The Modeling of a High-Project Object State Existing in the Conditions of a Developing Market

I.Z. Mustaev, E.A. Semivelichenko, V.YU. Ivanov, N.K. Maksimova, T.I. Mustaev

Abstract— The article is devoted to the description of the methodology of modeling the high-tech product state with a long life cycle. The instability of the developing market characteristics is in contradiction with the necessity to predict the characteristics of the object for large periods of time. It is the problem that prevents the effective use of known approaches. A new modeling tool based on modeling the dynamics of the object state was developed to overcome this problem. The state of the object is a fundamental property that is preserved in conditions of the high variability of the environment. The set of characteristics described in the article are used for modeling the high-tech object state.

Key words: high-tech product, potential, life cycle

I. INTRODUCTION

The cumulative duration of design, production and operation stages of innovative high-tech products such as aircraft is characterized by long durations. Thus, the life cycle of an aircraft engine reaches 40-50 years. In Russia the creation of such products is faced with a number of problems peculiar to developing markets in developing countries. They are caused by the necessity to conduct business in a technological gap in related industries that support the main competitive production. They are added with the problems of brain drain and limited financial and human capital. It is also necessary to note the increased instability and vulnerability of business due to the impact of global and local crises. Over the past 20 years we can mention the default of 1998, the crises of 2008 and 2013, i.e. one crisis at 6-7 years. These facts change significantly and indefinitely the characteristics of enterprises that support the life cycle of an object and this should be taken into account when making forecasts. It should also be emphasized that during its lifetime the object changes its shape developing from an idea to specific products and the enterprises that ensure its existence (life-cycle enterprises) differ in types and forms of ownership, size, financial and economic indicators, territorial affiliation, etc.

Known methods are oriented to large time horizons based on the forecasting of technological, economic, competitive, international, market and political factors (Ivashchenko N. P., 2013). However the prediction results are often incorrect and their effectiveness which means the feasibility of forecasts ranges from 30% to 90% (Komkov N. I., 2015). Predicting the state of an object that exists in conditions of high uncertainty in developing markets remains an unsolved problem. This implies both the development of existing approaches and models and the formation of new ones. The paper presents elements of a new methodology for modeling the state of an object of complex nature. A special feature is the robustness of the resulting models manifested as resistance to changes in the frequency of recording information and to random variations of external and internal factors. It is important that it allows to use models in predicting the object state consistent with the activities of enterprises supporting its life cycle. Additionally, it is possible to manage the state of the object on the horizon of the life cycle through the management of these enterprises.

The methodology is based on the object's integral characteristics and property called the accumulated potentials and the accumulated state, respectively (Mustaev, 2013, 2017). The content of the concept can be explained in the following examples. Let's fix the current time $t$and suppose that in the past, at the time $(t-\tau)$ it was made a single payment equal to a value $q(t-\tau)=q_0$. In order for a payment being invested in market instruments in the past at a point of time $t-\tau$ to lead to the current value of an asset, i.e. to q_0 at the moment of time t, it should be equal:

$$X_q^a(t,\alpha,\sigma)=q(t-\tau)\cdot\psi(\tau,\alpha,\sigma)=q_0\cdot\psi(\tau,\alpha,\sigma). \quad (1)$$

Here: ψ – the sociotechnical function of a system that includes an object as a control object, α – the amount of profitability that has developed over a period of time $(t-\tau,t)$, σ – risk. The value X_q^a is called *the accumulated potential* and makes sense of the current market valuation of a payment made in the past. Accumulated potential flow of past payments is determined by the formula:

$$X_q^a(p,t)=\int_{\tau=0}^{\infty} q(t-\tau)\psi(\tau,p)d\tau=\hat{A}q, \quad (2)$$

In (2) complex variable p is formed from two functions λ and $p=\lambda(\alpha)+j\nu(\sigma)$. The function λ is named the profit function, что-то – the function of uncertainty.

Revised Manuscript Received on April 12, 2019.

