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MULTIFACTORIAL ECONOMETRIC ANALYSIS OF PRODUCTION ACTIVITY IN AGRICULTURAL ORGANIZATIONS

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Abstract. Multifactorial econometric analysis in agriculture, currently, along with classical methods of analysis, is one of the most important methods of research and regulation of production efficiency, synthesizing the results of the use of all the organization resources. The article considers the application of econometric models in the analysis of agricultural production, allowing to provide management for the best development of production activities. The internal and external factors, providing direct impact on the results of economic activity, are formulated. It is proposed to use the Cobb-Douglas model in the analysis of agriculture, the peculiarity of which is that each of the factors of this model is necessary for the existence of the result, and the absence of even one resource shows that production will equal to zero, that is,

production is permissible only with the general availability of resources.

Keywords: econometric analysis, correlation and regression analysis, Cobb-Douglas model, system of interdependent equations, regression coefficient.

1. *Introduction*

One of the most important tasks of such sciences as statistics, econometrics is the scientific and practical explanation of objectively existing links between economic phenomena and processes, and their quantitative measurement.

In econometrics, the following variants of dependencies are distinguished, for instance, such as paired (reflects the relationship between two features) and multiple (examines the dependence of a productive feature on several factor features) correlation.

Nowadays, more and more econometric models of the relationship, based on correlation and regression analysis, are widely used in the analysis of agricultural production.

The purpose of econometric analysis is:

- establishment of the main factors influencing the variation of the effective feature based on the calculated paired correlation coefficients;

- evaluation of the resource efficiency, i.e. production factors included in the correlation and regression model;

- predicting the level of an effective feature by substituting expected or planned levels of factor features into the regression equation.

2. *Problem Statement*

Multifactorial econometric analysis allows us to evaluate the efficiency of resource use in the production activities of agricultural organizations, to identify the vectors of the best development. Also it helps to form internal and external factors that have a direct impact on the results of economic activity.

Econometric analysis occupies a special place in agriculture. So the efficiency and scale of both agricultural and any other production directly depends on the reasonable use and expenditure of its resources. Agricultural production is a rather complicated process whole year, depending both on the quantitative and qualitative combination of land, labor and means of production, and weather conditions that a person cannot influence in any way [4, 5].

It is strategically important for any enterprise to balance its resources in production [6]. It is well known that both external (natural and climatic conditions) and internal (crop cultivation technology, seed quality, choice of mineral fertilizers and plant protection products, etc.) factors have an impact on the production of products [3, 7]. Internal factors underlie the activities. The combination of material, labor and monetary resources (factors) in the production process can be very different, i.e. the level of production, productivity, labor productivity, etc. depends on resource availability [1, 2].

3. Research Questions

In most cases, research is limited to calculations of a simple linear equation and the relationship of one effective feature with many factors was measured.

From a scientific and practical point of view, analysis using a multivariate regression equation is most valuable, since it simultaneously covers a number of factors affecting the effective feature.

It is well known that both external (natural and climatic conditions) and internal (crop cultivation technology, seed quality, choice of mineral fertilizers and plant protection products, etc.) factors have an impact on the production of products [8]. Internal factors underlie the activities. The combination of material, labor and monetary resources (factors) in the production process can be very different, i.e. the level of production, productivity, labor productivity, etc. depends on resource availability.

4. Purpose of the Study

The purpose of the work is to determine the place and role of multifactorial economic analysis in agriculture, which makes it possible to carry out an economic assessment of further prospects for the functioning of an economic entity.

5. Research Methods

Abstract-logical, economic-statistical, comparative and system analysis methods, as well as multifactorial econometric analysis were used in the study, using an overview of information and statistical data of annual reports of agricultural organizations of the Tambov region and other sources.

6. *Findings*

Econometric analysis, along with classical research methods in agriculture, suggests using multivariate regression models of production processes for the most complete assessment. One of these is the Cobb-Douglas model, which is used to assess the impact of security, condition and resource costs on production:

$$Y = a_O x_1^{a1} * x_2^{a2} * \ldots * x_n^{an} \text{ где X} j, j = 1,2,\ldots,n \text{ –} resources.$$

The variables at xi aj, j=1,2,...,n are the elasticity coefficients.

