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Mathematical Modelling Justification of Financial and Economic Parameters of Enterprises

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Abstract: Prediction of the effective development of the enterprise implies the need for mathematical modelling of the leading financial and economic indicators of its life. High variability of approaches to the assessment and selection of indicators determines the existence of various approaches to their modelling.The complexity and complexity of the structure of economic activity of the enterprise, suggests the possibility of splitting the general situation into more specific cases, which allows you to apply a logical procedure to them, which is a simulation.The use of mathematical modelling allows you to speed up the economic analysis, contribute to a complete account of the influence of factors on the results of operations, increase the accuracy of calculations. It allows you to get a clear idea of the investigated object, to identify relationships, analyze features and give an accurate forecast of the development and changes in the basic financial and economic parameters of the enterprise.

Keywords : Economic Parameters, Enterprise, Financial Parameters, Mathematical Modelling.

I. INTRODUCTION

Mathematical modelling of economic phenomena or processes is an essential tool for financial analysis [1]. It allows you to get a clear idea of the investigated object, to characterize and quantitatively describe its internal structure and external relations [2-4].

A model is a conditional image of an object that forms an idea of it in some form different from the real existing object. The model displays the basic characteristic properties of an object in some abstract way. Economic and mathematical modelling makes it possible to study the purpose not directly, but through consideration of another object similar to it and more accessible - its model. The economic-mathematical model should be adequate to reality, reflect the essential aspects and relationships of the studied object.

Mathematical modelling of the studied economic object (process) is the basis of economic research, as it allows you to describe the quantitative laws of this process in the form of mathematical expressions [4-7].

The modelling process, including economic and mathematical, includes three structural elements: the object of study; subject (researcher); a model mediating the relationship between the knowing subject and the knowable object, which is clearly shown in the diagram Fig.1 [8-9].

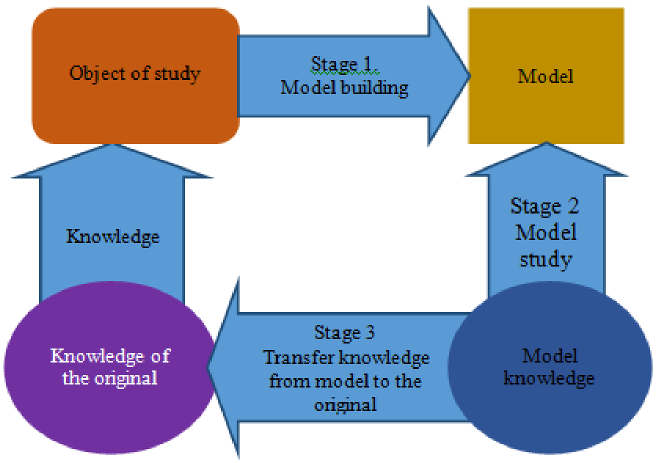

Fig. 1. The essence of the process of mathematical modelling

The most crucial concept in economic and mathematical modelling, as in any modelling, is the concept of model adequacy, i.e., the correspondence of the model to the modelled object or process [10-11]. The adequacy of the model is to some extent a conditional concept since there can be no full correspondence of the model to a real object, which is also characteristic of economic and mathematical modelling. When modelling, we mean not just adequacy, but conformity in those properties that are considered essential for the study.

A general idea of all the factors that distinguish a high-quality mathematical model is presented in Fig. 2.