I.Z. MUSTAEV, Professor, Doctor of Economics, Head of Innovation Management Department, Ufa State Aviation Technical University, Russia, (E-mail: fermi_moustaev@mail.ru)

E.A. SEMIVELICHENKO, Candidate of Law, Managing Director of PAO ODK - UMPO, Ufa, Russia, (E-mail: umpo@umpo.ru)

V.YU. IVANOV, Candidate of Technical Sciences, Deputy Director of JV «DBA-engineering», Ufa, Russia, (E-mail: ivanov.vladimir@mail.ru)

N.K. MAKSIMOVA, N.K., Head of Program and Project Management Department, PAO UMPO, Ufa, Russia, (E-mail: maksimova@umpo.ru)

T.I. MUSTAEV, Ufa State Aviation Technical University, Master, (E-mail: tima.mus.1321@gmail.com)

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

The formula (2) is used to determine the accumulated state potential of a variable of any type and not just cash flows. In whole, the accumulated potentials of variables' state characterize the accumulated potential of the object. The current state of the object is defined as *the accumulated state*. Thus the accumulated state of the object is in accordance with its accumulated potential. A function called a sociophysical function is subject to requirements similar to those imposed in the market valuation of flows and assets.

The object is in one of the states which number is finite or infinite. The object has various states which together mean the concept of the object's life cycle at different stages of the object existence. Using the proposed approach in relation to the enterprise assumes that it develops changing also its state. Below we present the results of the process control analysis for various accounting units of a modern enterprise. We use such desired variables as an enterprise in whole, separate production processes considered from system positions, i.e. as an enterprise management subsystem in one aspect of its activities as an object of management and structural units (workshops). This choice of accounting units allows us to answer questions related to the evaluation of the possibility of comparing the effectiveness of different accounting units and carrying out a similar comparison based on the calculation of potentials. The company's valuation is carried out on the basis of the comparison of information on the revenue dynamics and the main indicators of the enterprise's external reporting – of the balance sheet total, the value of current and non-current assets. A quantitative and qualitative estimate of uncertainty can be obtained from pairwise comparison of these quantities at the considered time interval. This comparison also allows us to answer the question about the degree of uncertainty in management decisions. If we take one of the quantities (x) as a control and the other one (y) as a response to this control, the chart $y = f(x)$ will illustrate a qualitative picture of the decision-making related to the regulation of a quantity (y) through an impact on the quantity (x). Figures 1 (a, b) show charts for various data pairs for the 14-year period (2004-2017). The analysis of the charts shows that the level of uncertainty exceeds 50% and in some cases it reaches 90%. All data on this and other charts are given in relative values.

(a) (b) (c)

Figure 1 – Characteristics of the enterprise manageability for 14 years. The comparison in pairs "quarterly revenue and balance sheet total", "quarterly revenue and non-current assets" and "accumulated potentials of revenue and assets"

We Illustrate the nature of an enterprise's production processes, i.e. characterization of internal processes of the enterprise on the example of production indicators of one of the assembly units. For this we have analyzed the dynamics of the dependence of the commodity output of the main production and the dynamics of the actual cost of the main production at various time intervals – annual, two-year and three-year. Data analysis shows that the variation of the output indicator relative to the average value reaches 25%, the variation of the cost index relative to the regression line reaches 30% of the value. Annual, two-year and three-year intervals were selected as characteristic for the economic analysis of the industrial enterprise. Comparison of the production values and prime cost allows us to characterize the nature of changes in production efficiency in changing the production plan, i.e. characterize the effect of scale. The expected value should illustrate the neutral or positive effect magnitude when an increase in the scale of production does not affect the change in prime cost of production or leads to the decrease in the cost of production. To illustrate this we compared the indicated values on one chart. We plotted down the output value on abscissa axis and the cost value on ordinate axis. The comparison results are shown in Figure 2. Data analysis shows that with an increase in product output the cost of production increases. This fact can be illustrated by the regression lines shown in the charts. These regression lines are described by a linear equation in the following form:

$$y = kx + b. \quad (3)$$

The essential value that in this case characterize the trend of changes in prime cost, i.e. characterize the effect of scale, is the coefficient k. A positive value of the coefficient k will indicate an increase in prime cost with an increase in the production, i.e. the negative effect of the production scale. On the contrary, a negative value will indicate a decrease in prime cost with an increase in the production, i.e. the positive effect of production scale. Actual values of the

