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PRODUCTION ACTIVITY CONTROL METHODS OF THE AGRICULTURAL ORGANIZATIONS*

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Abstract. At the present stage, the issues of information formation, its processing and use in management decision-making processes in the practice of commercial organizations are usually associated with the functioning of the controlling system. The subject of research is a system for controlling the production activities of organizations in the agricultural sector. In the economic literature, the management of production costs is called the main objective function of this system. The main scientific problem to solve is to study of methods of controlling production activities to improve the efficiency of managing the economic activities of the enterprise. The paper aims to suggest the application of regression analysis in relation to agricultural production in Russia as a whole, as well as in the framework of the crop and livestock industries. For the relevant indicators, taking into account the factors that influence them, the regression equations are compiled, its use is justified for analyzing the sensitivity of the resulting indicators to the dynamics of the factors taken into account, as well as for constructing economic forecasts, taking into account the dynamics of the development of factors that influence the studied indicator. The data obtained using such models can be used in the process of controlling the production activity of an agricultural enterprise for monitoring and analysis.

Keywords: controlling; production activity; regression analysis

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1. Introduction

An urgent problem for entities operating within the framework of the modern economic system over the past decades is the need to deal with an ever-increasing flow of various data both on a quantitative and qualitative level, directly affecting the sphere of their interests. This trend is due to the development of material and production capacities, which open up more and more new opportunities for economic activity every year. Another

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reason for the growth of the information flow was the development of a market infrastructure that allows entrepreneurs to use the services of various counterparties and stakeholders in various fields at all stages of the life cycle and production activities of business entities from raising capital to bringing manufactured products to consumers. A significant role was also played by the appearance of ever new achievements in economic science and technology, allowing not only to take a fresh look at economic activity, but also to use new opportunities in the field of contractual relations. Finally, in recent years, the development of computing devices and interfaces, which completely changed both the possibilities in the field of information processing and the ways of working with information flows, the active introduction of which in everyday practice has been called digital transformation of the economy?

Business entities, on the one hand, are faced with the task of introducing the above-mentioned innovations into the practice of economics and management, since only in this way can they maintain their competitiveness in a changing world. On the other hand, this sets them the task of making or rejecting certain decisions and technologies, since errors along this path can lead to violations in the detail of enterprises and organizations, economic losses and even bankruptcy. An example of this is the incorrect definition of key success indicators (KPI), which can seriously complicate the fulfillment of the tasks set for the entrepreneurial structure or financial losses caused by the use of excessively risky investment strategies.

In the practice of managing commercial organizations at the present stage, the issues of the formation of information, its processing and use in management decision-making processes are connected with the functioning of the controlling system (Girdzijauskaitė et al. 2019).

In contemporary scientific literature various facets of controlling are scrutinized (e.g. Bychkova et al. 2018; Nita 2018; Tengeh 2019; Masood et al. 2019).

2. Review of literature

In the course of the study of the controlling system, which was carried out as part of a non-systemic approach from the point of view of the theory of tetrads, an idea was formed of the controlling system as a combination of four types of subsystems:

- 1) the controlling environment in its various aspects: information, regulatory and organizational-technical, for which there are no spatial and temporal boundaries, that is, it exists throughout the existence of the organization, covering all aspects of its activities;
- 2) controlling processes, which include planning, monitoring, analysis, accounting and control processes - this subsystem is characterized by the presence of time boundaries in the absence of spatial boundaries, since each of the listed processes has a cyclic nature and must be completed in relation to each specific object, characterized by the achievement of definite results;
- 3) controlling objects covering various aspects of the organization's activities (having clear boundaries in its organizational structure): production, financial, investment, marketing activities, as well as activities in the field of personnel management, etc. These types of activities do not stop throughout the entire period of the organization's existence and, therefore, have no boundaries in time;
- 4) projects within the controlling system, which, as a rule, relate to a specific area of the organization's activity and have clear start and end dates and thus have boundaries both in space and in time.

The subject of this article is the subsystem for controlling the production activities of organizations in the agro-industrial complex sector. Within the framework of the classification of organization controlling subsystems under consideration, the production sphere should be identified as an object type system.

In the economic literature, production cost management is called the main objective function of this subsystem (Karminsky et al. 2013). Controlling tools in the manufacturing sector include deviation analysis, in which actual costs are compared with planned, as well as limiting deviations; analysis of capacity utilization, search for bottlenecks, as well as factor analysis, etc.