At the same time, each of the factors of this model is necessary for the existence of the result, and the absence of even one resource shows that production will equal to zero, that is, production is permissible only with the general availability of resources [9, 10].

Below, based on the existing economy of the Michurinsky district of the Tambov region, an example of its use is given.

The following variables were selected as factors, which are shown in Table 01.

Table 01

Initial data for the construction of the Cobb-Douglas model

Years	Labor costs per 1 ha of grain, man-hour	Availability of combine harvesters for 1 ha of sown area, units.	Sown area of grain, ha	Production costs for 1 ha of grain crops, rub.	Gross grain harvest, hundredweight
	Variable factors				Effective factor
	x_1	x_2	x_3	x_4	y
2010 г	2,8	0,0028	3 550	12 669,58	95 850
2011 г	3,3	0,0028	3 910	13 724,55	122 383
2012 г	3	0,003	3 708	18 558,79	111 240
2013 г	4,94	0,0028	4 048	13 405,63	131 964,8
2014 г	5,1	0,0028	3 905	21 658,64	157 098,2
2015 г	5,7	0,0037	3 480	23 683,05	142 332
2016 г	5	0,0033	3 572	25 199,05	132 878,4
2017 г	8,1	0,0028	4 281	32 020,79	209 769
2018 г	7,6	0,0031	3 912	29 284,8	176 396
2019 г	6,97	0,0019	4 306	33 428,94	193 456
2020 г	4,97	0,0023	3 856	39 100	222 074

As a result of statistical processing , the following model is obtained:

$$y = 0{,}03 * x_1^{0{,}1} * x_2^{0{,}035} * x_3^{1{,}4} * x_4^{0{,}47}$$

The elasticity coefficients for variables x1, x2, x3, x4 from the point of view of economics are interpreted as follows:

- (x_1) an increase in labor costs per 1 ha of sown area for grain crops by 1% should lead to an increase in the gross harvest of grain crops by 0.1%;

- (x_2) with an increase in the availability of combine harvesters by 1%, the gross grain harvest will increase by 0.035%;

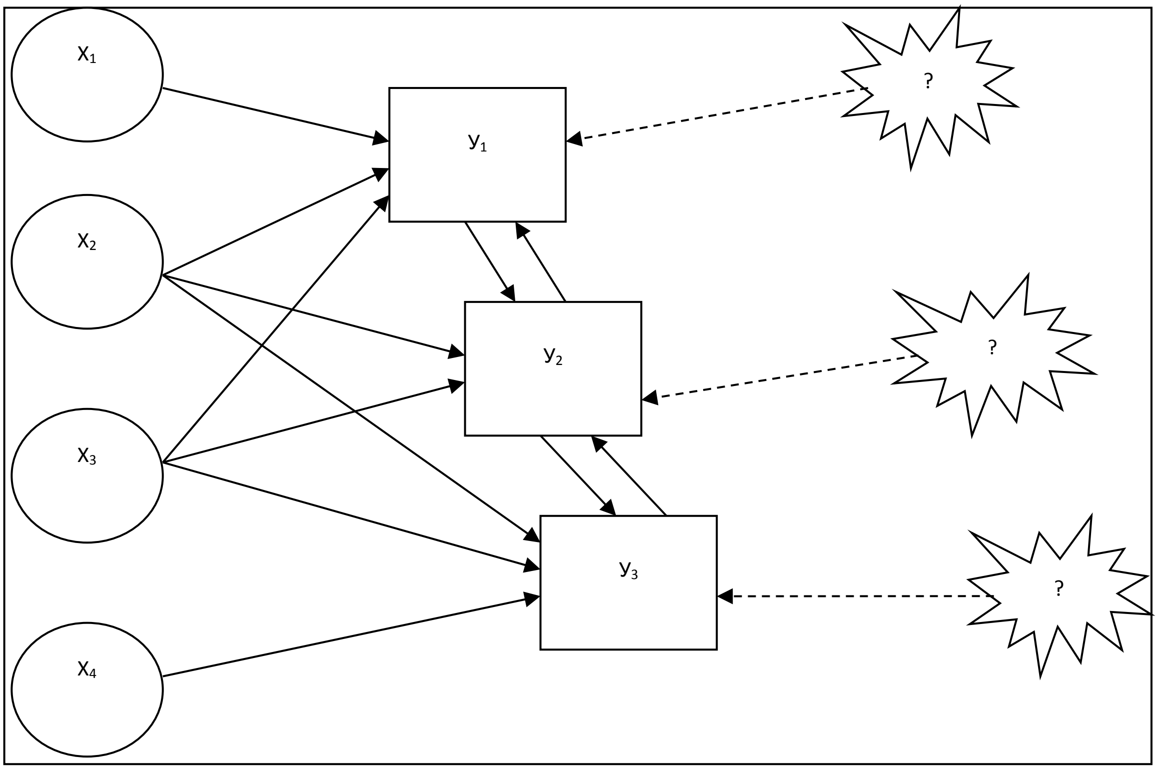
- (x_3) the expansion of grain sowing by 1%, under favorable working conditions, is accompanied by an increase in crop volume by 1.4%;

