Dynamic model of production enterprises based on accounting registers and its identification

R T Sirazetdinov¹, A V Samodurov, I A Yenikeev¹, D S Markov¹

¹ Kazan National Research Technical University. AN Tupolev KAI

Abstract. The report focuses on the mathematical modeling of economic entities based on accounting registers. Developed the dynamic model of financial and economic activity of the enterprise as a system of differential equations. Created algorithms for identification of parameters of the dynamic model. Constructed and identified the model of Russian machine-building enterprises.

1. Dynamic economic and mathematical model of the enterprise

In this paper are reviewed the problem of economic and mathematical modeling of industrial enterprises. The dynamic model of financial and economic activity of the enterprise was developed as a system of differential equations, which builds on the accounts. Algorithms for identification of parameters of the dynamic model have been developed. Work is carried out in line with the scientific directions initiated by academician of the Academy of Sciences of the Republic of Tatarstan T K Sirazetdinov at the Kazan Aviation Institute since 1970s.

In the framework these studies developed a general block diagram of the functioning enterprises based on accounting registers (Fig.1.) Principles of dynamic economic and mathematical modeling at the system of differential equations, algebraic equations and inequalities based on accounting records.

[4] In this article the method of identification of dynamic models based on financial statements that are implemented in the construction of the business model of manufacturing enterprise.

On the structural model the accounts are grouped by their purpose and presented as an blocks of the model. Communications between the blocks defined by correspondence of accounts and presents with a physical or financial flows.

Each block is described by differential and algebraic equations and inequalities. The whole model is a system of differential and algebraic equations with variable structure and corresponds to a chart of accounts of the enterprise.

In the base of a mathematical model of the enterprise laid the mathematical model of accounting bills, which in algebraic form is described as follows:

\[
S = S_0 + O_{\text{in}} - O_{\text{out}},
\]

где, \(S\) – residue of resources at a certain time \(t\);

\(S_0\) – residue the resources at the initial time \(t_0\);

\(O_{\text{in}}\) – the flow of resources in a time interval \((t_0, t]\);

\(O_{\text{out}}\) – produce of resource in the time interval \((t_0, t]\).
The above presented formula (1) in differential form is written as follows:

\[ \frac{ds}{dt} = o_{in} - o_{out}, \quad S(t_0) = S_0, \quad \text{with} \quad S > 0; \]
\[ o_{in} \geq o_{out}, \quad \text{with} \quad S = 0; \]  

where, 

- \( o_{in} \) – the flow of resources at time \( t \) (input);
- \( o_{out} \) – the flow release resources at time \( t \) (output).

In some cases we have communication between input and output flows as a delay. For example, the amount paid to suppliers for material resources at some time \( t \), the unit enters the "suppliers", and after a certain period of time \( \tau \), coming out of the unit at the same rate, only in the form of delivery. Blocks of this kind are described by the following equation:

\[ o_{in}(t) = o_{out}(t - \tau). \]  

where, \( \tau \) – the average time of resource spent in the block, for example, the average time delay between the delivery of material assets and its payment, etc.

The above formula (3) represents a net delay, and to identify its parameters need to know the background of the process, which is not always possible. So often to describe the use of such a formula depending on the inertial delay:

\[ \tau \frac{do_{out}}{dt} + o_{out} = o_{in}; \quad o_{out}(t_0) = o_{out0}. \]  

Thus, all blocks of the model may be of two types - type "warehouse" - expression (2), and the type of "delay" - the expression (4) is a differential equation. Links between blocks are described by algebraic equations.

For the identification of the model parameters used enterprise accounting data, because they are almost directly correspond to the blocks of the structural model and show sufficient detail the state of
the entity. However, some parameters of the model can not be directly derived from the financial statements and require special identification algorithms.

2. Identification of system parameters

The initial state of the system is determined by the balances at a given time t. As an example, such parameters include the balance of the financial result, the residue of finished products for sale as WIP residue etc.

Time parameters of the system, ie, delays associated with the time difference between input and output streams are identified by the formula of Professor Sherr:

$$\tau = \frac{\bar{S} P}{O}$$

Where, \(\bar{S}\) – the average balances on the account;

\(P\) – the duration of the analyzed period;

\(O\) – turnover for the period under review.

Average balances may be in the arithmetic mean formula

$$\bar{S} = \frac{S_B + S_K}{2}$$

Where, \(S_B\) – the balance of the account (s) at the beginning of the reporting period;

\(S_K\) – the balance of the account (s) at the end of the reporting period.

Temporal parameters of the system include, for instance, the time of production, time writing off fixed costs, the delay between payment to the supplier and obtaining resources, the delay between the receipt of resources and their payment, the delay between receiving the loan and the payment of the loan, etc.

Besides there are some system tuning parameters, which are values of these or other factors of production, which directly or indirectly affect the character of the movement of commodity and money flows. These parameters are on the one hand controls flow from another company reflect external factors affecting its operation.

The external factors include commodity prices, consumer purchasing power, taxation, etc. These values are generally set by experts. The internal factors can be attributed to the example of the economic policies in the enterprise. Shares of provided resources on credit and prepaid share of supplied goods on credit and prepaid production costs, etc.

Control these parameters and system solutions of equations in time, we get the options forecasting operation of the business in different types of external and internal factors.

3. Conclusion

Identification algorithm proposed by the authors, are implemented in Microsoft Excel environment with the use of the program on the algorithmic language VBA. A comparison of the predicted values of the parameters of the production facility with actual facts occurred. The results indicate quite close agreement of a number of identified parameters and their actual values.

4. References

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