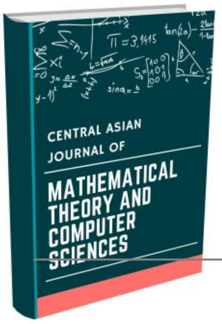

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METHODS OF ECONOMIC AND MATHEMATICAL MODELLING IN INTERNAL PRODUCTION PLANNING

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Abstract

The article shows the essence of mathematical modeling, its peculiarity as a method. Mathematical models in solving problems with economic content are presented.

A R T I C L E I N F O

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The process of developing innovation programmes (these programmes are aimed, among other things, at solving the problems of financial recovery and getting out of bankruptcy) for microelectronics enterprises is associated with the need to take into account a significant part of specific factors that distinguish these enterprises from the bulk of industrial enterprises. Taking into account these factors predetermines the use of the system analysis apparatus, a number of elements of which should be adapted to the peculiarities of production. This is most conveniently illustrated by the tools of economic-mathematical modelling - a certain set (system) of economicmathematical models that optimise the parameters of innovative development of both a set of enterprises (industries, state companies) and individual enterprises.

The planning method is understood as a specific method, technical technique, by means of which any planning problem is solved, numerical values of indicators of forecasts, programmes and plans are calculated. In the theory and practice of planning activities over the years, a significant set of different methods of developing forecasts and plans has been accumulated.

Formalised methods include extrapolation methods and methods of economic and mathematical modelling. They are based on mathematical theory.

Methods of economic and mathematical modelling or optimal planning allow solving the problem of finding the minimum or maximum values of the target function. The main provisions of economic-mathematical modelling consist in the definition of the methodology of selection and setting of the optimality criterion, formalisation of the model of functioning of the control object, construction of restrictions, on resources and tasks, development of the algorithm of numerical analysis of the model, analysis of the actual development and improvement of the developed means of forming decisions in production management.

Economic and mathematical models can be classified on various grounds.

1. According to the intended purpose, the models can be divided into:

- theoretical-analytical, applied to the study of the most general properties and regularities of the development of economic processes;
- applied, used to solve specific problems.

2. By levels of economic processes under study:

- production and technology;
- socio-economic.

3. By the nature of reflection of cause and effect relationships:

- deterministic;
- non-deterministic (probabilistic, stochastic), taking into account the uncertainty factor.

4. According to the way the time factor is reflected:

- static. Here, all dependencies refer to a single moment or period of time);
- dynamic, characterising changes in processes over time.

5. By the form of mathematical relationships:

- linear. They are the most convenient for analyses and calculations, so they are widely used;
- non-linear.

6. By degree of detail (degree of coarsening of the structure):

- aggregated ("macromodels");

- detailed ("micromodels").

Figure 1 presents economic and mathematical methods in the form of some aggregated groupings.