- (x_4) a competent increase in production costs per 1ha of sown area for grain crops by 1% (fertilizers, pesticides, etc.) should lead to an increase in the gross harvest of grain crops by 0.47%.

Another way to analyze economic indicators in agriculture is to use a system of interrelated equations, which most closely reveals the real structure of economic relations and processes. After all, the so-called effective signs are not really isolated, but interconnected with each other.

In some relationships, in a certain process, each of them can act as a productive factor, and in other relationships, the same factor is a variable feature. In particular, the yield is an effective factor in relation to the conditions of agricultural crop production: the quality of the soil layer, the amount of precipitation, the dose of fertilizers, etc. And already in relation to the cost of 1 ts of products, the productivity factor, along with other factors: production costs (fertilizers, fuel, etc.), labor costs per unit of production acts as a variable factor. It is not recommended to solve such diverse econometric models separately. In this case, a systematic approach to the analysis of interrelated indicators is desirable.

Thus, in the econometric analysis of yield, cost and profitability, it is recommended to solve such models in conjunction with each other.



X_1, X_2, X_3, X_4 - exogenous factors;

Y_1, Y_2, $У_3$ - endogenous factors;

? - unknown factors.

Fiqure 01 - The system of interrelations of factors

In Figure 1, an example is given that clearly shows the direction of influence of the variation of the attribute-cause to the attribute-effect in the form of an arrow. Signs that play only the role of a factor (cause) in the system are usually called exogenous (external), and signs that play both the role of a factor and the role of a dependent variable are endogenous (internal). The first are denoted by the letter X with the corresponding number, and the second by the letter Y with the corresponding number (Fig. 01).

The effective sign of y1 is influenced by exogenous factors x1; x2; x3, as well as the endogenous sign of y2. Y2, in turn, is influenced by exogenous variables x2; x3, as well as endogenous signs y1 and y3. Y3 is affected by exogenous factors x2; x3; x4, as well as the endogenous trait y2. In addition, each endogenous trait is affected by a number of unknown factors depicted as a "cloud". Such a system of relationships can be written in the form of structural econometric equations:

