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A Systematic Approach To The Methodology Of Agricultural Development And The Strategy Of Econometric Modeling

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Abstract

Econometric studies of agricultural development have their own characteristics, and in the process of econometric modeling of the development and management of agricultural production in the world experience, a number of issues are systematically studied. The importance of such a systematic approach in modeling lies in the fact that in order to make a final decision, it is not enough to observe a certain economic process in the network when a systematic analysis of existing problems and their causes is carried out. The article substantiates the need to highlight the main issues of the process and generalize the obtained components based on a systematic approach in econometric modeling of the development and management of the agricultural sector. An econometric modeling strategy has been developed that covers the main directions for solving the existing important problems of the industry

Keywords: agriculture, econometrics, econometric model, modeling, econometric modeling strategy, production function, kinetic productin function, optimization, production potential

Introduction

In the process of econometric modeling of the development and management of agricultural production in the world experience, a number of issues are systematically studied (Афанасьев В.Н. Развитие системы методов статистического исследования временных рядов // Вестник НГУЭУ. 2012. №1. С.10–24.). Reduced resource consumption (Oluwasegun B. Adekoya et al. How critical are resource rents, agriculture, growth, and renewable energy to environmental degradation in the resource-rich African countries? The role of institutional quality. Energy Policy. 164 (2022) 112888), the issue of optimization associated with increasing production volumes, rational use of land, ensuring product quality, as the main component of the food security system, the issue of ensuring the sustainability of the agro-food system by building dynamic models of the periodic development of agriculture, when determining promising directions for the development of the industry, the problems of multifactorial modeling on Based on the processing of information sources of indicators of existing systematic patterns, the problem of assessing the production potential and determining the potential using distinguish methods of comparison and analysis using multidimensional econometric models of agricultural development.

The importance of such a systematic approach in the development of agriculture lies in the fact that in the case of a systematic analysis of existing problems and their causes, it is not enough to observe a certain economic process in the network to make a final decision. For example, the agricultural network is used as a production function in national research.

Most research is limited to drawing primary conclusions based on a model built on labor resources and capital costs from a Cobb-Douglas-type production function (Cobb, G.W. A theory of production /G.W.Cobb, P.H.Douglas // Amer. Econ. Rev.,1928, March, p.139–165 //

). When calculating predictive indicators, although models that use only capital and labor resources are highly adequate, it cannot be concluded that the results obtained are highly accurate. In modern modeling, the Cobb-Douglas production function has taken the form of a growth trend in technical production over time, determined by the efficiency of the organization of production and management associated with technical processes (Алимов Р.Х., Болтаева Л.Р., Ишназаров А.И. Эконометрика-2. Ўқув қўлланма. "Иқтисодиёт" нашриёти.–Т.: ТДИУ, 2012. –115 б. (85 б.) //). Therefore, we can talk about the expediency of studying the patterns of the future development of agriculture using a new approach and multivariate modeling methods.

In our opinion, in econometric modeling of the development and management of agriculture, it is necessary to single out the main issues of the process based on a systematic approach and generalize the obtained components. At the same time, we are grouping the challenges facing the field of modeling into four main goals. At the same time, we, as organizers, distinguish between the goals of optimization, assessment of the effectiveness of the use of potential, assessment of the sustainability of economic growth in production and multifactorial econometric modeling.

The semantic inadequacy of economic theories requires the implementation of additional assumptions to obtain a fully defined econometric model, which introduces a clear specification uncertainty. The traditional or current approach to econometric modeling does not adequately account for specification uncertainty. This point is illustrated by two well-known examples from the spatial economics literature. Two alternative strategies for spatial economic modeling are proposed to improve the current approach to spatial econometric modeling. One of these strategies is used to analyze the specification of agricultural products in Eire (Hans J.Blommestein. Specification and estimation of spatial econometric models: A discussion of alternative strategies for spatial economic modelling. Regional Science and Urban Economics. Volume 13, Issue 2, May 1983, Pages 251-270 // https://doi.org/10.1016/0166-0462(83)90016-9). Econometric models are becoming an increasingly common element in the development and analysis of agricultural policy. Therefore, their nature and role are of potentially wide interest. However, the discussion of econometric models in this context is focused on technical issues. This article provides a non-technical discussion of econometric modeling and the role of econometric models in policy making, and addresses some of the methodological and practical/administrative issues associated with econometric models and their use. While we conclude that econometric models can make a potentially important contribution to agricultural policy making, the tone of the discussion cautions against being overly optimistic about what that contribution might be (David Hallam. Econometric models and agricultural policy. Agricultural Administration and Extension. Volume 25, Issue 1, 1987, Pages 49-62). These approaches also explain the uniqueness of econometric modeling of agriculture.

