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The Role of Statistical Methods in the Estimation of Management Efficiency

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Abstract

One of the tasks set for economic science is the study of the theoretical foundations for further improving production efficiency, which serves as the fundamental basis for modern economic development. A lot of work has been devoted to questions of the methodology for statistical studies on production efficiency and labour productivity. Nevertheless, some problems remain insufficiently studied, in particular, questions on a generalizing indicator of economic efficiency, and analysis of management efficiency growth factors. The authors of the paper consider the possibility of using statistical methods to identify the influence of organizational factors on improving production efficiency, and propose methods for calculating the impact of management on production efficiency. The paper discusses the methodology of statistical study of management effectiveness. Much attention is paid to the correlation and regression analysis. A model is proposed, making it possible to adequately use systematic approaches to the problem of the statistical study of the production and management.

Keywords: efficiency, factor analysis, production function, fixed assets, correlation and regression analysis, regression, management.

1 Introduction

Management is part of the entire production process. It is called upon to ensure the fullest use and development of the productive forces potential in order to satisfy the whole complex of social needs and achieve social goals with the least expenditure of total labour. From these positions, the category of management efficiency should reflect the contribution of management to the overall results of production and economic activity.

At the same time, management is a relatively independent sphere of productive labour application, which is characterized by the size of management resources and the value of total labour costs. In this regard, the results of managerial activity can be considered in two aspects: from the standpoint of the governing system itself as a subject of management and from the standpoint of the entire management system as an organic unity of the subject and the object of management (1). Accordingly, one can distinguish two approaches to assessing management effectiveness: assessing management effectiveness in the narrow and broad sense of the interpretation of this term.

Management efficiency in the narrow sense characterizes management as an independent sphere of labour application and is focused on studying the costs of living and materialized labour in the field of management and on the results achieved in the same field. Management effectiveness in the broad sense involves the study of the contribution of management itself to the final results of the production and economic activities of the respective units. The study of management effectiveness in the narrow sense is of independent interest.

2 Methods

To improve management, an assessment and analysis of its effectiveness is required. Of particular relevance are the issues of evaluating management effectiveness in the context of the work progress to strengthen an integrated approach to planning in economic sectors and solving major economic and social problems. It is important here already at the project stage to evaluate the effectiveness of the planned set of measures to improve management (2).

In recent years, many methods have been created in the field of evaluating management effectiveness. They highlighted a number of factors of management effectiveness, examined the issues of grouping these factors, and proposed indicators. This, for example, is an indicator being the ratio of the management expenditures growth volume to the production growth volume obtained by increasing labour productivity, or an indicator being the ratio of the sum of management expenditures to the net product output, etc. (3). Along with certain advantages, each technique contains controversial provisions. Analysis of existing methods for

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assessing management effectiveness leads to the conclusion that their main drawback is the lack of a systematic approach to the construction of indicators.

With a systematic approach, management at any level is considered, on the one hand, as a system that includes a number of subsystems of a lower level, and on the other hand, as a subsystem included in a more complex formation, namely production. This determines the need, firstly, for a systematic comprehensive assessment of management efficiency, which would allow taking into account all the essential aspects of management as a system, and the influence of individual factors on the overall level of efficiency. Such an assessment should include the use of a hierarchical system of indicators and a study of the effectiveness factors themselves. Secondly, it is necessary to take into account the specifics of management as a subsystem of social production. This means that the constructed system of indicators should take into account the dual nature of managerial activity in the system of social production, that is, it should be presented as indicators characterizing the influence of management on production results, and indicators of the control system effectiveness itself. Thirdly, the methodological linking of management performance indicators with social production efficiency indicators is mandatory. In particular, the subsystem of management performance indicators should be an organic part of the system of social production effectiveness indicators; a generalized management efficiency indicator should be calculated in such a way that it is simultaneously a parameter of a generalized production efficiency indicator (4, 11).

To implement this approach, statistical methods and modern technologies can be used. In particular, it seems promising to use production functions in combination with correlation and regression analysis to evaluate the management effectiveness of the apparatus of production functions.