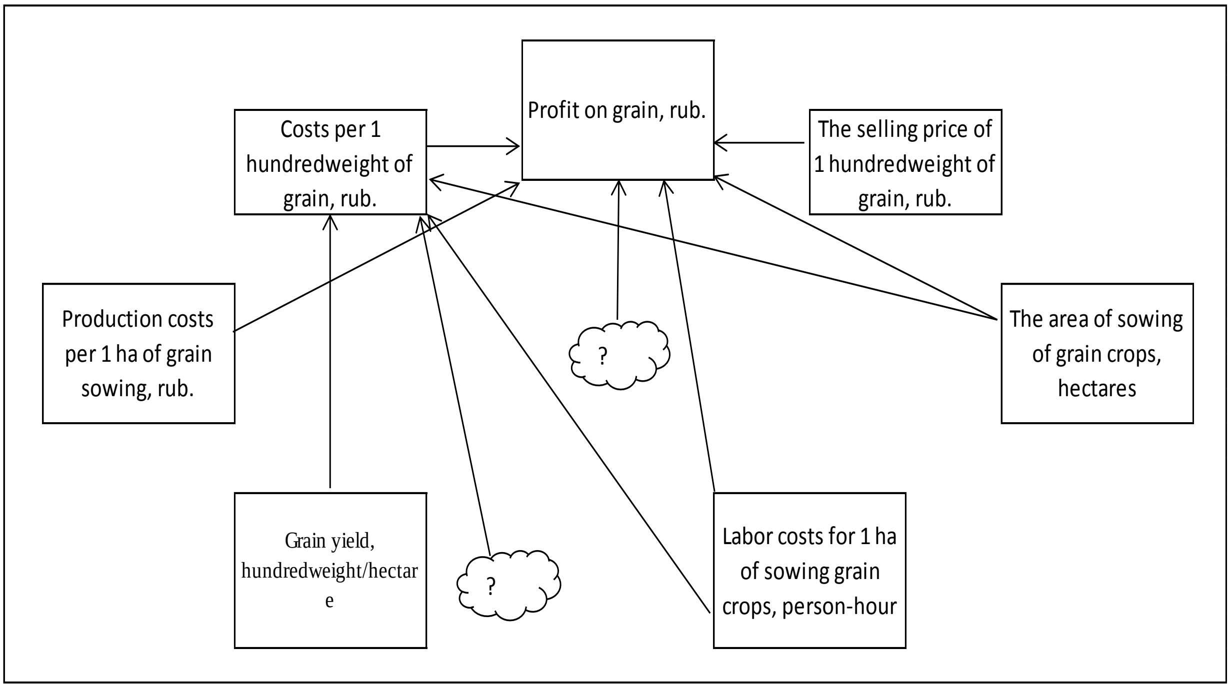
$$y_1 = a_1 + в_{11}x_1 + в_{12}x_2 + в_{13}x_3 + c_{12}y_2; (1)$$

$$y_2 = a_2 + в_{22}x_2 + в_{23}x_3 + c_{21}y_1 + c_{23}y_3; (2)$$

$$y_3 = a_3 + в_{32}x_2 + в_{33}x_3 + в_{34}x_4 + c_{32}y_{2;} (3)$$

The first number (digit) for regression coefficients is the number of the equation or endogenous variable on the left side of the equation, and the second digit is the number of the factor. The coefficients for exogenous variables are denoted ***b***, and for endogenous variables - *C*. The task of studying the system of equations is to determine estimates of the parameters of the equations based on the initial data on all the characteristics of a set (sample) of enterprises, firms, regions and other economic objects that (estimates) would be reliable, unbiased and consistent.

In practice, we will show its application on the basis of the existing economy of the Michurinsky district of the Tambov region interrelated models: cost and profit. The following variables were selected as factors, which are shown in Table 2 and the relationship of the factors is clearly shown in Figure 02.



Fiqure 02 - The system of connections of selected exogenous and endogenous traits

Table 02

Source data for building interconnected models

Years	Profit on grain, rub. $У_1$	Costs per 1 hundredweight of grain, rub. $У_2$	The selling price of 1 hundredweight of grain, rub. X_1	Production costs per 1 ha of grain sowing, rub. X_2	Grain yield, hundredweight/hectare X_3	The area of sowing of grain crops, hectares X_4	Labor costs for 1 ha of sowing grain crops, person-hour X_5	Costs per 1 hundredweight of grain, rub. (ttheoretical) Уt
2010	1 482 000	469,24	507,5	12 669,58	27	3 450	2,8	494,95
2011	11 675 000	438,48	556,9	13 724,55	31,3	3 910	3,3	440,05
2012	29 009 000	618,63	708,0	18 558,79	30	3 708	3	598,55
2013	8 447 000	411,22	608,0	13 405,63	32,6	4 048	4,94	416,27
2014	15 426 000	538,37	655,3	21 658,64	40,23	3 905	5,1	513,89
2015	57 967 000	579,05	805,9	23 683,05	40,9	3 480	5,7	576,56
2016	26 454 000	677,39	885,3	25 199,05	37,2	3 572	5	673,42
2017	378 000	653,49	725,6	32 020,79	49	4 281	8,1	651,97
2018	35 669 000	649,46	880,8	29 284,8	45,09	3 912	7,6	654,83
2019	46 933 000	744,07	994,4	33 428,94	44,93	4 306	6,97	751,45
2020	99 262 000	678,92	1130,2	39 100	57,59	3 856	4,97	686,37