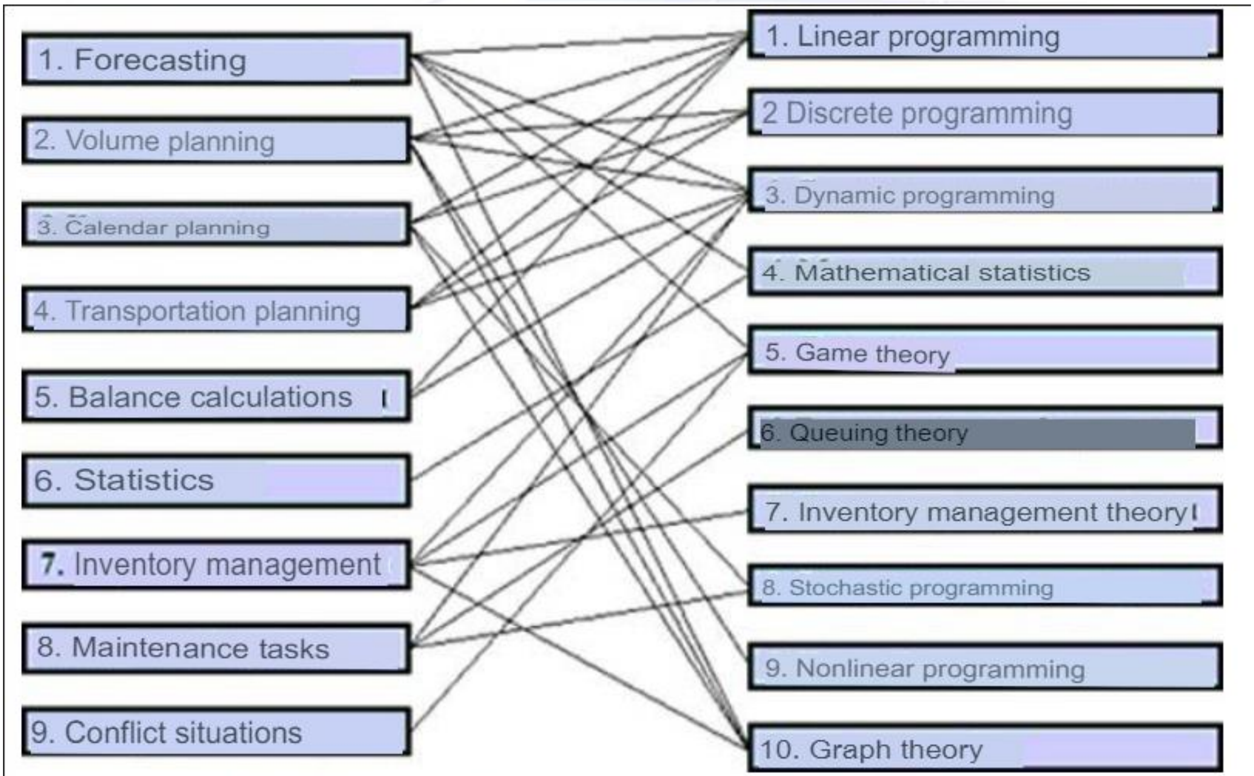


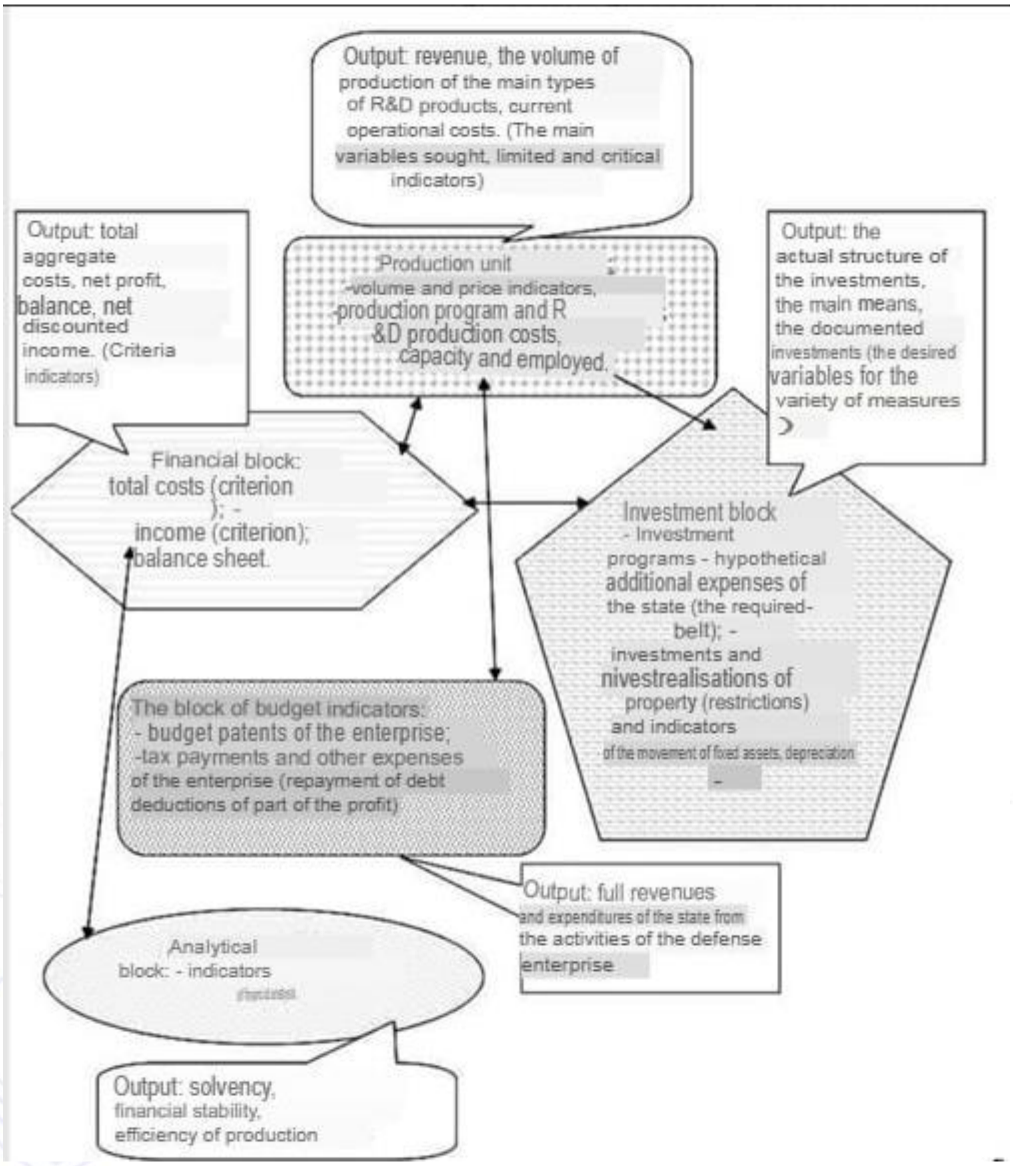
Fig. 1. The most important areas of application of the main EMM classes.