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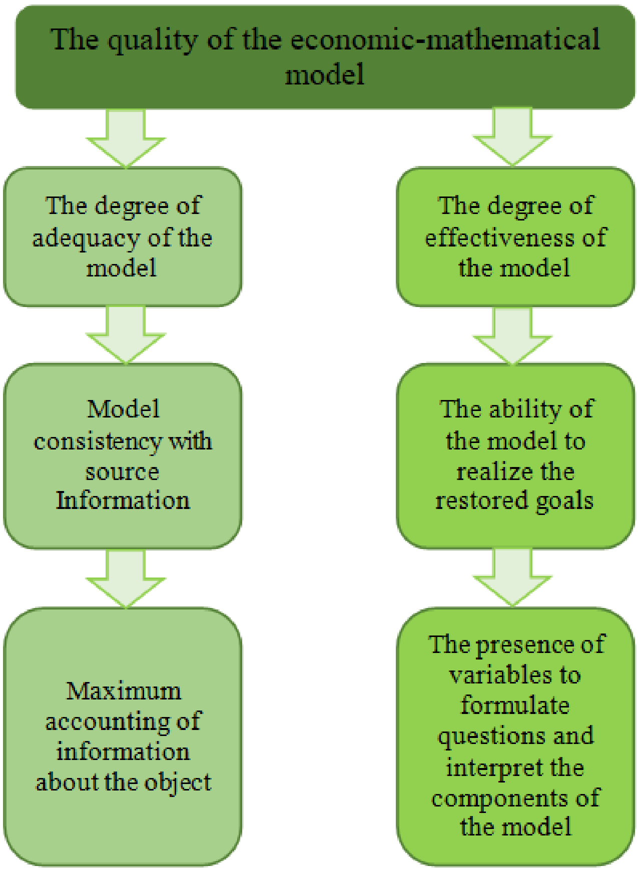

Fig. 2. Quality factors of the mathematical model of financial and economic indicators of a specific object (enterprise)

The practical tasks of mathematical modelling of financial and economic indicators are:

- analysis of commercial objects and processes;
- economic forecasting, prediction of the development of economic processes;
- development of management decisions.

It should be noted that the information obtained from economic-mathematical modelling can not always be used directly as ready-made management decisions. More often, it is used as a "consulting" means, the adoption of management decisions themselves remains with the management personnel of the enterprise.

II. CREATING THE MATHEMATICAL MODEL.

The modelling process can be divided into three stages:

1) analysis of theoretical patterns inherent in the studied phenomenon or process, and empirical data on its structure and features; based on this analysis, models are formed;
2) determination of methods by which it is possible to solve the problem;
3) analysis of the results.

An essential point in the first stage of modelling is a clear statement of the ultimate goal of building a model, as well as determining the criterion by which various solutions will be compared. In economic analysis, such criteria may be:

- the largest profit;
- lowest production costs;
- maximum load of equipment;
- labour productivity, etc.

The process of mathematical modelling can be divided into four main stages:

Stage 1: Formulation of laws linking the main objects of the model, i.e. writing in the form of mathematical terms of formulated qualitative ideas about the relationships between the objectives of the model.

Stage 2: Study of mathematical problems to which mathematical models lead. The main question is the solution of the direct problem, i.e. obtaining, as a result of the analysis of the model, the output data (theoretical consequences) for further comparison with the results of observations of the phenomena studied.

Stage 3: Correction of the accepted hypothetical model according to the criterion of practice, i.e. clarification of the question of whether the results of observations are consistent with the theoretical consequences of the model within the accuracy of representations. If the model was completely defined - all its parameters were given - then the determination of the deviation of the theoretical consequences of the observations gives a solution to the direct problem with the subsequent assessment of the deviation. If departures go beyond the accuracy of comments, then the model cannot be accepted. Often, when building a model, some of its characteristics remain undefined. Application of the practice criterion to the assessment of a mathematical model allows us to conclude that the provisions underlying the subject to study (hypothetical) model are correct.

Stage 4: Subsequent analysis of the model in connection with the accumulation of data on the phenomena studied and modernization of the model

The algorithm for solving the problem by the methods of economic and mathematical modelling can be represented in the form of a diagram Fig. 3.

In economic analysis, mainly mathematical models of the studied phenomena or processes are used. There are mathematical models:

- with quantitative characteristics specified in the form of formulas;
- numerical models with specific statistical features;
- logical recorded using rational expressions;
- graphic expressed in graphic images.