Main part

Taking into account the approaches outlined above, we presented the structure of the strategy of agricultural econometric research as follows.

The purpose of modeling should be to identify patterns in the development of agriculture, to ensure the reliability and effectiveness of the results achieved on the basis of correct decision-making in the management system. To do this, objects should be provided that represent the main problems of production, aimed at solving them. Econometric modeling of the development and management of agriculture in our area will be relevant on the basis of the four objects highlighted above (Table 1).

Table 1. *Strategy for econometric modeling of development and management of agricultural production**

1			
PURPOSE OF SIMULATION			
Production optimization	Evaluation of the effectiveness of the use of potential	Assessment of the sustainability of production and economic growth	Multivariate econometric modeling
2			
STEP-BY-STEP SIMULATION PROBLEMS			
Establishment of regulatory requirements for the consumption of production resources, analysis of performance indicators	Carrying out a cluster analysis of production potential and dividing the territory into clusters	Econometric analysis of the regularities of the cyclicity of the production process	Conducting an econometric analysis of factors affecting the production process
Development of guiding and regulated criteria	Building a kinetic production function for clusters	Development of dynamic econometric models	Development of multivariate econometric models
Optimal production planning	Evaluation of the effectiveness of the use of production potential	Calculation of predictive indicators of the main production indicators	
3			
EXPECTED MODELING RESULTS			
Development of recommendations for improving the efficiency of production in agriculture		Determining the patterns that ensure the economic growth of agricultural production, providing reliable forecasts	

*** Source:** *developed based on research by the author*

The phasing of modeling tasks is determined based on the goal. That is, it should consist of a sequence of high-quality actions that can give out a large-scale process in the form of understandable mathematical laws that are guaranteed to lead to a result. It is important that this sequence is short. It follows from this that it is necessary to take into account the development of tasks in the correct setting of the goal. In this sense, the volume of modeling should be taken in such a way that it reflects the essence, without deviating from the main content. In our opinion, operations performed on selected objects attached to the target satisfy the above requirements. Modeling methods underlie the task. They indicate the order in which tasks are to be performed. Typically, the methods differ depending on the application. The first is intended for the final development of the model, the second is used in the process of solving the developed model.

To solve the optimization problem, methods of mathematical programming are used. The choice of these methods depends on the nature of the constraint system, which is represented by the controlled function, also called the objective function. The goal is to minimize or maximize the function.

To determine the production potential, a probabilistic-statistical method is used. At the same time, the construction of the kinetic production function is the main task, and its adequate definition gives a structurally complete expression of the function of calculating the production potential. Also, with the help of specific methods, the issues of sustainability and multivariate econometric modeling are studied. Here we can present the methods of harmonic and spectral analysis, regression and correlation analysis.

The organization of production in agriculture begins with planning. The planning stage is the introduction of production activities and is of great importance in improving production efficiency. Requirements are set during planning. The basic potential of the manufacturer is analyzed. Planning should be carried out on the basis of a number of scenarios and among them the most optimal one should be determined. This process is related to the concept of optimization. Researchers at the University of Cambridge (Varma A. et al. An agricultural resources optimization model. 2012 Annual IEEE India Conference (INDICON)/ https://ieeexplore.ieee.org/document/6420815) investigated the evaluation of agricultural production optimization models using a large number of simulations. Thanks to this, a plan is drawn up to achieve efficiency based on the optimal allocation of resources.

When creating an optimal plan, the calculation of a limited amount of production resources, the fulfillment of regulatory requirements for the consumption of resources, the implementation of land distribution in the cultivation of products, taking into account market relations, are strictly controlled.

The issue of optimizing the production of agricultural products is presented in scientific studies (Плюта В. Сравнительный многомерный анализ в эконометрическом моделировании. – М.: Финансы и статистика, 1989. – 175с., Петренко И.Я. Экономика сельскохозяйственного производства. – Алма-Ата: Кайнар, 1992. – 560 с., Гордеев А.В. Приоритеты аграрной политики и перспективы развития крупных сельскохозяйственных предприятий России. Экономика сельскохозяйственных и перерабатывающих предприятий. 2001. – № 4. с.8-12.) as the establishment of criteria for reducing resource intensity and increasing production volumes in relation to a situation of limited resources . Mathematical programming is used to solve the problem. The simplex method brings such issues as increasing the efficiency of land use in agriculture, minimizing the cost of limited resources, the issue of transport is brought to the supply of technical and technological means (Safayeva Q. Matematik dasturlash. Darslik. “Ibn Sino” .T.:-2004, 324 b;, Raisov M. Matematik programma-lashtirish. O‘quv qo‘llanma. “Voris” nashriyoti. T.: – 2009 . – 176 bet). So, here the issue of optimizing agricultural production is reflected in the sense of creating an optimal production plan.

