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***Research paper***

# Prospects of Development of Agricultural Branches of the Regions of the Russian Federation: Correlation Models and Effectiveness of Management

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**Abstract**

Currently, Russia faces an urgent need for accelerated development of agricultural branches and rural infrastructure. The solution of the tasks of agricultural management is one of the most urgent problems of determining the reserves of growth of agricultural production in each of the Russian regions. In this regard, the authors set a goal to develop and evaluate correlation models describing the dependence of the volume of production of agricultural branches in the regions of the Russian Federation on the number of investments and the commissioning of fixed assets. The authors justify the choice of independent factors. The study was based on the economic and mathematical modeling of empirical spatial data, calculated on the basis of official statistical information on the regions of the Russian Federation. The conducted research permitted to identify factors, which directly determined the volumes of production in agriculture, to propose the use of high-quality correlation models to describe this effect, to prove that the economies of the examined regions did not reach saturation with agricultural products and there were significant reserves for their further development. The developed correlation models are effective tools for analyzing the development of the industry, and can also be used as management tools that allow for the assessment of the effectiveness of the use of the made investments, as well as the commissioning of fixed assets in the agriculture of each of the examined regions. The results of the research are of scientific and practical importance. They can be used in research and monitoring of agricultural development in the regions, determining the resource requirements, which are necessary for the development of agricultural industries, as well as the development of sectoral and integrated projects and agricultural development programs.

***Keywords***: *Correlation Model, Agriculture, Investment, Fixed Assets, Independent Factor, Resulting Indicator.*

## 1. Introduction

In modern conditions, taking into account the crisis and post-crisis development of the Russian Federation, the effects of economic sanctions, the distinctive characteristics of the development of agriculture in the regions, the formation of additional competitive opportunities in a number of sectors of the agricultural sphere are one of the urgent tasks for researchers, including the problems of the progressive development of agricultural markets and increasing the competitiveness of agricultural products, produced by the agricultural branches in the regions, which corresponds to the general trend in the development of the national economy [1]. In this connection, the issues of the influence of certain internal and external factors on the development of agriculture are also becoming topical.

Thus, in particular, one can note the study of certain aspects of increasing the competitiveness of products and agricultural enterprises in the works by Burobkin *et al*. [2], Uzun [3], Kurtsev [4] and others. In these works, the emphasis is placed on sustainable development, both for individual households and for the industry as a whole, which corresponds to the current vector of agricultural development in the Russian Federation.

In the studies by Borovskikh [5], Eldieva [6], Yurkova [7], Kulinin [8], Kendyukh [9], Golovin [10], Buzdalov [11], Barsukova [12] and other authors, key issues of competitiveness of agriculture in certain regions are revealed. In particular, key approaches and concepts of the development of competition in agricultural regions are examined, and the conditions, opportunities, and forms of competition in the regions of the Russian Federation are explored.

A separate point should be made about the statistical study of the factors that somehow influence the development of production processes in the agricultural branches. The application of economic and mathematical modeling of individual production processes makes it possible to quantitatively express various kinds of relationships between the factors that reflect costs, and the indicator characterizing the volume of production in the industry [13-15].

For example, Nosov and Aznabaeva studied the influence of certain factors on the number of people employed in the GDP of the BRICS countries [16]. Pshenichnikova and Romanyuk [17], Afanasev and Ponomareva [18] and Antipov [19] investigated the dependence of the GDP on the gross capital formation, the commissioning of fixed assets and the number of employees. The works that establish similar dependencies in the regions of the Russian Federation belong to Sokol *et al*. [20], Adamadziev and Khalilov [21], Sadovin and Kokotkina [22], Gafarova [23] and Baranov [24].

Separately, the studies should be mentioned, devoted to the analysis of external factors on the development of agricultural industries, in particular, the economic crisis, the WTO factor, etc. [25-26]. In addition, the processes of development of agricultural processes in foreign countries have been extensively studied [27-29].

In the majority of the above-mentioned works, the main funds of enterprises and organizations, the flows of investment in fixed assets and gross accumulation are considered as determining internal factors, and the number of employees engaged in the production processes under consideration and labor costs are used. In addition, most studies use time series or spatial data for a certain period.

Thus, the evaluation of production functions is related, as shown by the analysis of the above works, to a number of problems. The use of the method of constructing time series over a long period does not allow taking into account the crisis phenomena in the branches, as well as other external factors that are essential for a branch. The use of spatial data, in its turn, does not take into account regional and territorial features. In addition, the choice of a factor is also associated with a number of limitations. Thus, in particular, the reliability of information on the commissioning of fixed assets used in this or that branch is a problem. The assumption of the full use of fixed assets does not reflect the actual situation. The presence of such lacunae leads to errors in the assessment of the examined factors. However, almost all studies based on official statistics have such drawbacks.