The Russian economic literature describes several different approaches to the processing and interpretation of data for the purpose of controlling the organization's production activities. V.V. Berdnikov in 2009 proposed the use of the distance method that allows one to take into account the degree of deviation of the absolute values of the indicators of an economic entity from the values of the best enterprise according to the estimated indicator.

The nature of the relationship between the cost of a unit of production and the cost of individual factors forming the costs of on-farm and external origin is interpreted in the form of an equation (Berdnikov 2009):

$$\text{Cost} = a_0 + \sum a_i * x_i + \sum b_i * y_i, \text{ where:}$$

Cost – production cost per unit of output

a_0 – free term of the correlation-regression equation

a_i – regression coefficients for factors of on-farm origin

x_i – factors whose value is formed within the enterprise

b_j – regression coefficients for factors of external (mainly industrial) origin;

y_i – factors of external origin.

Regression indicators are calculated by statistical processing of information arrays. It is proposed to use the obtained relationships for short-term forecasting of the movement in the cost of livestock production with changes in the cost of a unit of factors.

Similarly, the use of a composite multivariate regression model to determine performance indicators in a controlling system was proposed by M.N. Pavlenkov and illustrated him on the example of the study of planned and actual indicators of the cost of production activities. The use of this technique, according to the author, is able to solve problems in an interfunctional controlling system to increase the validity of plans, study the effectiveness of indicators, analyze deviations of planned and actual indicators, study the effectiveness of managerial decisions and forecast indicators (Pavlenkov 2007).

Similar methods in relation to the cost of agricultural products are offered by researchers of the Kuban State Agrarian University, studying promising mathematical and instrumental methods of controlling (Orlov et al. 2015; Shelyag, Lutsenko 2009, etc.). In the articles of these researchers, the use of controlling methods of automated structural and cognitive analysis, based on the Eidos universal cognitive analytical system developed by this group of scientists, is proposed. Using this system, all stages of this type of analysis are implemented: cognitive structuring of the subject area, its formalization by constructing classification and descriptive scales and gradations that connect factors with the resulting indicators and the preparation of a training sample, the synthesis

of a system of domain models, the assessment of reliability and improving the quality of the system domain models, solving problems of identification, forecasting and decision support, as well as the study of a simulated object that one.

The application of structural-cognitive analysis methods in controlling has been substantiated (Orlov et al. 2015), its application has been tested in relation to cost analysis in the production activities of agricultural enterprises (Krokhmal 2004, Shelyag, Lutsenko 2009). In studies on the management of production volumes in the agricultural sector based on the cost structure by the above authors, we also used the method of finding the regression equations of cognitive functions of the dependence of agricultural production on the share of costs of various kinds in the total cost structure. It should be noted that these studies were carried out on the basis of the region, however, in our opinion, it is possible to apply them to individual organizations or holdings.

3. Materials and methods

Thus, within the framework of all the approaches considered, the use of regression analysis as one of the methods of controlling production activity was justified. Speaking about the effectiveness of controlling in agricultural production, it is advisable to consider it from the standpoint of a certain system of indicators used in the monitoring of this type of activity. We illustrate the application of this method, operating with data at the macroeconomic level.

V.V. Berdnikov (2012) identifies performance indicators depending on the specialization of agricultural production. For livestock, he distinguishes:

- the productivity of farm animals, determined by the ratio of the mass of products to the average annual number of animals;
- feed conversion ratio, calculated as the ratio of product mass to the number of feed units;

For crop production V.V. Berdnikov highlights:

- crop yields per hectare of crops;
- the conversion rate of mineral fertilizers, defined as the ratio of the mass of crop production to the mass of the active substance.

Moreover, for both segments they are allocated such performance indicators as the ratio of sales to the average number of employees, return on sales and return on current assets.

In practice, access to these indicators for an individual enterprise or group of enterprises may be difficult, but it seems promising to consider these factors at the macro level. In the table 1 shows the relevant indicators characterizing various aspects of agricultural production in the Russian Federation. Based on the data presented in the table, it seems possible to conduct a regression analysis of agricultural production as a whole, as well as within the framework of crop and livestock industries, expressed in the value of the output.

