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# Evaluación de los factores que afectan el volumen de la producción agrícola en las regiones de Rusia

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## RESUMEN

El estudio se basó en el desarrollo de las funciones de producción que caracterizan las actividades de las empresas agrícolas en las regiones de Rusia. Se utilizó información estadística oficial sobre 65 regiones de Rusia para 2017 y 2018. La investigación realizada permitió identificar factores (inversiones en activos fijos, salarios de empleados y área de tierra cultivable) que afectan el volumen de producción en el sector agrícola en las regiones de Rusia y sugiere utilizar funciones de producción de tres factores de alta calidad para describir esta influencia. Está comprobado que la economía de las regiones del país no ha llegado a la saturación de productos agrícolas y existen importantes reservas para un mayor desarrollo de este sector. Las funciones de producción desarrolladas son herramientas de gestión efectivas que permiten evaluar el nivel de uso de los recursos financieros y laborales. Los nuevos conocimientos y herramientas adquiridos para evaluar las actividades agrícolas en las regiones rusas son de importancia científica y práctica. Pueden ser utilizados en la investigación del sector agrícola de la economía, el seguimiento de los volúmenes de producción, en la determinación de las necesidades de los recursos necesarios para el desarrollo de la agricultura, fundamentando los planes y programas para su desarrollo.

**Palabras Clave**: Función de producción, agricultura, inversiones en activos fijos, salarios, superficie de tierra cultivable, regiones de Rusia.

# Assessment of factors affecting the volume of agricultural production in the regions of Russia

## ABSTRACT

The study was based on the development of production functions that characterize the activities of agricultural enterprises in the regions of Russia. Official statistical information on 65 regions of Russia for 2017 and 2018 was used. The conducted research made it possible to identify factors (investments in fixed assets, wages of employees and arable land area) that affect the volume of production in the agricultural sector in the regions of Russia and suggest using three -factor production functions of high quality to describe this influence. It is proved that the economy of the country's regions has not reached saturation with agricultural products and there are significant reserves for further development of this sector. The developed production functions are effective management tools that allow assessing the level of use of financial and labor resources. The acquired new knowledge and tools for assessing the activities of agriculture in the Russian regions are of scientific and practical importance. They can be used in research of the agricultural sector of the economy, monitoring of production volumes, in determining the needs for resources necessary for the development of agriculture, substantiating plans and programs for its development.

**Keywords:** Production function, agriculture, investments in fixed assets, wages, arable land area, regions of Russia

## INTRODUCTION

To date, agriculture in Russia has received significant development. Currently, it is among the top four countries that have the largest areas of arable land. According to some estimates, about 9% of the world's farmland is located in Russia (Petrikov, 2020). The solution of managerial tasks in the Russian economy requires an understanding of the factors that affect the volume of agricultural production. In Russia, there is currently an urgent need for accelerated development of agriculture. The efficiency of agricultural production, as one of the directions of increasing the productivity and competitiveness of this branch of the economy, is directly related to the use of resources, with the degree of their involvement in the production process. To a large extent, efficiency depends on the quantitative and qualitative ratio of resources among themselves, on their balance. Determining the cost structure that ensures an increase in output per unit of resource becomes an urgent task of the management system. Therefore, in recent years, one of the most pressing problems is to determine the growth reserves of this sector of the economy in each region of Russia. The justification of these reserves, as well as the resources necessary for the effective functioning of agriculture, can be based on such economic and mathematical models as production functions.

The purpose of our research was to develop economic and mathematical models to assess the impact of indicators characterizing the use of resources on agricultural production in the regions of Russia. Our study responds to the calls for taking into account the regional characteristics of agricultural production, formulated in publications (Margono and Sharma, 2004; Zhang Dengjun et al. 2017).

Our article makes a certain contribution to the knowledge about the regional peculiarities of the development of agriculture in Russia. The theoretical contribution is related to the methodology proposed by the authors, which makes it possible to assess the dependence of agricultural production volumes on factors such as investments in fixed assets, wages of employees and arable land area based on the development of economic and mathematical models representing production functions. Based on empirical data in the course of the study, new knowledge was obtained about the impact of each factor on the volume of agriculture production. In addition, regions were identified in which high and low values of resource efficiency were noted.