In this paper, the authors attempted to analyze the influence of a number of factors on production volumes in the agriculture of the regions of the Russian Federation to develop practical recommendations for adjusting regional policy in this direction.

It is considered worthwhile to substantiate the choice of the analyzed factors. The whole set of factors affecting productivity in agricultural branches can be divided into two groups (Table 1).

**Table 1:** Factors affecting the productivity of agriculture in the regions

| Internal factors | |
|---|---|
| State support system | State programs, subsidy system, etc. |
| Fiscal regime | Availability of tax credits |
| Environmental conditions | Soil quality, duration of the frost-free period; the frequency of unfavorable meteorological conditions, the level of water supply; other features of the terrain, etc. |
| Use of innovations | Automation, chemicals, etc. |
| Qualification level of the staff | Availability of a sufficient number of specialists |
| Dynamics of commissioning of fixed assets | Forest range, livestock, existing buildings, premises, transport and other types of fixed assets |
| Investments | Number of all types of investments |
| Infrastructure development | Availability of transport routes, communications, etc. |
| Presence of processing industries | The presence of an enterprise for processing agricultural products in the territory |
| **External factors** | |
| Competitive market | The presence of foreign products on the market |
| Economic crisis | Fluctuations of inflation, a decrease in demand, an increase in purchasing prices, etc. |
| Scientific and technical progress | Creation of advanced production technologies |

The influence of environmental factors and the level of state support on the development of agriculture are undeniable and proven in a number of studies [5-6]. The influence of external factors has also been studied in a number of papers [7-8]. A great contribution to the study of individual agricultural branches in various countries of the world was made by the following authors: Kim and Arnhold, Aydın and Aktürk, Wagena et al., Yamashita and Hoshino, Ramos et al. [30-34]. The authors also considered it expedient to determine the degree of influence on the productivity of agriculture of such factors as the use of innovations, investments and commissioning of fixed assets with the aim of possible adjustment of the existing regional policy, since such estimations were practically not conducted. The study of these factors can have a significant impact on the resulting indicator by means of state regulation of these processes.

## 2. Methods

The authors set a goal to determine the dependence of the volume of the production in the agricultural branches of the Russian regions on a number of factors: the use of innovations, the number of investments, the commissioning of fixed assets of agriculture using methods of correlation regression modeling.

The whole aggregate of agricultural branches in the regions of the Russian Federation is the object of research.

Guided by the general principles of statistical research, the volume of products produced by agricultural branches will be characterized by a total turnover, including the value of produced goods, performed works and services, as well as profits from the sale of goods not of own production.

The number of factors, according to the recommendation of Granberg [35], should not be large, since, thus, the necessary calculations and the economic interpretation of the obtained results are simplified. Given the conducted analysis, the authors selected the following as factors: the use of innovations, the number of investments and the commissioning of fixed assets of agriculture, which include transport, buildings and premises, forest range, livestock and other types of fixed assets. At the same time, it should be emphasized that the estimation of fixed assets does not include objects in the unfinished construction stage. Correlation analysis showed that the use of innovations is not interrelated with the volume of production in the agricultural branches, and the obtained model is not statistically significant. At the same time, the other two factors have a significant effect on the resulting indicator (the volume of the production in agricultural branches). Moreover, there is no mutual connection (collinearity) between them, which is proved later in the paper. It should be noted that in other sectors of the economy (for example, in the industry), investments also have significant impact on the volume of production. Such a conclusion was made in the papers by Bessonov and Tsukhlo [13] and Gavrilenkov [36].

The conducted study included several stages (Figure 1):

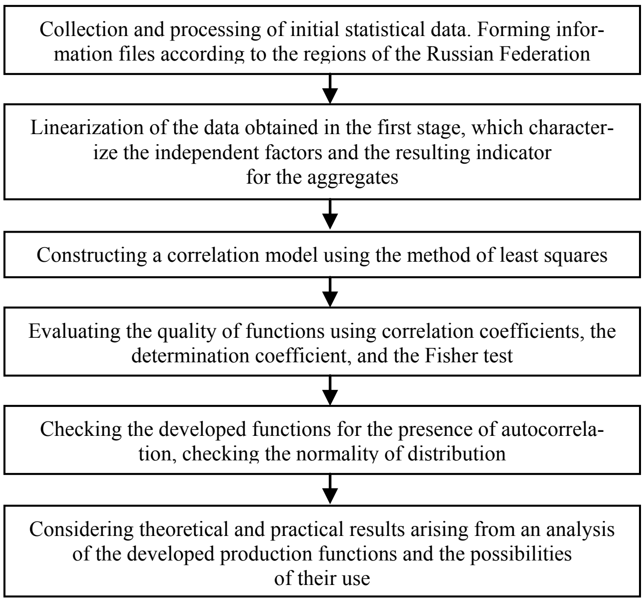


**Fig. 2:** Methods of research

The study used official statistics of the Federal State Statistics Service on the results of agricultural development in the regions of the Russian Federation.

