geographic location of the district belongs to the first group in terms of soil quality and general climatic condition. The climate throughout the CFD is moderately continental; the average temperature ranges from -7 to -14 C ° in January and from +16 to +22 C °. The area of agricultural land in the Central Federal District is approximately 2,785 thousand hectares. The largest share of land falls on arable land and accounts for 78% of all land.

The region is the leading district in Russia in terms of population, with a population of 39.3 million people or 27% of the total population of the country. The total length of railways is 16.4 thousand km, motor roads is 22.5 thousand km. The CFD is one of the main producers of agricultural products; its share in the total milk production is 28.4%, meat - 21.0%, 17.2% - grain. Production indicators in the agricultural sector in value terms have a positive trend (Table 01).

Table 1. Dynamics of total agricultural production in the CFD of Russia, million USD

Indicator	2015	2016	2017	2018	2019
Agricultural products	20694	19521	22362	23383	24520
including crop production	10747	10193	10816	11832	12723
livestock products	9947	9328	11546	11550	11797

Source: Authors calculations using data of Rosstat (https://rosstat.gov.ru/)

The total growth for the period since 2015 is 18.5%, including 18.4% in crop production and 18.6% in animal husbandry.

Correlation analysis of grain yield in agriculture by regions showed that the influence of natural and climatic conditions on this indicator is quite significant, the greatest strength is manifested in the relationship between grain harvest and soil bonitet score, the correlation coefficient is 0.953. In the regression model, the coefficient for this variable is also quite large, equal to 1090.52. P value is equal to

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0.00026 and below the predetermined significance level of 95% (a = 0.05). This suggests that this coefficient has an impact on the change in the model.

First of all, this is due to the fact that the assessment of soils is carried out according to a number of significant indicators that have a direct impact on the productivity of crop crops. Especially significant indicators for us, which include the process of assessing the land: soil acidity, humus content, the content of mobile forms of phosphorus, the content of exchangeable potassium. In fact, we should interpret the results of the analysis specifically for these four indicators and interpret the result as the dependence of volumes on them. The characterized dependence of productivity on soil quality is direct, that is, the higher the soil bonitet score, and, in fact, the more rationally the above indicators are distributed in the soil of the region, the greater the volume of agricultural products obtained.

The second most influential indicator is the average air temperature. The correlation coefficient is positive and amounts to 0.854, which suggests that the relationship between productivity and temperature in the regions is moderate. Since the dependence is direct, it can be argued that with an increase in temperature in the region, the volume of products obtained also increases. An example of this conclusion can be the regions located to the south, where the productivity of the agrarian complex is much higher than other regions and, as a rule, belong to the first group in terms of productivity.

The third place in terms of the power of influence on the productivity of the agricultural complex is taken by the indicator of the amount of precipitation in the region per year. The correlation coefficient between the gross harvest of agricultural products and the amount of precipitation is - 0.4464, is negative and confirms the conclusion that excessive precipitation negatively affects the performance of the agrarian complex of the Central Federal District. However, it should be borne in mind that a negative coefficient is obtained only in the central region, where the amount of water resources is sufficient to support the growing season of plants. With a lack of water resources in the regions, the opposite picture is observed. An example of this is a number of southern regions, where water resources are unevenly distributed, and, as a consequence, agriculture in a number of regions will be heavily dependent on rainfall.

Thus, the three-factor linear regression model of the relationship between the total grain harvest and climatic factors in agriculture is as follows:

$$Y = -32908 + 1090X1 + 1928.77X2 - 24.16X3. \quad (1)$$

where: X_1 is the soil bonitet score; X_2 is the average annual temperature sum; X_3 is the average annual rainfall.

The calculated values based on this model can be compared with the actual ones, thereby visually making sure that the model is correct (Figure 01).

In our case, for all three parameters, the coefficient of normalized determination was 0.9, which indicates that with a 90% probability the change in gross harvest is explained by three factors. The standard error is 5874.45 thousand centners. Fisher's calculated coefficient is 46.3, with a critical 3.4. The calculated value is greater than the critical value; therefore, the null hypothesis that the model is statistically significant is accepted. The multiple correlation coefficient is 0.956. The Student's coefficient confirms the significance of the correlation coefficient, since its value is outside the calculated critical value.