**Literature review**

Scientific research conducted in the twenty-first century has shown the possibility of applying production functions in the economic analysis of the activities of enterprises and entrepreneurs that operate in the agricultural sector. Production functions are economic and mathematical models of production processes and quantitatively express a stable natural relationship between factors describing capital and labor costs and an indicator characterizing the volume of agricultural production (Parlinska and Dareev, 2011; Ahmetov et al. 2019; Petrick and Kloss, 2018).

Most scientific publications considered data for a number of years (the so-called time series). For example, in the article (Ghoshal and Goswami, 2017), according to the agricultural sector of India, the efficiency of farms was evaluated using the Cobb-Douglas production function. When constructing this function, data for the period from 2005 to 2014 were analyzed. Modeling of agricultural production in China was described in the article (Binghun and Zhou, 2021). While data were analyzed in 12 prefectures during the period from 2009 to 2019. In contrast to the above articles, the study (Kea et al. 2016) developed models using spatial data for 25 provinces of Cambodia. Four models were built corresponding to the information for each of the four years from 2012 to 2015.

Capital and labor costs were used as factors influencing agricultural production volumes in most previously performed scientific studies (Czyzewski and Majchrzak, 2017; Prager et al. 2015; Nowak et al. 2015; Rezitis and Kalantzi, 2016). Such factor as the area of arable land was used as a factor of the production function in publications (Ahmetov et al. 2019; Petrick and Kloss, 2018; Zhang Dengjun et al. 2017).

A certain place in scientific publications on the problem of the development of production functions of the agricultural sector is occupied by studies in Russia and its regions. Table 1 shows an analysis of the agricultural sector's production volumes using examples from Russian studies.

**Table 1.** Characteristics of Russian studies

| Authors | Factor of capital | Factor of labor | Research object |
|---|---|---|---|
| 1 | 2 | 3 | 4 |
| Shestakov and Yakovlev (2020) | capital expenditures | labor costs | agricultural production volumes for 2005-2018 in Russia as a whole |
| Tolmachev (2011) | indices of the physical volume of fixed assets | index of total working time expenditures | indices of the physical volume of agricultural products in Russia for 1996-2008 |
| Potapov (2020) | costs of mechanical engineering products, fuel and energy resources, chemical products | - | gross agricultural output in Russia in 2011-2015 |
| Naumov (2017) | fixed capital | number of employees | production volumes in agriculture in the Chelyabinsk region for 2005-2015 |
| Kutenkov (2020) | cost of fixed assets | number of people employed in agriculture per 100 hectares of acreage | three groups of regions of Russia, data for 2017 |
| Zyukin and Zhilin (2014) | production funds | value of labor costs | volume of production of the agricultural complement of the Kursk region for 2000 - 2011 |
| Zhilyaskova (2008) | fixed assets | number of employees | agricultural production volumes in the Rostov region for the period 2004-2006 |
| Germanova and Rudaya (2017) | fixed assets | number of employed workers | Production volumes in agriculture of the Krasnodar Territory for 2000-2014 |

Source: Compiled by the authors.

The data in table 1 show that in most cases the objects of research are agricultural sectors in specific regions (five cases). The other three publications discuss production functions for Russia as a whole. The initial data in seven studies were time series, only one publication used spatial data for one year. In most studies (seven cases), the number of employees was used as labor costs. In two publications, the values of working time costs were considered. Data on fixed assets of agricultural enterprises were used as capital factors in six publications. In two cases, the costs of production assets were considered, and in one case, the costs of purchasing products from the machine-tool, fuel and chemical sectors. In addition, in one of the articles (Zhilyaskova, 2008), the area of arable land was used as a factor of the production function. It should be noted that previous Russian scientific publications did not pay sufficient attention to the comparative analysis of regional features of agricultural production in Russia.

## MATERIALS AND METHODS

Agricultural complexes located in the regions of Russia were considered as the object of the study. The use of initial data for several years (time series) is complicated by the fact that inflationary processes that have taken place should be taken into account. In addition, it is necessary to proceed from the assumption that the conditions of functioning of the object under consideration for a certain period of time will be identical or, at least, undergo few changes, which in practice is not always fulfilled. Time series are often limited in length, especially since due to crisis phenomena in the economy, the dynamics of changes in indicators experiences significant fluctuations. The influence of these trends is especially great when evaluating functions in which there are restrictions on the sum of exponents with factors, i.e. with a constant return on scale. When using the values of fixed assets as a factor describing capital expenditures, the main problem is the reliability of information regarding the share of fixed assets actually used in production processes of the economic system under consideration. The assumption of the full use of fixed assets does not always correspond to their actual utilization. The situation is similar with the second factor. The number of people directly employed in production processes does not always coincide with the actual labor costs, since workers are often not employed all day. This leads to erroneous indicators when assessing labor factors.