During the regression analysis of the data presented, the following equations were compiled:

- 1) for agricultural production in general:

$$P_{ac} = 1297,15 + 3,66 * a_1 + 12,34 * a_2 + 8,91 * a_3,$$

where P_{ac} – agricultural production, billion rubles;

a_1 – the ratio of the volume of production to the average number of employees, thousand rubles for 1 person.;

a_2 – profitability of agricultural products sold, %;

a₃ – return on assets of agricultural organizations, %.

Table 1. Indicators characterizing the efficiency of agricultural production in agricultural organizations of the Russian Federation

Indicator	Period, years								Growth rate 2018 r. to 2011 r., %
	2011	2012	2013	2014	2015	2016	2017	2018	
Agricultural production, billion rubles	3098,7	3160,3	3458,3	4031,1	4794,6	5112,3	5109,5	5119,8	165,22
Crop production, billion rubles	1566,7	1491,6	1730,2	1986,7	2487,3	2710,3	2599,7	2569,0	163,98
Livestock production, billion rubles	1532,0	1668,7	1728,1	2044,4	2307,3	2402,0	2509,8	2550,8	166,50
The ratio of the volume of production to the average number of employees, thousand rubles for 1 person	472,00	488,68	543,42	645,29	884,94	951,30	1006,90	-	-
Profitability of agricultural products sold, %	9,1	10,6	5,5	15,7	20,2	15,7	13,2	12,3	135,16
Return on assets of agricultural organizations, %	3,9	3,5	1,7	4,9	6,9	6,8	4,3	6,4	164,10
Milk yield per 1 cow, kg	4306	4521	4519	4841	5140	5370	5660	5945	138,06
Average egg production of 1 laying hen, pieces	308	306	305	308	310	308	311	305	99,03
Average shear of wool from 1 sheep, kg	2,2	2,3	2,3	2,4	2,3	2,2	2,2	2,6	118,18
Feed consumption for livestock and poultry per 1 conditional head of cattle, c	28,25	28,76	27,95	29,19	28,65	28,93	28,57	28,33	100,28
Productivity of grain and leguminous crops, c/ha	23,3	19,3	23,1	25,4	25	27,6	31	27,2	116,74
Potato yield, c/ha	196	181,7	197,5	207,4	233,5	226,2	258,3	255,6	130,41
Conversion rate of mineral fertilizers for grain and leguminous crops	0,555	0,483	0,578	0,605	0,556	0,541	0,534	0,4533	81,68
The conversion rate of mineral fertilizers for potatoes	0,703	0,745	0,737	0,678	0,712	0,694	0,73	0,652	92,75

Source: Federal state statistics service. 2019; Unified interdepartmental information and statistical system (EMISS). 2019

2) for livestock production:

$$P_a = 0,65*c_1 + 20,87*c_2 - 54,34*c_3 + 94,77*c_4 - 10162,67,$$

where P_a – livestock production, billion rubles.;

c₁ – milk yield per 1 cow, kg;

c₂ – average egg production of 1 laying hen, pieces;

c₃ – average shear of wool from 1 sheep, kg;

c₄ – feed consumption for cattle and poultry per 1 conditional head of cattle, c.

3) for crop production:

$$P_c = 21,36*b_1 + 13,58*b_2 + 587,27*b_3 - 878,93*b_4 - 1072,84,$$

where P_c – crop production, billion rubles;

b_1 – the yield of grain and leguminous crops, centners per hectare;

b_2 – yield of potatoes, centners per hectare;

b_3 – conversion rate of mineral fertilizers for grain and leguminous crops;

b_4 – the conversion rate of mineral fertilizers for potatoes.

At the same time, for the production of agricultural products, the correlation coefficient characterizing the level of connection is 0.9889 for this equation, which indicates a very high dependence of the data, while the high value of the Fisher test indicates the reliability of the relationship between the factors under consideration and the result. In relation to livestock products, the value of the correlation coefficient is 0.9711, indicating an even higher level of communication, and the value of the F-criterion allows us to conclude that the regression is significant.

For crop production, however, with a rather high correlation coefficient (0.8331), the value of the F-criterion does not allow us to conclude that the relationship is significant. It seems that this is due to the limited number of crop production sectors considered in the model: unfortunately, the available statistical data do not allow calculating the conversion rates of mineral fertilizers for some other crops.

The obtained equations can be used both for forecasting agricultural production volumes and for sensitivity analysis.