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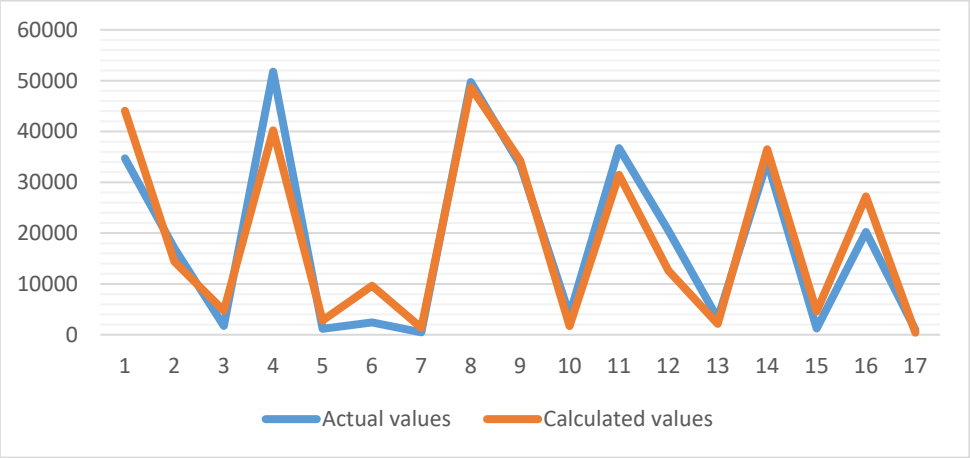

Figure 1. Comparison chart of calculated and actual values of gross grain harvest

Further, the impact of labor force indicators on the performance of the agricultural sector was considered. As a result of the pair wise correlation analysis, the following coefficients of the influence of the labour force parameters on the TAP of the region were obtained: wages – 0.588, the number of skilled workers – 0.942, unskilled workers – 0.932.

There is a strong point correlation between the level of wages and the level of qualifications, which is 0.970. Student's coefficient for paired correlation coefficient is 12.87 with a critical 2.16. Since the calculated value is greater than the tabular value, the hypothesis that the correlation coefficients are not statistically significant is rejected.

All coefficients are positive, therefore, the relationship between the parameters is direct. The highest coefficient is observed in the relationship between the number of unskilled workers and the volume of production. This is explained by the high productivity of skilled labor.

A fairly strong correlation coefficient is observed between the dependence of the volume of production on the number of low-skilled personnel, which is 0.932. Low-skilled work is understood as work that does not require special educational training. These are loaders, personnel for harvesting and sowing crops, cleaners, auxiliary workers and others. To a greater extent, this is justified by the fact that the agricultural sector is characterized by a strong involvement of labor resources not so much at the time of production, as in the subsequent stages of processing the harvested crop and its transportation.

The lowest correlation coefficient is inherent in the relationship between TAP and the level of average wages in the regions. The level of wages is formed under the influence of a large number of factors. In this case, the small correlation is explained by the fact that the level of wages has little effect on the performance of companies.

The regression model built on the basis of factorial parameters took the following form:

$$Y = -109018.05 + 3.585X_1 + 0.463X_2 + 2.71X_3, \quad (2)$$

where: X_1 is the level of wages; X_2 is the number of low-skilled personnel; X_3 is the number of highly qualified personnel.

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Fisher's statistic confirms that the regression model is statistically significant because the significance of F belongs to the interval up to the established significance level of 95%. The correctness of the model is confirmed by a line graph comparing the calculated and actual values (Figure 2).

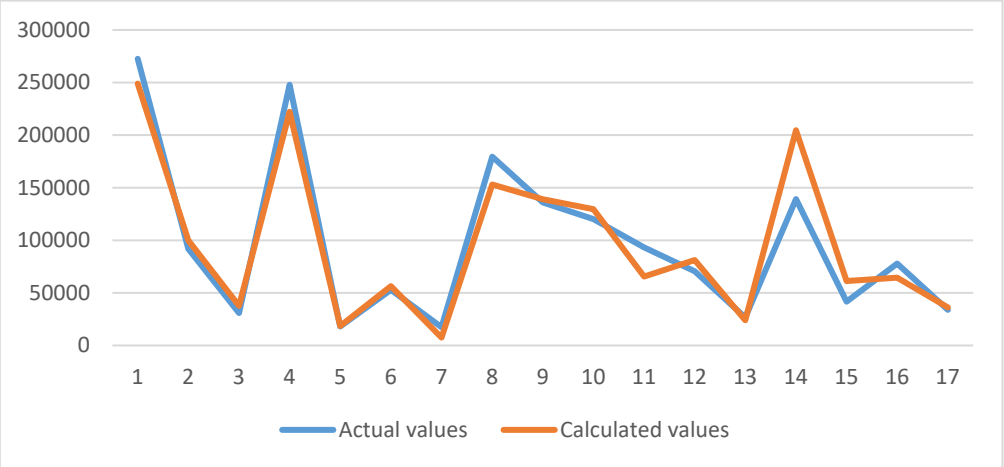

Figure 2. Comparison graph of calculated and actual TAP values

An analysis of the transport accessibility of the location of agriculture, which includes the accessibility of the main highways and an assessment of the quality of roads, shows the following results. The mathematical model of the influence of these parameters on the GRP takes the form:

$$Y = -1805 + 573X_1 + 21.03X_2 + 42.01X_3 \quad (3)$$

where X_1 is the density of railways in the region; X_2 is the density of highways in the region; X_3 is the assessment of the quality of highways.