The stage of building the model requires some knowledge about the original object. Cognitive capabilities of the model are since the model reflects any significant features of the object - the original. The question of the necessary and sufficient degree of similarity between the original and the model requires specific analysis. Obviously, the model loses its meaning both in the case of identity with the original (then it ceases to be the original) and in the case of excessive differences in all essential respects from the original.

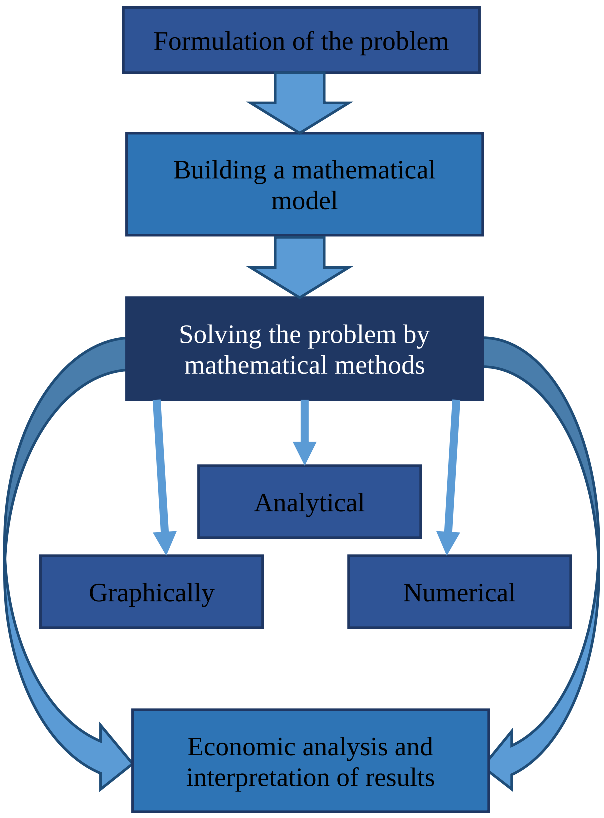

Fig. 3.The algorithm for applying mathematical modelling to solve economic problems

Thus, the study of one side of the simulated object is carried out at the cost of refusing to reflect the other parties. Therefore, any model replaces the original only in a strictly limited sense. It follows from this that for one object, several "specialized" models can be built that concentrate attention on certain sides of the object under study or characterize the object with different degrees of detail.

From an economic point of view, optimal solutions obtained using economic-mathematical modelling have the following basic properties:

1) The optimality of the answer depends on the goals set in the process planning. For example, the choice of the type of transport according to the criterion of the cost of transportation will differ from the choice of the criterion of speed.
2) The optimality of the solution depends on the current economic situation (in other words, the optimum is always concrete; it cannot be calculated abstractly).
3) Significant changes in the optimal variant occur only with significant changes in the situation - this property is called the stability of the basis of the optimal plan for relatively small changes in conditions (that is, optimal solutions can be found reliably, despite the approximate nature of almost all economic information).
4) In determining the interdependence of decisions on all objects of the economy, the feedback of objects and the costs of feedback are of particular importance. For example, if enterprises A and B consume the same limited resource, an increase in the share of enterprise A reduces the share of enterprise B (feedback).

III. METHODOLOGY

As a methodology, we consider the solution of the problem of choosing the range of products under various restrictions. The construction of a mathematical model to solve this problem will be based on the financial and economic indicators of the enterprise, which will allow us to come to the appropriate conclusions.

The main goal of creating an assortment is to maximize profits, i.e. it is necessary to determine under what economic parameters, the enterprise will be able to get the maximum effect.

We write the task of maximizing profit in the form of a formula:

$$G = \sum_i (p_i - v_i) \cdot x_i - F \rightarrow max \quad (1)$$

where *G* is the target criterion, p is the price of the i-th product, *v* is the direct cost of manufacturing the i-th product, *F* is the overhead, *x* is the output of the i-th product.

Given the constancy of overhead costs F, the task of maximizing profit is equivalent to the task of maximizing marginal profit:

$$M = \sum m_i \cdot x_i \rightarrow max \quad (2)$$

$$m = p - v \quad (3)$$

where *M* is the marginal profit of the enterprise, and *m* is the marginal profit of a unit of production.