4. Results and discussion

Table 2 shows the data characterizing the sensitivity of agricultural production in relation to the selected factors. It is shown how ten percent growth of each of the considered factors will affect the resulting indicators: the volume of agricultural production in Russia as a whole, crop production and livestock production. As the data in the table show, agricultural production is most affected by the indicator of the ratio of the volume of production to the average annual number of employees, which characterizes, in fact, labor productivity. Profitability ratios for sales of agricultural products, and especially the return on assets of enterprises operating in the industry, have a significantly smaller impact. Among the factors considered as influencing the volume of livestock production, the most significant indicator is the efficiency in egg production, and the least significant is in wool production.

The data obtained in relation to the influence of selected factors in relation to crop production confirm the hypothesis of the unreliability of the regression model under consideration, since the assumption that growth in yield in potato production has a greater influence on crop production than growth in cereal and leguminous crops does not seem appropriate reality.

Table 2. Sensitivity analysis of agricultural production in the Russian Federation

With an increase of 10%:	Change in the volume of agricultural production,%
the ratio of the volume of production to the average number of employees, thousand rubles for 1 person	7,11
profitability of agricultural products sold,%	0,31
return on assets of agricultural organizations,%	0,07
With an increase of 10%:	Change in the volume of livestock production,%
milk yield per 1 cow, kg	14,85
medium egg laying 1 laying hens, pieces	24,62
average shear of wool from 1 sheep, kg	-0,55
feed consumption for livestock and poultry per 1 conditional head of cattle, c	10,39
With an increase of 10%:	The change in the volume of crop production,%
yields of grain and leguminous crops, kg / ha	2,17
yield of potatoes, c / ha	12,99
the conversion ratio of mineral fertilizers for grain and leguminous crops	1,00
the conversion rate of mineral fertilizers for potatoes	-2,14

Source: Authors' calculations

To forecast the value of production in the agricultural industry on the basis of the available data, it is possible, by calculating the forecast value for each factor, to determine the results, as shown in table. 3 and 4, which presents the corresponding forecast values for agricultural production and livestock production.

Table 3. Forecast of agricultural production in agricultural organizations of the Russian Federation

Indicator	Linear trend equation	Forecast value for 2019
The ratio of production to the average number of employees (A1), thousand rubles for 1 person	$y = 102,5521a_1 + 303,01$	1225,98
Profitability of agricultural products sold (a ₂), %	$y = 1,3286a_2 + 7,5429$	19,50
Return on assets of agricultural organizations (a ₃) %	$y = 0,4643a_3 + 2,7143$	6,89
Agricultural production (Pac), billion rubles.	$P_{ac} = 1297,15 + 3,66*a_1 + 12,34*a_2 + 8,91*a_3$	6090,31
	$Pac = 352,61t + 2648,83$	5822,32

Source: Authors' calculations

For crop production, due to the established inaccuracy of the calculated model, determining the forecast value does not seem to make sense.

The practical significance of the calculated forecast can be determined by comparing the forecast value calculated using the presented regression model with the forecast value calculated on the basis of the linear regression equation, calculated independently for the resulting indicator.

Table 4. Forecast of livestock production of agricultural organizations of the Russian Federation

Indicator	Linear trend equation	Forecast value for 2019
Milk yield per 1 cow (c_1), kg	$y = 238,3333c_1 + 3965,25$	6110,25
Average egg production of 1 laying hen (c_2), pieces	$y = 0,1786c_2 + 306,8214$	308,43
Medium wool cut with 1 sheep (c_3), kg	$y = 0,0226c_3 + 2,2107$	2,41
Feed consumption for livestock and poultry per 1 conditional head of cattle (c_4), c	$y = 0,0239c_4 + 28,4711$	28,69
Livestock Production (P_a), billion rubles	$P_a = 0,65*c_1 + 20,87*c_2 - 54,34*c_3 + 94,77*c_4 - 10162,67$	2806,94
	$P_a = 162,16t + 1363,15$	2822,62

Source: Authors' calculations

If in the forecast of livestock production between these values there was no significant difference, then for the production of agricultural products as a whole, such a difference seems noticeable. This difference is clearly illustrated in Fig. 1