The multiple correlation coefficient between the GRP of the regions and the factor indicators is 0.74 with a t-calculated 3.66. Since R <0.8, the strength of the relationship between the parameters is moderate rather than high. F-significance is in the range of the established level, therefore we can talk about the significance of the model. Below is a graph of comparison of the actual GRP values of the regions and its calculated values based on the model presented above (Figure 3).

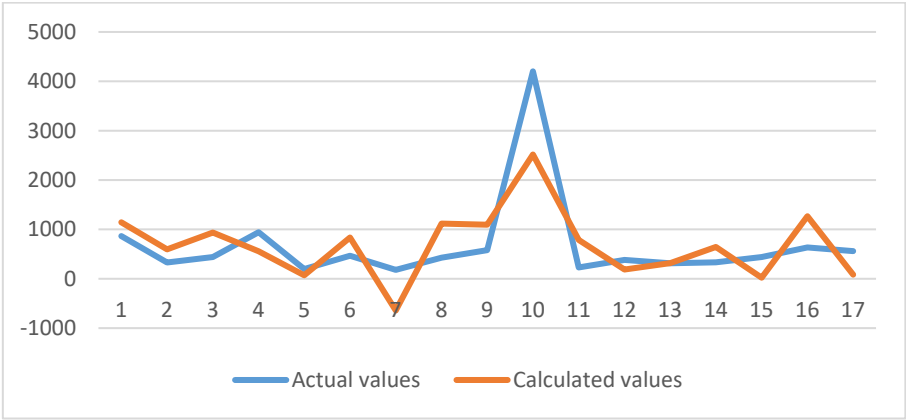

Figure 3. Comparison graph of calculated and actual values of the GRP

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However, the model itself is not of high quality, the coefficient of determination is 0.5. Therefore, the calculated GRP values will greatly differ from the actual ones and, therefore, the use of the model as a tool to predict the trend of the GRP movement in the future, based on the logistic components of the regions, will be accompanied by certain errors.

7. Conclusion

The general conclusion that can be drawn from the analysis of the influence of factors related to the natural group on the volume of harvested agricultural products is as follows. When placing an agricultural complex, the greatest influence on the productive factor is exerted by the quality of the soil and the average temperature in the region. As for the soil, in fact, some of the soils with low fertility can be compensated by resorting to agro chemistry, thereby supplementing the composition of the soil with the necessary elements and increasing the overall quality of the soil. However, in this case, one must understand that the cost of agricultural products will increase significantly due to the fact that the price of finished products will be formed with the inclusion of fertilizer costs. This, in turn, will affect the decrease in external demand for the products of this region and, in the future, will lead to subsequent problems with the sale of the region's products to foreign markets. The situation is the same with the weather conditions in the region, if the agricultural sector is planned to be located in a region with an unfavorable climate; of course, there is an opportunity to resort to technologies or special varieties of seeds.

The level of labour resources is quite low in all regions, and, according to trends, continues to decline. To maintain a sufficient level of labor in the regional market, especially in agriculture, it is necessary, along with the growth of personnel qualifications, to also increase the wages of workers. Basically, the problem with personnel is that it is quite difficult for agricultural enterprises to predict the required number of workers for future seasons, so some of the workers either decrease seasonally or remain unemployed.

As for the rural population, most of the population does not see employment prospects due to low wages. Agricultural wages remain the lowest in the economy. In addition, the modern village is characterized by a contradictory situation: in the presence of unemployment among rural residents, there is an increase in the real shortage of workers - the key mass professions in agriculture.

Since agricultural production implies the presence of perishable products. It is important to take into account the logistics component of the location, which should include a preliminary assessment of the quality of roads, the accessibility of the main highways, the operational length of railways, the average price for transportation in transport companies, the estimated values of the route length, and so on. Thus, when choosing the location of the agricultural sector, it is necessary to take into account the development of not only highways, but also the railway networks of the potential region with other large regions and the main markets for agricultural products.

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