The chosen methodology allows quantifying the characteristics of the development of agricultural branches in the regions, which gives an opportunity and at the same time justifies the need for strategic decisions at the municipal and regional level, taking into account specific factors.

## 3. Results[1]

Based on the analysis of the examined statistical data, the authors have hypothesized that the relationship between all possible values of independent factors and the resulting indicator is linear.
As a result of calculating the regression parameters, the authors obtain regression equations for two factors: 1) the application of innovations – the connection is not detected, and the resulting model is not statistically significant; 2) the number of investments y = 0.4673 x + 37,821.3588, commissioning of fixed assets y = 6.0693 x + 47,280.4359.
It is suggested to consider in more detail the dependence of the production volume of agricultural branches on the amount of investments.
The authors calculate the correlation coefficient for the first dependence:
*Covariance*.

$$\operatorname{cov}(x,y)=\overline{(x\cdot y)}-\overline{x}\cdot\overline{y}=14{,}523{,}636{,}843.121-$$
$$-114{,}161.071\cdot 91{,}171.5=4{,}115{,}400{,}719.37$$

Then the selective linear correlation coefficient is calculated:

$$r_{x,y}=b\cdot\frac{S(x)}{S(y)}=0.467\frac{93{,}842.008}{56{,}689.06}=0.774.$$

In this case, the relationship between the feature Y and the factor X in accordance with the Chaddock scale is high and direct.
It is advisable to evaluate the significance of the correlation coefficient.
For this purpose, the value of a random error is calculated, according to the Student's table; the critical point will be found by the initial level of significance and the number of degrees of freedom:

$$t_{nabl}=0.774\frac{\sqrt{12}}{\sqrt{1-0.774^2}}=4.229$$
$$t_{nabl}=r_{x,y}\frac{\sqrt{n-2}}{1-r_{x,y}^2}.$$

According to the Student's table at a significance level α=0.05 and degrees of freedom $k$ = 12, the authors calculate $t_{crit}$ ($n-m-1$; $\alpha/2$) = (12; 0.025) = 2.179. Consequently, the correlation coefficient is statistically significant.
The authors perform an analysis of variance to assess the quality of the obtained model using the variance decomposition theorem. The general variance of the feature under consideration can be decomposed into the regressions of variance, explained and unexplained by the equation.
The variance of the dependent variable will be analyzed (Table 2):

**Table 2:** The data of the analysis of variance of the dependent variable

| Variant object | Result of the sum of squares | Number of degrees of freedom | Estimate of variance by 1 degree of freedom | Estimate of the F-criterion |
|---|---|---|---|---|
| Model (explained) | 26,925,123,594.999 | 1 | 26,925,123,594.999 | 17.88 |
| Residual | 18,065,970,284.5 | 12 | 1,505,497,523.71 | 1 |
| Total | 44,991,093,879.5 | 14-1 | | |

[1] Calculations were based on official data of the Federal State Statistics Service.

The quality indicators of the regression equation are calculated (Table 3).

**Table 3:** Indicators of quality of the obtained regression equation

| Indicator | Value |
|---|---|
| Value of the determination coefficient | 0.5985 |
| Value of the average coefficient of elasticity | 0.585 |
| Mean error of approximation | 36.07 |

It should be concluded that the dependence of the volume of output production in the agricultural branches on the number of investments has been studied. At the initial stage of the study, a linear pair regression was chosen. Using the method of least squares, an estimate of its parameters was obtained. In addition, the statistical significance of the equation was checked with the help of the determination coefficient and the Fisher criterion. As a result, the data was received that in the investigated situation, 59.85% of the total variability in production volumes in the agricultural branches is due to a change in investment volumes. In addition, it is proved that the parameters of the obtained model are statistically significant. Economically interpreting the results of the study, it can be stated that an increase in investment in the industry by one unit of measurement leads to an increase in production volumes by an average of 0.467 units of measurement. The calculated estimates of the regression equation can be used in forecasting. At $x$ = 0.05, Y will be in the range from –53,908.52 to 129,551.28 units of measurement and with a probability of 95% will not go beyond these limits.
Furthermore, an analysis will be performed aimed at detecting autocorrelation.
The coefficient of autocorrelation will be estimated and its significance will be checked using the standard error criterion:

$$S_{eY}=\frac{1}{\sqrt{14}}=0.267$$
$$r_1\approx\frac{\sum\varepsilon_i\varepsilon_{i-1}}{\sum\varepsilon_i^2}=\frac{-1{,}598{,}745{,}608.121}{18{,}065{,}970{,}284.502}=-0.0885.$$