The number of factors, in accordance with the recommendation of Granberg (1988), should

be small, since in this case the necessary calculations and interpretation of the results are simplified. Taking into account the analysis, we consider investments in fixed assets, wages of employees and arable land area as factors of production functions. Correlation analysis has shown that these factors have the greatest impact on the volume of agricultural production in the regions. At the same time, there is no mutual connection (collinearity) between them. It should be noted that the flow of investments provides more acceptable results compared to such a factor as fixed assets. This conclusion was made in the works of Bessonov and Tsukhlo (2002), Gavrilenkov (2000) based on the incomplete use of fixed assets in agricultural production. Wages of workers employed in agriculture is a complex indicator that takes into account not only labor costs for production, but also the characteristics of a particular region (price level, employment and other socio-economic aspects).

In our study, spatial data were used to characterize the factors under consideration and the resulting indicators for agricultural sectors in the regions of Russia. It should be noted that spatial data allows you to get away from the problems that are characteristic of time series. The advantages of using spatial data in the evaluation of production functions are described in detail in the work (Charoenrat and Harvie, 2013).

Our study included the following stages:

1. Collection and processing of initial statistical data. Formation of arrays of information based on data characterizing the activities of enterprises and entrepreneurs in the agricultural sector of 65 regions of Russia. These arrays describe the values of production volumes, investments in fixed assets, wages of employees and arable land area.

2. Linearization of the data obtained at the first stage, which characterize the independent factors and resulting variables for agricultural production in the regions.

3. Development of production functions using the least squares method.

4. Evaluation of the quality of functions using correlation and determination coefficients, Fisher-Snedekor and Student tests, as well as the corresponding significance levels.

5. Checking the developed functions for the presence of autocorrelation, heteroscedasticity and multicollinearity, as well as determining whether the distributions

of residuals for each of the regressions are functions of the normal distribution.

6. Consideration of theoretical and practical results arising from the analysis of the developed production functions and the possibilities of their use.

The study used data from the Federal State Statistics Service on agricultural Activity in the regions of Russia for 2017 and 2018 (Federal State Statistics Service, 2021). The work is based on information on 65 regions of Russia in which agricultural production has received the greatest development. In our study, three hypotheses were tested:

- the first hypothesis is that production functions can be used to model the production volumes of the agricultural sector in the regions;

- the second hypothesis is that production functions demonstrate the presence of stable dependence of agricultural production volumes on factors such as investments in fixed assets, wages of employees and arable land area;

- the third hypothesis is that investments in fixed assets have a less impact on production volumes than wages and arable land area.

In the course of the study, two production functions were developed, reflecting the dependence of agricultural production volumes on investments in fixed assets, wages of employees and arable land area by regions of Russia. The functions constructed by the authors have a specification similar to the well-known Cobb-Douglas functions. The parameters of production functions were determined using the regression analysis methodology (Pindyck and Rubinfeld, 2013). The first function describes the activity of sets of all enterprises and entrepreneurs that are located in each of the 65 regions under consideration for 2017, and the second function - according to data for 2018.

## RESULTS

In the course of the computational experiment, two production functions were developed that reflect the dependence of agricultural production volumes on investments in fixed assets, wages of employees, arable land area in Russian regions. The formulas and tables given in the article are developed by the author.

The first production function reflects the dependence of the production volume agricultural industry in 2017:

$$y_1(x_1, x_2, x_3) = 2.893 \times x_1^{0.140} \times x_2^{0.247} \times x_3^{0.368}, \quad (1)$$

$y_1$ - the turnover of all enterprises and entrepreneurs in the agriculture sector located in a certain region of Russia per year, billion rubles;

$x_1$ - the investments in fixed assets of all regional enterprises and entrepreneurs in the agriculture sector per year, billion rubles;

$x_2$ - agricultural industry employees' wages in the region per year, billion rubles;

$x_3$ - arable land area in the region per year, thousand hectares.