1. Linear programming - linear transformation of variables in systems of linear equations. This can include: simplex method, distributive method, static matrix method of solving material balances.
2. Discrete programming is represented by two classes of methods: localisation and combinatorial methods. Localisation methods include linear integer programming methods. Combinatorial methods include, for example, the method of branches and bounds.
3. Mathematical statistics is used for correlation, regression and variance analysis of economic processes and phenomena. Correlation analysis is used to establish the closeness of the relationship between two or more stochastically independent processes or phenomena. Regression analysis establishes the dependence of a random variable on a non-random argument. Analysis of variance - establishing the dependence of the results of observations on one or more factors in order to identify the most important ones.
4. Dynamic programming is used to plan and analyse economic processes in time. Dynamic programming is represented as a multi-step computational process with sequential optimisation of the target function. Some authors also include *simulation modelling*.
5. Game theory is a set of methods used to determine the behavioural strategy of conflicting parties.
6. Mass service theory is a large class of methods where various parameters of systems characterised as mass service systems are estimated on the basis of probability theory.
7. The theory of inventory management combines the methods of solving problems, which in a general formulation are reduced to the determination of the rational size of the stock of any product under uncertain demand for it.
8. Stochastic programming. Here the parameters under study are random variables.
9. Nonlinear programming is one of the least studied mathematical areas in relation to economic phenomena and processes.
10. Graph theory is a branch of mathematics, where on the basis of certain symbolism a formal description of interconnectedness and interdependence of a set of elements (works, resources, costs, etc.) is presented. So far, the greatest practical application has been given to the so-called *network graphs*.

The economic and mathematical model in the operational and production planning of the microelectronics enterprise, which carries out research and development work and has pilot production, is built taking into account the following conditions (along with the above mentioned):

1. The two main areas of activity are R&D and product manufacturing.
2. Production of products for the State Defence Order (including under state export contracts).
3. Predetermined nomenclature and subject matter of R&D and products produced under the GOZ.
4. Underutilisation of main production facilities.
5. Necessity of renewal and modernisation of mobilisation capacities.
6. Regulated pricing of R&D and GOZ products that does not correspond to the real costs of R&D and production.
7. Necessity of implementation of investment projects and programmes of the enterprise.

The proposed model represents organisational-economic, innovation, investment and financial processes, so for the base year the information on technical-economic, financial status, existing production technology, development programme is set. The structure of input and output (sought) information for the model is shown in Fig. 2.



In general terms, the economic and mathematical model of an enterprise is summarised as follows.

Production block. Let the enterprise in each year of the programme period produces products under GOZ and export contracts, performs R&D in certain volumes. The base prices for all types of products and R&D costs, forecast indices of changes in these prices and costs are set. In addition, the volume of production of civilian products is specified. Then, in each year, the volume of work performed in value terms will be equal to the sum of production volumes of all types of products and R&D performed multiplied by the corresponding prices and indices of their change.

In principle, under the existing GOZ pricing procedure, when the parent organisation sets the price for components on the basis of the value of the contract with the top-level organization without taking into account the peculiarities and costs of the enterprise producing components, the latter has a desire (in analytical interests) to determine a "fair" price for its products. In this case, either the index or the price of each type of product itself may appear in the model as the sought variable.

The same can be said for R&D. The price of products produced under export contracts may change in the programme period under the influence of market factors and can also be represented as a demand variable. The volume of output may also be the variable of interest. In this case, the total volume of work performed in roubles can act as a criterion indicator, the value of which can be maximised in optimisation calculations.