Given that $-0.582 < r_1 = -0.0885 < 0.582$, then the independence property of the residues is satisfied. Autocorrelation is absent.
Further, the normality of the distribution of the residual component will be checked. The calculated value of the RS test amounts to:

$$RS=\frac{\varepsilon_{\max}-\varepsilon_{\min}}{S_\varepsilon}.$$

where $\varepsilon_{\max}$ = 71,422.0331 is the the maximum amount of residues, $\varepsilon_{\min}$ = –80,358.5502 is the the minimum level of some residues.
$S_\varepsilon$ is mean-square deviation. Unbiased estimate of mean-square deviation.

$$S_e=\sqrt{\frac{\sum e^2}{n-1}}=\sqrt{\frac{18{,}065{,}970{,}284.502}{14-1}}=37{,}278.456$$
$$RS=\frac{71{,}422.033-(-80{,}358.55)}{37{,}278.546}=4.072.$$

The calculated value of the RS test does not fall within the interval (2.7–3.7); therefore, the normal distribution property is not satisfied, but it is close to normal.
It is suggested to consider in more detail the dependence of the volume of output production of agricultural branches on the commissioning of fixed assets.
It is suggested to calculate the correlation coefficient:
*Covariance*.

$$\text{cov}(x,y) = \overline{(x \cdot y)} - \bar{x} \cdot \bar{y} = 858{,}374{,}029.643 -$$
$$- 7{,}231.643 \cdot 91{,}171.5 = 199{,}054{,}302.89.$$

Then the selective linear correlation coefficient is calculated:

$$r_{x,y} = b \cdot \frac{S(x)}{S(y)} = 6.069 \frac{5{,}726.885}{56{,}689.06} = 0.613.$$

In this case, the relationship between the resulting feature and the factor in accordance with the Chaddock scale is evident and direct.
The significance of the correlation coefficient will be estimated.
For this purpose, the value of the random error will be calculated and using the Student's table, taking into account the given level of significance and the number of degrees of freedom, the critical point will be found:

$$t_{crit} = 0.613 \frac{\sqrt{12}}{\sqrt{1 - 0.613^2}} = 2.689.$$

Using the Student's table with the significance level α=0.05 and the degrees of freedom $k = 12$, it is estimated:
$t_{crit}$ (n – m – 1; α/2) = (12; 0.025) = 2.179, where $m = 1$ is the number of explanatory variables.
Thus, the correlation coefficient is statistically significant.
An analysis of variance will be performed to assess the quality of the model obtained using the variance decomposition theorem, according to which the overall variance of the resulting property includes the explained and unexplained dispersion equation.
The variance of the dependent variable will be analyzed (Table 4).

**Table 4:** The data of the variance analysis of the dependent variable

| Variant object | Result of the sum of squares | Number of degrees of freedom | Estimate of variance by 1 degree of freedom | Estimate of F-criterion |
|---|---|---|---|---|
| Model (explained) | 16,913,704,779.613 | 1 | 16,913,704,779.613 | 7.23 |
| Residual | 280,77,389,099.89 | 12 | 2,339,782,424.99 | 1 |
| Total | 44,991,093,879.5 | 14-1 | | |

The quality indicators of the regression equation are calculated (Table 5).

**Table 5:** Quality indicators of the regression equation

| Indicator | Value |
|---|---|
| Value of the determination coefficient | 0.3759 |
| Value of the average coefficient of elasticity | 0.481 |
| Mean error of approximation | 43.98 |

It can be concluded that the dependence of the volume of output production of the agricultural branches on the commissioning of fixed assets has been studied. At the initial stage of the study, a linear pair regression was chosen. Using the method of least squares, an estimation of its parameters was made, the statistical significance of the equation was proved, and it was checked using the coefficient of determination and the Fisher criterion. In addition, it is proved that 37.59% of the total variability in production volume is explained by the dynamics of commissioning of fixed assets in the analyzed situation. The statistical significance of the obtained model and its parameters is substantiated in the work. If one economically interprets the results of the study, it can be summarized that the increase in the rate of commissioning of fixed assets by 1 unit of measurement leads to an increase in the volume of production in the industry by an average of 6,069 units of measurement.
Further, an analysis aimed at detecting the autocorrelation will be performed.