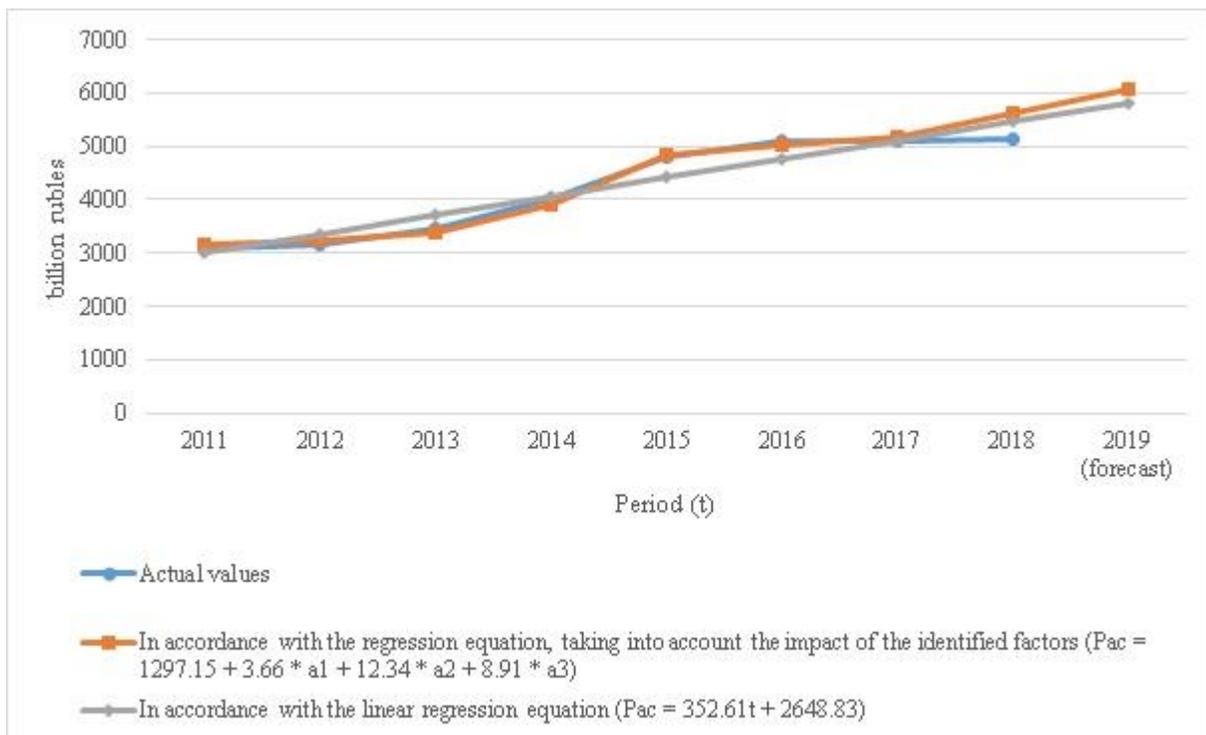


Fig.1. Agricultural production indicators

Source: Authors' calculations

In our opinion, the difference is due to the fact that a certain regression model allows you to take into account existing trends in the dynamics of factors that affect the resulting indicator. Thus, the more optimistic forecast

results for agricultural production obtained using the regression model take into account primarily the growth potential of production per employee.

Conclusions

Thus, a number of conclusions can be drawn from the results of the study. Within the four-link structure used to describe the system of controlling agricultural enterprises, the control of production activity is a subsystem of the object type that has limitations in space, but not in time.

A study of the works showed that a promising method for studying the production activities of enterprises engaged in agricultural production is the use of regression models. The data obtained using these models can be used in the process of controlling the production activity of an agricultural enterprise for monitoring and analysis, and as a result, for making informed management decisions.

In accordance with the existing ideas about the efficiency of agricultural production, an experiment was conducted to build regression models describing the production of agricultural products in general, as well as products of the livestock and crop production sectors, taking into account the impact on them of selected performance indicators characterizing the relevant industries. The study showed the effectiveness of using such models along with well-known limitations in their application regarding the need to identify factors that influence the resulting indicator and control the reliability of the identified relationships, both on the basis of statistical criteria and on the level of compliance of the results of applying the model to the real situation.

The use of regression models is justified for analyzing the sensitivity of the resulting indicators to the dynamics of the factors taken into account, allowing us to draw conclusions about the stability and risks in production, as well as to build economic forecasts that take into account the dynamics of the development of factors that influence the studied indicator.

The use of regression models is justified not only at the macro level. They can also be used at the level of individual enterprises or their associations, where their application is advisable primarily in relation to production costs as part of a system of controlling production activities. At the same time, at this level, their application requires a large amount of specific data on the activities of organizations, which sets the task of harmoniously building a monitoring system and internal management accounting of agricultural producers.

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