The task of optimizing the increase in profits by optimizing the assortment, we will solve using the single-criterion single-resource optimization “cost-effectiveness”, providing a choice of priority areas according to the criterion

$$\alpha_i = \frac{m_i}{a_{ik}} \rightarrow max \quad (4)$$

where *k* is the number of the scarce resource.

Depending on the type of restrictions at an industrial enterprise, the following submodels of assortment optimization can be considered:

- analysis criterion: marginal profitability;
- analysis criterion: specific marginal profitability;
- analysis criterion: bottlenecks in production;
- analysis criterion: EVA of the product (no restrictions);
- analysis criterion: net income (for long-term projects).

Consider each option in more detail.

A. Margin profitability.

Traditionally, under the “Resource” in the formula for the purposes of assortment analysis are considered “Direct costs”, which are calculated on the basis of estimates. In this case, the performance criterion is:

$$\alpha_i = \frac{m_i}{a_{ik}} \rightarrow max \quad (5)$$

$$\alpha_i^{MP} = \frac{m_i}{a_{ik}} \to max \qquad (6)$$

This is a way of writing off resources (material, energy, labor) to costs, it can be used in the analysis of products with approximately the same turnaround time, or if the scarce type of resource is determining in the cost structure.

B. Specific Margin Profitability (URI).

When funding is limited, the performance criterion is the indicator

$$\alpha_i^{\varphi} = m_i/I_i \to max \qquad (7)$$

where *I* is the value of an investment in output.

In the task of determining the current issue, it is assumed that non-current assets are already available, and financing is necessary only for existing assets.

The task of accounting for the actual use of working capital in specific types of products is not simple. One of the simplifications is the use of a turnover period. Express investment in working capital through revenue and turnover:

$$I = S \cdot k_{wc} \qquad (8)$$

After transformations

$$\alpha_i^{\varphi} = \alpha_i^{MP}/(1+\alpha_i^{MP})/k_{wc_i} \to max \qquad (9)$$

Thus, subject to restrictions on current assets, the priority of production is determined by both marginal profitability (direct profitability per turnover cycle) and the speed of turnover.

C. Bottlenecks in production.

If the bottleneck in sales and production is not financing, but a technological or resource constraint, use the indicator correctly:

$$\alpha_i^{L} = m_i/R_i \to max \qquad (10)$$

where *R* is the value of the scarce resource (raw materials, personnel, capacity).

If the limitation is human resources, then the criterion for choosing priority actions will be:

$$\alpha_i^{L} = m_i/L_i \to max \qquad (11)$$

where *L* is the value of labour (personnel) resources for output.

D. EVA product (no resource limits).

In the absence of resource restrictions, the logic of the result/resource relationship is not suitable. The option of accounting for restrictions is through the introduction of a fee for the resource. An analogue of the EVA indicator, economic added value, can serve as such an indicator. But EVA is used for the enterprise as a whole. In fact, this indicator introduces a fee for the use of financial resources in the form of capital. We use a similar indicator in the form

$$\alpha_i^{EVA} = m_i - \sum_{j=1}^{J} c_j \cdot R_j \to max \qquad (12)$$

where *c* is the coefficient of payment for the resource, *R* is the value of the consumed resource, *j* is the index of the resource, **J** is the number of considered resources.

The resources may include working capital, leased space and other resources. A part of the expenses related to invoices (rent, interest on loans) is linked to the output, that is, their transfer to direct costs.

E. Net present value (for long-term projects).

Margin profit indicators "work" in the case of bulk goods with a turnover period of less than or comparable with the analysis period. If the turnover period of a product is much longer than the analysis period (for example, for heavy engineering, aircraft manufacturing, shipbuilding, as well as agriculture, construction), then the concept of marginal profit for a period (month, quarter, even a year) is not indicative. For example, what is the monthly benefit in crop production if "autumn day feeds the year"?