When assessing the stability of economic growth in production, determining the periodicity in its development helps to understand the causes of events occurring in the system. The importance of the concept of risk in agriculture can be explained by the high level of risk in the industry. Determining the periodicity in sustainable agricultural development can make it possible to develop the necessary solutions.

The fact that a factor influencing output in the agricultural sector is low or high in a certain period creates fluctuations in a continuous process. It is always reasonable to assume that fluctuations in the resultant factor exist as a reaction to fluctuations in the base. Only the degree of reaction can be different. If we look at examples, then the response to the volume of grain cultivation in the region in terms of its yield can be high, and the impact of the number of productive categories of farms can be low. Because the reduction in production capacity does not entail a reduction in land resources. Accordingly, the presence of a large amplitude of oscillations of the base may not reflect a high response of the system. When analyzing the sequence of periods describing the dynamics of agricultural processes, several methods are used, including seasonal or periodic fluctuations.

Modeling

The most common harmonic analysis and the less commonly used methods of spectral analysis can be used to infer the sustainability of agriculture based on the observation of a certain periodical repetition of reality occurring in the field (Важенина В. С. и друг. Применение гармонического и спектрального анализа для выявления основных циклов развития социально-экономической системы (на примере сельского хозяйства). Национальные интересы: приоритеты и безопасность. №11(2016) стр. 4–14.). Harmonic and spectral analysis is one of the methods for studying technological processes and is used to determine the quality of a system pulse signal, as well as to determine periodic or non-periodic signals of a complex dynamic system. The signals we receive are time-separated statistical data that form a time series.

Harmonic analysis involves the expansion of the obtained values of the factors in a Fourier series for further analysis. In this case, the time series, consisting of periodic fluctuations and a random component that supports the trend, formed under the influence of factors, has the form

$$Y = (y_0, ..., y_t, ..., y_n).$$

Here y_t – is the row level ($0 \le t \le n$). Then we can write the arbitrary economic time series as follows:

$$Y' = Y^{tr} + \sum_{k=1}^{K} Y_k^{garm} + \varepsilon \qquad (1)$$

Here Y^{tr} - trend, Y_k^{garm} - part of the general trend (harmonics), ε - is a random variable. If we take the average of the change value of the resulting factor for a long-term period as $\overline{Y}$ the formula (1) is expressed in the following form.

$$Y' = \overline{Y} + \sum_{i=1}^{K} a_k cos\frac{2\pi kt}{n} + \sum_{i=1}^{K} b_k sin\frac{2\pi kt}{n} \qquad (2)$$

Here a_k and b_k are quantities representing the existence of annual recurring fluctuations and are defined as follows:

$$a_k = \frac{2}{n}\sum_{i=1}^{K} Y' cos\frac{2\pi kt}{n}, \; b_k = \frac{2}{n}\sum_{i=1}^{K} Y' sin\frac{2\pi kt}{n}. \qquad (3)$$

Fourier coefficients are determined by the formula (2). In order to exclude insignificant coefficients from the model, they are checked by Student's test.

To apply spectral analysis, we determine the trend in formula (1) in a linear structure. Also here we get the following representation of the harmonic represented by the cosine

$$Y' = a + bt + \sum_{k=1}^{K} cos\left(\frac{2\pi kt}{n} - \varphi_{0t}\right) + \varepsilon \qquad (4)$$

Here φ_{0t} - the initial phase of vibrations. The presence of a trend in a time series can be checked using the series criteria, and the presence of a monotonic trend can be checked using the inversion criterion. The process of separating significant harmonics, that is, separating a high-frequency signal from a low-frequency signal, is based on the estimation of the spectral power density of the process using a discrete-time Fourier autocorrelation sequence.

The important aspect of the econometric model built on the basis of the time series trend of the result factor and the fluctuation dynamics of free factors in forecasting the future performance of agriculture is that the source of the model construction is statistical information of many years, and it is sufficient to determine the trend of any one free factor (closely correlated with the result factor).