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

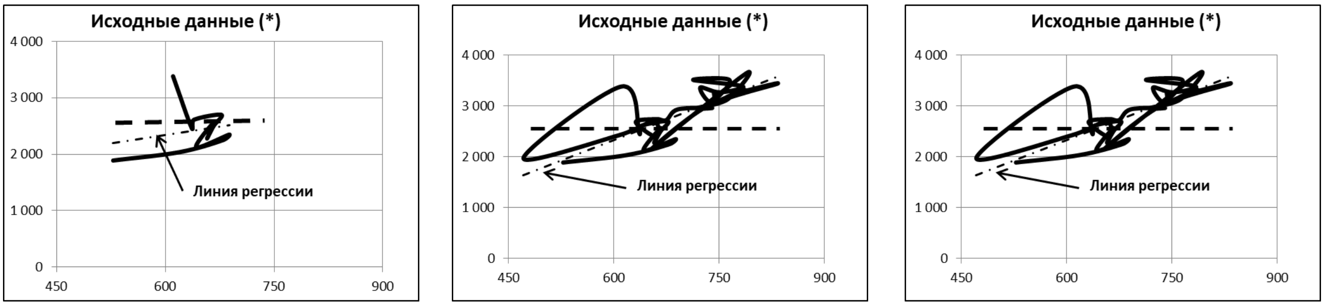
coefficient k in comparing annual and three-year data indicate a possible more than twofold change in the coefficient k:

$$K = \frac{k_{2015-2017}}{k_{2015}} = \frac{5{,}4}{2{,}0} = 2{,}7.$$

On the other hand, a positive coefficient value may indicate the need for technological re-equipment in connection with the achieved maximum values of production efficiency. However, such conclusion cannot be unambiguous on the basis of the initial data since the magnitude of the uncertainty exceeds 100%. In other words, the coefficient k determined from the source data is insignificant and is determined with low confidence.

Another interpretation of the data may indicate an unchanged overall cost of production of marketable products. This is illustrated by the horizontal dashed lines in the charts on Figure 2. These examples indicate a high degree of uncertainty in the source data which prevents the adequate determination of real trends in prime cost of production. It should be emphasized that this complicates the timely detection of possible negative trends in the enterprise in whole and may lead to management decisions with negative results, – reduced efficiency, sustainability stocks, etc.

RESULTS & DISCUSSIONS



(а) (б) (в)

Figure 2 – Characteristics of the controllability of the production processes in the enterprise. The comparison in the pair "commodity output for the main production workshops and – the actual cost of main production" in 2015 (a); in the period of 2015-2016 (b); in the period of 2015-2017 (c). The ordinate axis shows the prime cost value, the abscissa axis – the commodity output

We illustrated the nature of the production processes of the structural units in the enterprise on the example of production indicators of the selected assembly unit by workshops. To do this we analyzed the dynamics of the dependence of commodity output by the workshops of the main production and the dynamics of the actual prime cost developed at various time intervals – annual, two-year and three-year. Annual, two-year and three-year intervals were selected as characteristic for the economic analysis of the industrial enterprise activity. The data analysis shows that within 3 years there is a change in the trend of changes in output in maintaining the trend of increasing prime cost. We assume that the regression lines can be described by such linear equation as:

$$y = l \cdot t + b. \qquad (4)$$

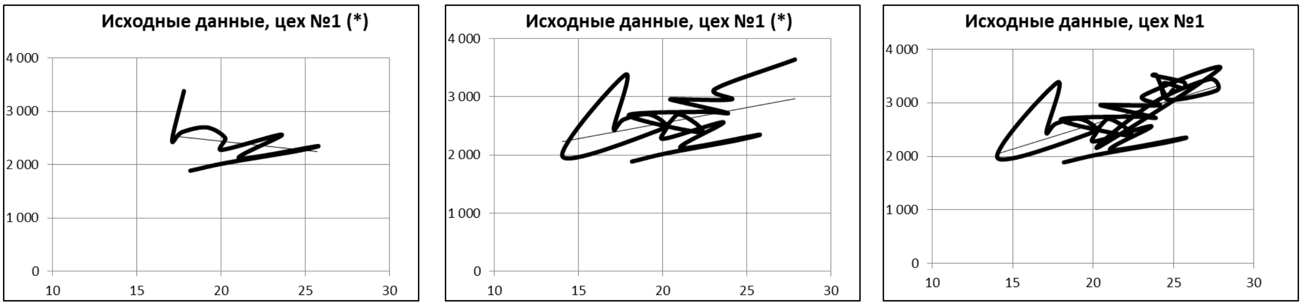
Essential value characterizing the trend of changes in prime cost in this case, i.e. characterizing the effect of scale, is the coefficient l. A positive value of the coefficient l indicates an increase in prime cost or product output over time. On the contrary, a negative value indicates a decrease in the cost or production volume over time. The actual values of the coefficient l show that over 3 years there has been a change in trends both in the dynamics of production by the workshop and in the dynamics of the production prime cost of the main manufacture. The change in trends is not formalized as unconditionally established since the significant values are achieved by the variation of values in each of the time intervals. Comparison of data at specified intervals is demonstrated by the charts in Figure 3. The actual prime cost values are plotted down monthly on the ordinate axis at annual, two-year, and three-year intervals. The abscissa axis shows the values of commodity output of this workshop recorded monthly at annual, two-year and three-year periods of time, respectively. Such data presentation allows to compare the effects of scale in the enterprise with a similar effect in the workshop. The values of the coefficient k in the case of hypothesis acceptance of linear regression of variables in comparing annual and three-year data indicates the possible more than a twofold change in the coefficient l:

$$K = \frac{l_{2015-2017}}{l_{2015}} = \frac{92.8}{-35.2} = -2{,}6.$$

The accrual of ratio was $\Delta l = 92{,}8 - (-35{,}2) = 128$ units. The sign " – " indicates a qualitative change in the trends under study from negative values to positive ones. The disadvantage of the analysis is the insignificant accuracy of the results caused by high uncertainty in the

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

behavior of the curves. Also it should be noted the impossibility of direct comparison of coefficients k for the enterprise and its divisions.



(a) (b) (c)

Figure 3 – Commodity production of workshop in 2015 (a); in the period of 2015-2016 (b); in the period of 2015-2017 (c). The ordinate axis shows the actual monthly prime cost of main production, monetary units (*). The abscissa axis shows the monthly commodity output of the workshops

We can make a general conclusion that the analysis of the source data does not allow to determine the nature of changes in production efficiency reliably both at the enterprise level and at the level of its structural divisions.

The use of potentials helps to identify trends in the enterprise. In particular, Figure 1 (c) shows the ratio of the accumulated potentials of an enterprise. The inclination angle of the straight line tangential to the potential line at the point corresponding to the current values of the potentials illustrates the level of the technological structure of the object under study at the analyzed time point. Interpretation of the chart is that the angle tangent of the slope of the tangent to the potential curve demonstrates the competitiveness of the product in the corresponding period of the life cycle. It should be emphasized that the smoothness of the potential lines allows us to use them in predicting the state for long periods of time as it is shown in the figure. We would like to note that the production of different types of products in the enterprise leads to the necessity of calculating the potentials of the used resources and the potentials of the results separately for each type of product. The concavity of the curve indicates the innovative development of the enterprise. On the contrary, its convexity indicates the degradation of the enterprise competitiveness and its corresponding high-tech products. The direct line of dependence of potentials indicates the stabilization of the enterprise technological structure. It is possible for the above case to state an almost constant value of the technological structure level for a long period of time – more than 7 years despite the enterprise changing indicators for various reasons. This allows us to make a forecast for the future with high confidence. Meanwhile, it is necessary to note a significant difference in the use of the proposed methodology from the known ones. In accordance with the methodology of potentials the state of the object under study but not individual variables or processes is predicted.

REFERENCES

1. Bailey R., Myers S. Principles of Corporate Finance. M.: Olymp-business, 1997. – 1086pp. (in Russian)
2. Ivashchenko N. P. Methodical foundations and organization of scientific and technological forecasting in developed countries / ed. N. P. Ivaschenko. M.: MAX Press, 2013.– 296pp. (in Russian)
3. Komkov N.I., Bondareva N.N., Romantsov V.S., Didenko N.I., Skrypnyuk D.F. Methodological and organizational framework for managing the development of companies. Peter the Great St. Petersburg Polytechnic University; The Institute of Economic Forecasting of the Russian Academy of Sciences. Moscow, 2015. – 520pp. (in Russian)
4. Mustaev I. Z. Economic models of innovation. Ufa: RIK USATU. 2012, – 201pp. (in Russian)
5. Mustaev I. Z. Sociotechnical models of innovation. Ufa: RIK USATU. 2017, – 173pp. (in Russian)
6. Sharp W., Alexander G., Bailey J. (2001). Investments. M.: INFRA-M, 2001, – 1028pp. (in Russian)