Based on Figure 02, we will draw up the structural equations:

$$Y1 = a + b1x1 + b2x2 + b3x3 + b4x4 + b5x5 + btyt \ (1)$$

$$Y2 = a + b2x2 + b3x3 + b4x4 + b5x5 \ (2)$$

Equation (2) does not contain endogenous variables in the right part, therefore, it can be solved by the usual least squares method.

As a result, we get Y2 =-607.792+0,024x2-17,58x3 +4,11x5.

The equation included three variables x2, x3, x5, and x4 in this case was not statistically significant and was excluded.

We check the reliability of the parameters: the equation as a whole is reliable: the F - criterion is 111.45; the coefficient of multiple determination is 98.96. The cost model of 1 ts of grain is quite reliable.

In equation (1), there is an endogenous variable Y1 in its right part, if the actual values of Y1i are used as a result of solving this equation, then unknown factors Y1 will also affect Y1. We have bypassed this danger by using the system's recurrences, we have already solved the second equation and calculated the calculated cost values of 1 kg of grain from it (the column depends only on the variation x2, x3, x5).

As a result of the solution, the following model was obtained:

$Y1=-3331651+316792,5x_1+5206763x_3+4571403x_4-26195,2x_5-368978U'_2$

We check the reliability of the parameters: The F - criterion is 24.76; the multiple determination coefficient is 98.6. The profit model is reliable.

The signs of the regression coefficients correspond to the economic essence of the links: the higher the cost (Y!)– the lower the profit, the higher the yield (x3) and the price of products (x1), the greater the profit. The whole system of interconnected models is solved.

7. Conclusion

For the analysis of production activity in agriculture, various multifactorial models of production activity can be used for evaluation and forecasting.

It should be noted that the construction of correlation and regression models does not allow to fully disclose all cause-and-effect relationships. In this regard, it is certainly impossible to absolutize econometric models, as well as it is not necessary to abandon their use in the analysis of agricultural production. Thus, the main task of using such models is to analyze the use of enterprise resources and the opportunity to fully show the best vector of the direction of increasing the efficiency of its production.

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МНОГОФАКТОРНЫЙ ЭКОНОМЕТРИЧЕСКИЙ АНАЛИЗ ПРОИЗВОДСТВЕННОЙ ДЕЯТЕЛЬНОСТИ СЕЛЬСКОХОЗЯЙСТВЕННЫХ ОРГАНИЗАЦИЙ

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Аннотация. Многофакторный эконометрический анализ в сельском хозяйстве в настоящее время, наряду с классическими методами анализа, является одним из важнейших методов исследования и регулирования эффективности производства, обобщающим результаты использования всех ресурсов организации. В статье рассматривается применение эконометрических моделей при анализе сельскохозяйственного производства, позволяющих обеспечить управление для наилучшего развития производственной деятельности. Сформулированы внутренние и внешние факторы, оказывающие непосредственное влияние на результаты хозяйственной деятельности. Предлагается использовать модель Кобба-Дугласа при анализе сельского хозяйства, особенность которой заключается в том, что каждый из факторов этой модели необходим для существования результата, а отсутствие даже одного ресурса показывает, что производство будет равно нулю, то есть допустимо только производство при общей доступности ресурсов.

Ключевые слова: эконометрический анализ, корреляционно-регрессионный анализ, модель Кобба-Дугласа, система взаимозависимых уравнений, коэффициент регрессии.

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