One of the models describing the laws of agricultural production is the production function. The most important aspect of taking the production function as a model for describing the laws of agricultural production, through which it is possible to estimate the production potential of the sector.

Let's say that production requires a resource of type *n*. We designate the volume of production with *Y*, and resource costs with $X = (x_1, ..., x_n)$. Then we can write the following equation

$$Y = f(x_1, ..., x_n) \qquad (5)$$

A Cobb-Douglas-type production function is usually used to determine (5), but it is considered a classical model and does not assume non-equilibrium situations. For this reason, it is necessary to improve the model in the assessment of the production potential. In fact, the relative rate of growth according to the production function of the Cobb-Douglas type is determined by multiplying the absolute rate by the ratio of the product produced with any production resource, i.e.

$$\alpha_j = \frac{dY}{dx_j} \cdot \frac{x_j}{Y} \qquad (6)$$

Suppose there is an increase in the cost of some *j*- resource. Then this equality holds for (5):

$$\Delta Y = f(x_1,...,x_j+\Delta x_j,...,x_n) - f(x_1,...,x_j,...,x_n) \tag{7}$$

When there is an increase in the cost of a *j*-resource, it is necessary to increase the efficiency of the use of this resource above the average in order to ensure an increase in the volume of production. It can be expressed as follows.

$$\Delta Y = \left(\alpha_j \cdot \frac{Y}{x_j} + a_j \cdot Y\right) \cdot \Delta x_j;\; j = \overline{1,n} \tag{8}$$

Here a_j – is the coefficient representing the change of *Y* depending on the amount of *j*-resource. Let us consider the result obtained from the generalization of expressions (6) and (8).

$$\frac{\Delta Y}{\Delta x_j} = \frac{\partial Y}{dx_j} + a_j Y \tag{9}$$

Equality (6) follows from the fulfillment of $\Delta x_j \to 0$ relations in the Cobb-Douglas type production function. But in this case it is clear from (9) that $a_j Y = 0$ or $a_j = 0$ results. This relationship creates a conflict if resource *j* is known to affect output. Therefore, the production function of the Cobb-Douglas type is not enough to express the generalized potential of production.

Let's assume that $\Delta x_j \to 0$ relations are valid out of $a_j \neq 0$ relations in (8), then we create the following differential equation and its solution:

$$Y' = Y \cdot \left(\frac{\alpha_j}{x_j} + a_j\right),\; Y = a_0^{-1} \cdot e^{a_j x_j} \cdot x_j^{\alpha_j} \tag{10}$$

Here a_0 – is a constant positive number. If the formula (10) is taken for a discretionary resource, then the following production function is formed.

$$Y = a_0^{-1} \cdot \prod_{j=1}^{n} e^{a_j x_j} \cdot x_j^{\alpha_j} \tag{11}$$

If we enter the amount of general elasticity as a constant in the expression (11), then we get the kinetic production function for the agricultural network, i.e.

$$Y_k = \frac{A_k \cdot Y}{a_0} = A_k \cdot \prod_{j=1}^{n} x_j^{\alpha_j} \cdot e^{a_j x_j} \tag{12}$$

Here $A_k = a_1 + ... + a_n$ - an is the amount of total elasticity. It has been emphasized by foreign scientists that the Cobb-Douglas production function (as a special case of the Cobb-Douglas function (12)) among the formula-type models are the main functions that represent the modern production potential of the economic network (Смагин, Б.И. Кинетическая производственная функция – как основа описания закономерностей сельскохозяйственного производства /Б.И. Смагин // Научные основы функционирования и управления АПК. Научные труды НАЭКОР. Вып.6. Том 3. – М.: СХА, 2002. – С.258-264).

The efficiency of the production potential of agricultural products is determined by the volume of products produced by the production farms using the available resources. An increase in the number of resources is not the reason for the growth of production capacity. According to some economists (Пацкалев А.Ф. Производственный потенциал АПК, его оценка и эффективность / А.Ф. Пацкалев // Проблемы совершенствования хозяйственного механизма в системе АПК: Материалы Всерос. науч.-практ. конф. – М.: 1990. – ч. 1.), the concept of production potential should include the maximum possible final result of the development of the agro-industrial complex and its structural links. It can be concluded from this idea, that is, taking into account the nature of the influence of resources on the volume of production, agricultural production, production potential is determined not by a mechanical collection of individual resources, but by their system, in which the interdependence of all elements is clearly manifested.