3 Results and Discussion

The production function is a model of the production results dependence on expended production factors. In the study of economic development using production functions, two main factors are usually distinguished: expended living labour estimated by the number of industrial production personnel L, and the average annual value of fixed assets C:

$$Y = f(L,\ C)\ . \tag{1}$$

If we take into account that the result of the production and economic activity of a object is determined not only by the costs of production resources, but also depends on the so-called managerial factors, then the allocation of these components or the use of production and management functions of the form seems reasonable:

$$Y = f(L_1,\ L_2,\ C_1\ C_2) \tag{2}$$

where Y is the result of the production activities of the object; L_1 is the number of workers; L_2 is the number of administrative personnel; C_1 is the average annual value of fixed assets of the management apparatus; and C_2 is the average annual value of production assets, minus the value of fixed assets of the management apparatus. A function of the form (2) allows us to evaluate the contribution of management to the overall results of production activities. It is a particular type of production and management function.

It is advisable to especially highlight in the composition of fixed assets the computer equipment and study their influence on the achieved production results. A sufficiently large number of factors can be included into production functions, that is, they are quite suitable for describing multifactorial economic processes. In the general case, the production and management function have the form:

$$\omega = F(X_1, \dots,\ X_m,\ X_{m+1}, \dots, X_{m+n}), \tag{3}$$

where $X_1, \dots, X_m$ are expended production factors; $X_{m+1}, \dots, X_{m+n}$- expended management factors. For a function of the form (3) that is non-negative, continuous, and differentiable with respect to all arguments, a number of characteristics of control efficiency can be calculated:

- The marginal rate of effectiveness for each factor

$$\gamma x_i = \frac{\partial f}{\partial x_i},\quad i = 1,\dots,\quad m+n \tag{4}$$

Which will show the change in the result of the production activity of a object when the production or managerial factor changes by one and at the fixed values of the remaining factors;

- Change in the result of the production activity of the system due to the cumulative change in production factors:

$$\Delta\omega_1 = \sum_{i=1}^{m} \frac{\partial f}{\partial X_i} \Delta X_i$$

(5)

- Change in the result of production and economic activity due to the cumulative change in management factors

$$\Delta\omega_2 = \sum_{i=m+1}^{m+n} \frac{\partial f}{\partial X_i} \Delta X_i \tag{6}$$

- Marginal rate of substitution for factor $i(i = 1,\dots,\ m+n)$ with factor $j(j = 1,\dots,\ m+n),\ i \neq j$,

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$$x_{ij} = \frac{\gamma x_i}{\gamma x_j} \tag{7}$$

- Management efficiency indicator in the form of the ratio of the production growth volume resulting from the strengthening of intensive growth factors to the managerial resource expenditures growth volume

$$Э = \frac{\sum_{j \subset I} \frac{\partial f}{\partial x_j} \Delta X_j}{\sum_{j \subset I} \Delta X_j}, \tag{8}$$

where I is a set of indices of all intensive production volume growth factors; ΔX_j is an increment of j-th factor compared to the baseline period or plan. If some factor j used in formula (8) is not given in the form of expenditures, then it can be reduced to them using values x_{ij} showing how many factor i increment units is equivalent to one factor j increment unit. For example, if the value of the factor i interchangeable with factor j expressed in the form of expenditures is known, then the notional expenditures for achieving the actual value of j factor will be:

$$X_j' = x_{ij}\Delta X_j \tag{9}$$

Then the formula (8) will take the form:

$$Э = \frac{\sum_{j\in I}\frac{\partial f}{\partial x_j}\Delta X_j}{\sum_{j\in I_1}\Delta X_j + \sum_{j\in I_2} X_j'}, \tag{10}$$

where I_1 is the set of all indices j of management factors presented in the form of expenditures; and I_2 is the set of all indices j of management factors presented in a different form, moreover $I_1+I_2=I$.