The autocorrelation coefficient will be calculated and its significance will be checked using the standard error criterion:

$$S_{eY} = \frac{1}{\sqrt{14}} = 0.267$$
$$r_1 \approx \frac{\sum \varepsilon_i \varepsilon_{i-1}}{\sum \varepsilon_i^2} = \frac{-3{,}452{,}670{,}084.787}{28{,}077{,}389{,}099.887} = -0.123.$$

Given that –0.582 < $r_1$ = –0.123 < 0.582, then the independence property of the residues is satisfied, which indicates that autocorrelation is absent.
Then, the normality of the residual component's distribution will be checked.
The calculated value of the RS test amounts to:

$$RS = \frac{\varepsilon_{\max} - \varepsilon_{\min}}{S_\varepsilon}.$$

where $\varepsilon_{\max}$ = 111,951.2306 is the maximum amount of residues, $\varepsilon_{\min}$ = –57,214.8802 is the minimal level of some residues.
Unbiased estimation of mean-square deviation.

$$S_e = \sqrt{\frac{\sum e^2}{n-1}} = \sqrt{\frac{280{,}773{,}890{,}099.887}{14-1}} = 46{,}473.639$$
$$RS = \frac{111{,}951.231 - (-57{,}214.88)}{46{,}473.639} = 3.64.$$

The calculated value of the RS test falls within the interval (2.7–3.7); therefore, the condition of normal distribution is observed. Thus, the model is adequate for the normality of distribution of the residual component.

## 4. Discussion

The developed correlation models prove the existence of the influence of the examined factors on the volume of output production in the agricultural branches of the regions of the Russian Federation. Correlation coefficients are statistically significant for both factors; therefore, it can be stated that the stimulation of the development of agricultural branches in regions can be ensured by an increase in the number of investments and the commissioning of fixed assets. The amount of marginal return for both factors for all models is positive on the considered intervals of change in the values of the factors. Consequently, it can be concluded that the development of agriculture in the country's regions has not reached saturation with agricultural products, and they have substantial reserves for the further development of industrial and infrastructural processes. That is, there are opportunities in all regions to increase the number of volumes of agricultural production. An increase in the number of investments by 1 unit of measurement leads to an average increase in production volumes by 0.467 units of measurement. In other words, the growth of the investigated factor exceeds the growth of the resulting indicator. In the second case, the growth of the indicator exceeds the factor growth (1 unit of measurement of the factor leads to an increase in the volume of production by an average of 6.069 units of measurement).
The progressive increase in production, given the stable growth of factors, has an important economic and social significance. To achieve a rapid increase in the volume of agricultural production in the Russian regions, it is advisable to ensure the simultaneous growth of one of the factors that can ensure an increase in returns depending on a scale.
The use of production functions is possible when solving such an urgent problem as rating and ranking regions based on the effec-

tiveness of using such resources as investments in agriculture and commissioning of fixed assets. At the same time, a comparative analysis of the actual volume of agricultural output in the region and the value of turnover predicted on the basis of the correlation model in the same region can be used. From the authors' point of view, the relatively large positive value of this amount (that is, the excess of the actual volume of production over the calculated one) indicates favorable conditions for the development of agriculture in the respective regions. And accordingly, a large negative value of this amount allows the authors to conclude that there are problems with the conditions created in the corresponding region.

## 5. Conclusion

The conducted research has a certain scientific and practical significance.
The scientific significance of the study is as follows:
– in the process of research, correlation models were developed reflecting the influence of two factors on the volume of output in agriculture in the regions of the Russian Federation: the number of investments; and commissioning of fixed assets. With the use of a number of tests, the efficiency of the developed models and the good level of approximation of the initial data were confirmed;
– the developed models have proved that there are significant reserves for the further development of agriculture in the regions of the Russian Federation, namely, in all the examined regions, saturation with agricultural products has not been achieved yet. The change in one of the factors of the correlation model leads to the dynamics of changes in the conditions of another factor's use.
The obtained results can be used in scientific research, in the educational process while preparing bachelors and masters, as well as in training specialists in the problems of agricultural development in the regions.
The developed correlation models are effective management tools that allow evaluating the efficiency of the use of investments and fixed assets in the regions. The results of the work can be used in the current state activities, municipal and public organizations related to regulation and support of agriculture and rural infrastructure, including correcting their actions on the basis of the scientific data.
The results of the study can be used by the state and regional authorities to monitor the effectiveness of investments in agriculture, the development of sectoral and integrated projects and programs for agricultural development, as well as rural infrastructure.

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