Therefore, the relationship between the volume of the produced product and the amount of resources used is described by the kinetic production function. Also, it is necessary to assess the resource scarcity, the efficiency of its use and the production potential in the potential management of production. It uses probabilistic and statistical modeling methods. Based on foreign experience (Василенко Ю.В. Производственный потенциал сельскохозяйственных предприятий / Ю.В. Василенко. – М.: Агропромиздат,1989. – 152с;, Ким Дж.-О. Факторный анализ: Статистические методы и практические вопросы / Дж.-О. Ким, Ч.У. Мьюллер // Факторный, дискриминантный и кластерный анализ / Дж.-О. Ким, Ч.У. Мьюллер, У.Р.Клекка и др. – М.: Финансы и статистика,1989. – С. 5-77), we suggest using a linear regression equation to evaluate the efficiency of resource use.

One of the main problems in determining the agricultural production potential of the region is the large number of production facilities that embody the production complex. In this case, it is possible to solve the problem by summarizing the objects that are less differentiated by certain indicators and creating a group of objects. We offer a cluster management method. For this, cluster analysis is conducted. We will consider cluster management as a potential management in the next step. In general, the economic and social efficiency of clusters is widely studied by the scientists of our country (Ergashev R., Beglaev U. The Ways Of Fishing Farms Management And Developing The Production Activity. International journal of scientific & technology research. Volume 9, Issue 02, february 2020, ISSN 2277-8616919 ijstr©2020.p-92).

In cluster analysis, the following approach is distinguished by its importance today, that is, the indicators of the availability of resources per unit land area and the absolute amount of resources should be taken as the basis for clustering (Смагин, Б.И. Некоторые свойства производственной функции Кобба-Дугласа / Б.И. Смагин // Экономика и математические методы.–1990.–т.26, вып. 3.– С.561), as well as the amount of gross product (Y) spent for each cluster a production function is constructed depending on the amount of resources.

For the production function built on the production potential, the coefficients defined for each resource are required to be non-negative. Because, in our opinion, the increase in the price of any type of resources is accompanied by a slight increase in the volume of manufactured products.

To analyze the production of agricultural products, we select the variables of the kinetic production function.

$$Y_k = A_k \cdot e^{a_j x_j} \cdot \prod_{j=1}^{4} x_j^{\alpha_j}\ ,\ \ln(Y) = \ln(a_0) + \sum_{j=1}^{4} a_j x_j + \sum_{j=1}^{4} \alpha_j \ln(x_j) \quad (13)$$

Here x_1 – agricultural land area; x_2 – average number of workers; x_3 – annual average value of the main production funds; x_4 – amount of working capital; Y – volume of gross agricultural product.

(13) according to international experts (Юзефович, А.Э. Аграрный ресурсный потенциал: формирование и использование / А.Э. Юзефович. – Киев: Наукова думка, 1987. –176 с.), it is very flexible and satisfactorily describes the basic production and technological interdependence of agricultural production. If we pay attention to its structure, the xj resource in it comes with its logarithmic value. This situation indicates that resource consumption has decreased or increased. This can be seen in the following relationship:

$$c = \alpha_j + a_j x_j\ ,\ j = 1,2,...,4 \quad (14)$$

If, in (14), α_j is not zero, the optimal state of j-resource amount sufficient for the growth of production volume (Y) is determined by the ratio α_j / a_j;

if the multiplier $a_j x_j$ in (14) is equal to zero value, then a 1% increase in resource j means a direct increase in Y by α_j % (α_j must always be positive);

if α_j is zero, then a 1 percent increase in j-resource means a direct $a_j x_j$ percent increase (or decrease) in Y.

More precisely, if $a_j x_j$ is determined to be negative, the increase in the amount of the resource is accompanied by a decrease in the efficiency of its use (the efficiency of resource use is below average), an increase of 1 percent of the j-resource means a direct decrease of Y by $a_j x_j$ percent. Also, in model (13), each resource is involved.

Conclusion

The essence of the assessment of the production potential is that it provides an opportunity to identify resource shortages in the region, to optimally organize resource exchange as a result of the analysis, and to develop proposals for increasing the efficiency of resource use. For example, logically, working capital directed to the production of agricultural products has a great impact on the size of the gross agricultural product. It is possible to have processed information to obtain optimal options for covering the shortage of working capital spent on agricultural production in the region.

According to the results of the research, the production of agricultural products and its management is a very complex and multifactorial process, and in its research, econometric modeling serves to obtain specific and targeted results and conclusions. In particular, it helps to meet the high need for the results of econometric analysis in the development of ways to identify and eliminate seasonal fluctuations.

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