In this case, as an “effect”, it is necessary to consider the indicator of net present income for all periods of the product life cycle:

$$NPV_i = \sum_{t=1}^{T} \frac{m_{t,i}}{(1+r)^t} - I_i \to max \qquad (13)$$

Note that when choosing priority long-term products, the main criterion will be:

$$\alpha_i^{T} = NPV_i/R_i \to max \qquad (14)$$

IV. CARRYING OUT THE EXPERIMENT

As an experiment, we consider the question: what additional marginal profit can be obtained by redistributing resources to more profitable ones?

The company produces 4 types of products, shown in table 1, each of them has several economic indicators. In this experiment, the financial cycle is one month.

Table- I: Financial and economic parameters of the production of goods

Products	Revenue, K USD	Variable costs, K USD	Price, USD	Volume of sales	Unit costs, USD
Product 1	2000	500	220	9091	55
Product 2	1000	333	180	5556	60
Product 3	5000	3846	430	11628	331
Product 4	500	526	120	4167	126
Total	8500	5205		30441	

First of all, we will determine the current marginal profit, for one product it will be:

$$M = \sum m_i \cdot x_i = (220 - 55) \times 9091 = 1.500.000\ USD$$

Similar calculations for other products, data on margin profitability of each product are summarized in Table 2.

Table- II: The data of the mathematical model for marginal profit and profitability

Products	Marginal Profit, K USD	Marginal profitability, %
Product 1	1500	300%
Product 2	667	200%
Product 3	1154	30%
Product 4	-26	-5%
Total	3295	63%

The constructed mathematical model, albeit very simple, nevertheless makes it possible to understand in which indicators of the enterprise there are weaknesses, which makes it possible to make a management decision to change the current situation.

If there is a limiting criterion in the form of limiting the volume of production due to the availability of a scarce resource, we will take this indicator into account as a factor that does not allow increasing the volume of production by more than 20% of the given. Table 3 shows the redistribution of working capital, taking into account the achievement of the greatest profitability indicator, in particular by reducing the production and sale of goods providing low margin profitability.

Table- III: Calculation of the redistribution of working capital to maximize profits

Products	Marginal profitability, %	Revenue, K USD	Variable costs, K USD	Profit margin, K USD	Quantity change, %	Modified sales, K USD	Working capital increase, K USD	Change in margin profit, K USD
Product 1	300%	2000	500	1500	120%	2400	100	300
Product 2	200%	1000	333	667	120%	1200	67	133
Product 3	30%	5000	3846	1154	102,5%	5125	96	29
Product 4	-5%	500	526	-26	50%	250	-263	13
Total	63%	8500	5206	3294	106%	8975	0	475

V. RESULT AND DISCUSSION

The analysis shows that to achieve a given indicator of profit maximization, it is necessary to change the production volume of individual goods from -50% (partial reduction of product 4) to + 20% (increase in production volumes of product 1 and product 2).

From the most disadvantageous goods (even with negative margin profitability), working capital is directed to more profitable ones, until the maximum sales volume is reached. Additional marginal profit is 475 thousand dollars, or 14%, which is undoubtedly a very positive result.

Moreover, if overhead costs are equal to 3,000 thousand dollars, then the profit will increase from 294 thousand dollars to 770 thousand dollars or 162%, but in such a situation, additional costs for scarce types of resources may increase.

In general, the analysis shows the possibility of making managerial decisions based on the study of a mathematical model of financial and economic indicators.

VI. CONCLUSION

The possibilities of mathematical modelling allow us to realize what, when using other approaches, can be either excessively costly or impossible at all. Experience shows that setting the right task and choosing the right financial and economic indicators allows you to simulate any process and predict the potential development of the enterprise, and therefore make an informed decision on creating an effective strategy.

The mechanism of mathematical modelling of the financial and economic parameters of the enterprise enables experts to make informed economic decisions. Besides, this technique provides the ability to model and calculate any even the most incredible scenarios for the development of the economic situation.

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