The second production function reflects the dependence of the production volume agricultural industry in 2018:

$$y_2(x_4, x_5, x_6) = 3.320 \times x_3^{0.152} \times x_4^{0.268} \times x_6^{0.334}, \quad (2)$$

$y_2$ - the turnover of all enterprises and entrepreneurs in the agriculture sector located in a certain region of Russia per year, billion rubles;

$x_4$ - the investments in fixed assets of all regional enterprises and entrepreneurs in the agriculture sector per year, billion rubles;

$x_5$ - agricultural industry employees' wages in the region per year, billion rubles;

$x_6$ - arable land area in the region per year, thousand hectares.

Table 2 shows the analysis of the function's quality. It presents the calculated values of the correlation and determination coefficients, Fisher-Snedecor and Student's tests (column 2), as well as the significance of the Fisher-Snedecor test and p-values for Student's test (column 3).

The correlation coefficients more 0.9 and close to 1 in both functions. Regression models are known to be of high quality when the coefficient of determination more than 0.8; for both functions this requirement is met. The coefficient of determination characterizes the proportion of dispersion, which is caused by the influence of the considered factors. The difference between 1 and this coefficient describes the influence of factors that are not included in the regression equation. Thus, the effect of variables not included in the functions under consideration is less than 9 percent. The calculated statistic

values (181 and 163) are higher than the table value of the Fisher-Snedecor test, which is 3.98 at a significance level of 0.05. For three functions, all calculated Student test values for the coefficient and the exponents are in the range from 3.25 to 8.04; in absolute value they exceed the table amount, which is 1.99 at a significance level of 0.05.

Results presented in Table 2 allow us to conclude that there is a high quality correlation between the resulting values and the three factors of the functions (1) and (2). All levels of significance given in column 3 of Table 2 have values less than 0.01. Therefore, the coefficients of the developed functions and the degree values in these functions are statistically significant with the precision of 99 percent. Functions (1) and (2) were checked using the Durbin-Watson test, which showed the absence of autocorrelation; the Breusch–Pagan test indicated the absence of heteroscedasticity. Collinearity does not exist, which is proved by the criterion of the inflation dispersion factors (VIF).

**Table 2.** Values of calculated statistics.

| Characteristics | Calculated Values | | Significance Level |
|---|---|---|---|
| | Function (1) | Function (2) | |
| 1 | 2 | 3 | 4 |
| Determination coefficient | 0.899 | 0.889 | - |
| Correlation coefficient | 0.948 | 0.943 | - |
| Standard error | 0.282 | 0.295 | - |
| Calculated value of the Fisher-Snedecor test | 180.749 | 162.658 | less than 0.01 |
| Calculated value of the Student's test for y-intersection | 4.153 | 4.443 | less than 0.01 |
| Calculated value of the Student's test for $X_1$ and $X_4$ | 3.253 | 3.381 | less than 0.01 |
| Calculated value of the Student's test for $X_2$ and $X_5$ | 4.093 | 4.133 | less than 0.01 |
| Calculated value of the Student's test for $X_3$ and $X_6$ | 8.034 | 6.829 | less than 0.01 |

In the process of the source data approximation using the least squares method, residues are obtained, showing deviations of the calculated values from the source data. Checking the distribution of these residues by production functions is carried out based on the histograms assessment, normal distribution functions and tests of normality for these functions. Residue histogram charts are characterized by the maximum heights of the constructed rectangles in the middle of the histogram and the minimum heights of the rectangles located on the right and left sides of the histogram (so-called "tails"). Histograms are symmetric in relation to the middle. They demonstrate that residues are concentrated around zero. The same conclusion can be made after conducting the analysis of the density functions of the normal distribution (3) and (4), which have average values close to zero.

The distribution function of residuals corresponding to the production function (1) is shown below:

$$y_3(x_7) = \frac{4.875}{0.079 \cdot \sqrt{2\pi}} \cdot e^{\frac{-(x_7 - 0.002)^2}{2 \times 0.079 \times 0.079}}. \quad (3)$$

The test shows the high quality of the function (3) and confirms the normality of the distribution described by this function. These conclusions are made after a check using three tests:

- the calculated value of 0.95 according to the Shapiro-Wilk test is greater than the tabular one - 0.93;
- the calculated value of 4.39 for the Pearson test is less than the tabular one - 9.49;
- the calculated value of 0.08 by Kolmogorov-Smirnov test is less than the tabular one - 0.15.