4 Summary

The proposed approach to the construction of a system of management performance indicators ensures the interconnection of production and management performance indicators. It also opens up the possibility of creating a system of indicators which are logically interconnected and united by a single target area.

The use of multifactor production functions for each particular case encounters two main difficulties: firstly, the need for an analytical expression of the function f; secondly, the need to select factors for building the model. Both of these problems can be quite effectively solved using statistical methods.

Several statistical methods can be used to select and group the most significant production and managerial factors: expert assessment methods, correlation analysis, cluster analysis, and various versions of factor analysis (5,15,16).

To select the most significant factors, as a rule, the method of correlation analysis is used: the matrix of pair correlation coefficients between the considered factors, including the effective one, are analysed, and the most significant of them are selected on this basis. Correlation analysis as a formal mathematical apparatus is advisable to combine with expert methods, which allow, firstly, to obtain informal assessments of specialists and, secondly, to assess the impact of quantitatively immeasurable factors (6, 17).

When assessing the degree of influence of each factor on the final indicator, it is advisable to use analysis of variance. This method allows not only to evaluate the contribution of each factor to the final indicator, to find out how significant the influence of factors not included in the model is, but also, without starting modelling, to study the combined effect of a number of factors on the modelled indicator.

Modern requirements for the analysis of economic development require consideration of all its significant factors. In this case, it is often necessary to identify factors assigning them to one or another group. As a rule, a scheme for classifying factors has already been set. However, it is often more useful in the construction of classification to go based on the object's properties in their diversity and not based on a predetermined scheme to the natural types, which often leads to a result having a great heuristic value. In this case, the apparatus of cluster analysis can be successfully used (7). It is not necessary to express factors in quantitatively similar assessments; moreover, the use of appropriate similarity factors opens up the possibility of the simultaneous use of quantitative and qualitative characteristics. The type of grouping obtained depends on a given criterion for the optimality of the grouping or objective function. Thus, depending on the objective function, various partitions of the initial set of factors and objects can be obtained (8, 13).

5 Conclusions

In real conditions, most economic phenomena are interconnected by certain dependencies. In addition, specific modelling conditions may require aggregation of the initial information about the object in question with minimal losses. In this case, the problem arises of reducing the description of a system consisting of many variables, some of which are connected by dependencies, to the description of a system consisting of a smaller number of independent derivatives of variables. In this case, a factor analysis apparatus can be used to determine the model parameters. The main advantages of factor analysis are the ability to use dependent factors and taking into account the hidden components of factors. If, for example, technical and economic factors include the scale of production, then when constructing a factor analysis model, the hidden components of this factor are also taken into account - the size of fixed assets, the number of employees, and gross output. To establish the type of function f, multiple correlation and regression analysis can be used (9, 12). The mathematical basis for identifying the type of connection by this method is the possibility of a fairly accurate representation of the response function f by a Tailor polynomial Y:

$$Y = a_0 + \sum_{i=1}^{m+n} a_i X_i + \sum_{i\langle j}^{m+n} a_{ij} X_i X_j + \sum_{i=1}^{m+n} a_{ii} X_i^2 + \ldots$$

With decomposition coefficients $a_0, a_1, a_2, ..., a_{12}, ..., a_n, ...$

Modelling allows us to get sample regression coefficients $b_0, b_1, b_2, ..., b_{12}, ..., b_n, ...,$ which are sufficiently close in their values to the coefficients of the theoretical expansion. Correlation analysis is based on a number of prerequisites necessary for its implementation: the availability of information for a certain period of time, the independence of factors, the uniformity of sample estimates, and some others (10, 14, 15). All of these conditions may be observed when solving the task under consideration. For example, the fulfilment of the independence condition can be achieved by switching from a model of indicators to a model of growth, and by elimination of two strongly correlated factors the one which is less correlated with the final indicator. After the elimination of each factor, as well as after the final creation of the model, it should be checked for adequacy to the real process (significance) by any criterion (for example, by the Fisher criterion). If a polynomial of the chosen degree does not provide a sufficiently good approximation, then the exponent should be increased (18, 19, 20).

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