Items or R&D types with the highest production volumes can be selected as representatives of the main nomenclature of activities (the limitation of the number of items is related to the problem of dimensionality of the problem; if the nomenclature of activities is relatively small, the production volumes of all items can be considered as the required variables). In this case, the production volumes for the selected part of the nomenclature are considered as the sought variables, the values of which can be searched for within given limits, e.g. labour input, throughput of equipment, etc. The production volumes for the selected part of the nomenclature are considered as the sought variables.

The production block of the model provides calculations of economic indicators of costs of works for each year of the programme period - both for each allocated item by cost items and total costs for the whole scope of works by cost elements:

- direct costs associated with the performance of work by type in the base year and in general for the entire scope of work (production cost estimates). Direct costs can be calculated by types of costs for: fuel, materials, wages (with accruals), energy for technological purposes, etc. Taking into account cost change indices, direct costs are calculated for all years of the programme period;
- overheads (taking into account indices of change by years of the programme period) and depreciation of fixed capital.

The production block also interacts with the investment block by calculating the efficiency of the investment programme measures related, for example, to output and overhead cost savings. In each year of the programme period, the obtained (projected) effect from the implementation of innovative measures by variants in roubles is deducted from the full cost of work performed.

In particular, the effect of increased capacity can be expressed through additional output. In this case, it is calculated as the sum of the effects on overheads and other costs in the current year for all variants of innovative measures multiplied by an integer variable (1 or 0) reflecting the implementation or non-implementation of the innovative measure (variant) and the effects associated with the output of products for which direct (variable) costs have changed.

Restrictions on the use of material (in value terms) and energy resources can be introduced into the general model, for example, to evaluate measures to reduce material intensity of production and energy saving.

It should be noted that all specific indicators of electricity consumption by types of work may change as a result of either the implementation of special measures on electricity saving provided for in the investment programme, or as a result of the implementation of technological measures of the innovation programme, or as a result of the implementation of innovations, organisational and technical measures aimed at electricity saving and requiring monetary expenses. Therefore, the financial block for the latter should include in the aggregate costs the corresponding costs for electricity saving.

Similar conditions are written for thermal energy. The model can also provide constraints for individual types of materials.

Investment block. The overwhelming majority of microelectronics enterprises need to modernise and upgrade their production, stabilise their financial condition; only after these tasks are solved, it will be possible to talk about full-fledged innovative development.

In the investment block of the model it is possible to provide for the movement of fixed (production and non-production) assets of the enterprise in the programme period. The input of fixed assets is carried out due to the implementation of the Investment Programme activities, and the average annual physical disposal of fixed assets value is determined by the share of the total value.

The values of the output indicators of the investment block are related to other blocks of the model: with financial - through the indicator of investment costs per ruble of work performed, included in the aggregate costs of enterprise development and through the indicator "fixed assets" (without depreciation) used in the balance sheet of the enterprise; with budget - through the limitation on the total amount of investment for the implementation of the Innovation Programme.

Financial block. In the process of optimisation calculations, all financial indicators are also considered: resulting indicators - revenue, profit; cash flow indicators; balance sheet. In this block the total costs of the enterprise for economic activity are calculated.

It is possible to impose a condition on the total value of aggregate costs not to exceed a given value, for example, the one established in previous years:

If the total cost acts as a criterion value, the criterion function of the optimisation problem should tend to minimise.

The use of total costs, which act as cash outflows, makes it possible to use the method of discounted cash income (DCI) to assess the economic efficiency of the enterprise. As you know, it is based on modelling and analysis of cash flows (CDI), formed by the forthcoming costs and the results obtained in this case. In the form of inflows - results - can be the volume of work performed or full revenue of the enterprise. For optimisation purposes, the NPV indicator should tend to the maximum.

The analytical block calculates indicators of solvency and financial stability of the enterprise. For analytical purposes, this block may contain the condition of achieving a positive or normative value of any indicator in a certain year, for example, the equity ratio.

Thus, the implementation of the described model can be presented as the optimization of technical, economic and financial recovery of the enterprise in the process of implementation of its innovation programme. The results of problem solving by the enterprise model are transferred to the industry level, the implementation of the model of which corrects the main parameters of the industry development. On the basis of the optimised nomenclature and volumes of work obtained in the enterprise model, the problem of optimising the ratio of R&D and production can be solved.

Thus, an economic and mathematical model is understood as a mathematical description of the economic process and object under study. This model expresses the regularities of the economic process in abstract form with the help of mathematical relations. The use of mathematical modelling in economics allows to deepen quantitative economic analysis, expand the field of economic information, intensify economic calculations.

Application of economic and mathematical methods allows to significantly improve the quality of planning and obtain additional effect without involving additional resources in production.

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