The distribution function of residuals corresponding to the production function (2) is shown below:

$$y_4(x_8) = \frac{5.107}{0.081 \cdot \sqrt{2\pi}} \cdot e^{\frac{-(x_8 - 0.003)^2}{2 \times 0.081 \times 0.081}}. \quad (4)$$

The test shows the high quality of the function (4) and confirms the normal distribution, described by this function. These conclusions are made after a check using three tests:

- the calculated value of 0.97 according to the Shapiro-Wilk test is greater than the tabular one - 0.93;
- the calculated value of 1.32 in the Pearson test is less than the tabular one - 9.49;
- the estimated value of 0.07 by Kolmogorov-Smirnov test is less than the tabular one - 0.15.

The data obtained allow us to make a general conclusion that the developed functions (1) and (2) fully meet the econometric requirements and, therefore, can be used to describe the dependencies of agricultural production volumes in the regions on

investments in fixed assets and workers' wages. Consequently, the first hypothesis was confirmed.

## DISCUSSION

The developed production functions (1)-(2) prove the influence of investments in fixed assets, wages of employees and arable land area on the volume of production of enterprises and entrepreneurs belonging to the agricultural sector of the economy of the regions of Russia. It should be noted that in both functions there are small differences in the values of both coefficients and degrees. Thus, it can be concluded that the developed functions show the existence of established stable dependencies of agricultural production volumes in the regions on the factors under consideration for the period from 2017 to 2018. Thus, the second hypothesis was confirmed.

The values of degrees for three factors in the functions are positive, therefore it can be stated that the stimulation of agricultural production in the regions can be provided by an increase in the wages of employees, investments in fixed assets and arable land area. Thus, third hypothesis was confirmed. The production functions for all the considered values of the factors do not reach their maximum. This is confirmed by the fact that the values of the maximum return on three factors for all functions are positive on the considered ranges of changes in the values of the factors. Thus, it can be concluded that the economy of the Russian regions has not reached saturation with agricultural products. In all regions there are significant reserves for the further development in this sector of the economy, including on the basis of increasing the number of enterprises and the number of employees in them, as well as increasing the volume of arable land.

Factors of wages of employees and arable land in both production functions affect turnover to a greater extent than the factor of investments in fixed assets. This follows from comparing the values of the degrees, in the first function 0.282 and 0.336 are greater than 0.155, and in the second function 0.268 and 0.334 are greater than 0.152. Therefore, the third hypothesis has been confirmed. A comparison of the returns on scale according to data for 2017 and 2018 shows that the values of this indicator (equal to the sum of the values of the degrees in the functions) are almost the same and amount to 0.755 (function 1) and 0.754 (function 2). This suggests that with a simultaneous increase in three factors, the growth in agricultural production over the years under review was

almost the same. The return on scale in agriculture over the years under review was less than 1. This is due to the relatively small number of people employed in every agricultural enterprise, which leads to a combination of the functions performed. According to the authors of the study (International Labor Conference, 2015), this leads to a relatively low level of personnel training, a decrease in labor productivity and, as a result, low resource efficiency in such enterprises. To increase agricultural production in the Russian regions, it is advisable to ensure the simultaneous growth of three factors, that is, investments in fixed assets, wages of emploeers and arable land area. The most important thing is the full use of all reserves for increasing arable land in the regions. It should be noted that for regions with an excess of able-bodied population in rural areas, the main direction of agricultural production development is associated with attracting new workers, including the creation of family businesses. In regions where there are not enough potential workers, the main direction of increasing agricultural production is associated with investments in fixed assets. The cross-derivatives of the production functions for each of the three factors are positive for all values of the range of changing factors, so increasing one factor improves the conditions for using other factors. The second derivatives of all isoquants are positive. The level of convexity decreases with an increase in the volume of production, which indicates an increase in the elasticity of replacement factors: with the growth of agricultural production, the possibility of replacing one factor with other factors increases.

The use of production functions is possible when solving such an important task as ranking regions by resource efficiency, namely investments in fixed assets and wages of employees. In addition, production functions can be used to compare the actual volume of production of agricultural sector enterprises in the region and the amount of agricultural production in the same region, projected on the basis of the production function. In our opinion, a relatively large positive value of this value (that is, the excess of the actual turnover over the estimated one) indicates a good use of available resources in the region. And accordingly, a large negative value of this value allows us to conclude that there are problems with the functioning of enterprises specialized in agriculture in the relevant region.

A comparative analysis of the actual values of production volumes and the data predicted on the basis of the production function (1) showed a high level of resource efficiency in 2017 in the following regions: Voronezh region (6.3%), Chelyabinsk region (6.7%), Rostov region (7.9%), republic of Tatarstan (9.2%), Krasnodar territory (10.5%), Leningrad region (11.8%), Belgorod region (12.3), republic of Tyva (12.8%), republic of Kalmykia (15.9), Karachay-Cherkess republic (20.1%), republic of Sakha (33.3%). The deviations of the actual values from the predicted values are indicated in parentheses. The low level of use of the considered factors of production was in such regions as Vologda region (-13.3%), Kirov region (-12.1%), Smolensk region (-11.9%), Khabarovsk territory (-9.5%), Tver region (-9.5%), Perm territory (-8.5%), Ivanovo region (-8.5%), Tomsk region (-7.7%), Krasnoyarsk Territory (-7.1%), Kostroma region (-6.8%), Penza region (-6.8%).

A comparative analysis of the actual values of production volumes and the data predicted on the basis of the production function (2) showed a high level of resource efficiency in 2018 in the following regions: Kursk region (6.7%), Novgorod region (6.9%), republic of Tatarstan (8.7%), republic of Tyva (9.5%), Krasnodar Territory (10.4%), Leningrad region (10.8%), Republic of Kalmykia (12.8%), Belgorod region (14.5%), republic of Ingushetia (19.2%), Karachay-Cherkess republic (24.0%), republic of Sakha (27.9%). The low level of use of the considered factors of production was in such regions as Vologda region (-13.5%), Smolensk region (-13.4%), Kirov region (-12.5%), Primorsky territory (-10.4%), Kostroma region (-8.6%), Novosibirsk region (-8.1%), Khabarovsk territory (-7.6%), Perm territory (-7.0%), Amur region (-6.9%), Penza region (-6.6%), Republic of Crimea (-6.1%). The above lists showed that most of the regions in 2018 retained their characteristics shown in 2017.

## CONCLUSION

The conducted research has a certain scientific and practical significance. The scientific significance of the study is as follows:

- methodological aspects of the evaluation of functions describing the volumes of agricultural production in the regions of Russia are considered. It is proposed to use investments in fixed assets as a capital factor and employees' wages as a labor factor. In addition, as a third factor, it seems appropriate to consider the area of arable land. At the same

time, spatial data (by regions) is used for one year;

- in the course of the research, two three-factor production functions similar to the Cobb-Douglas functions were developed. These functions describe the dependence of production volumes in the agricultural sectors of each of the regions on the factors under consideration. Using a number of tests, the high quality of both developed production functions and their good approximation of the empirical data were confirmed;

- production functions have proved that there are significant reserves for the further development of agricultural sectors of the economy in all discussing Russian regions;

- an increase in one of the factors of the production function improves the conditions for using other factors. With the growth of agricultural production in the regions, the possibility of replacing one factor with another factors;

- using the production functions, the regions of the country with high and low levels of efficiency in the use of available resources were identified.

The developed production functions are effective management tools that allow assessing the level of use of financial, labor and land resources in agriculture in specific regions of Russia. The results of the work can be in demand in the current activities of state, municipal and public organizations related to the regulation and support of agriculture, including when adjusting their actions based on scientific data.

The practical significance of the work lies in the possibility of using the results obtained to justify resources and monitor the level of efficiency of agriculture. The results of the study can be used by state and regional authorities to monitor the effectiveness of investments in fixed assets and wages, i.e. to assess how well these resources are used. In addition, the functions allow you to identify an imbalance in the values of factors for each of the regions. The functions can be used in the justification of programs to increase investments in fixed assets and wages, the formation of plans and programs for the further development of agriculture.

There were limitations in the research process, since 65 regions of Russia were considered in which agricultural production has received significant development. At the same time, data on 17 regions of Russia in which the agricultural sector has not received significant

development were not taken into account when constructing production functions. Further research may be related to the development of similar functions in the years following the publication of the relevant official statistics.

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