Modeling parameters of the production project

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Abstract. This article presents the problem of modeling and optimization of large-scale production project parameters. The creation of model structures and algorithms is associated with a strict interdependence of their elements. The authors propose the creation of the target base center of the model, which is characterized by multi-aspect study, dynamism and flexibility. The model consists of eight blocks, four of which – blocks of resource modeling, and four others – blocks of organizational and economic modeling. The basis of the target base center is a cognitive system based on the work of the stochastic and deterministic method, which allows one to smooth complementarity and not to go beyond the established efficiency.

1. Introduction
The resumption of economic growth is impossible without the formation of strategic development, the basis of which is the modeling and evaluation of the effectiveness of long-term large-scale projects in the field of production. In the modeling of projects when solving problems with the choice of optimal production options, there is a need to form the parameters of technical and economic indicators. Such indicators may include elements of resource endowment, restrictions related to market conditions, the tax system, and others [1,2].

Innovation and production activity involves a certain set of scientific and technical, organizational, managerial, financial and commercial activities [2,3].

The basis for determining the feasibility of choosing the option and method of technical and technological renewal of production are the specific conditions for the implementation and nature of projects, scientific, technical and resource-technological potential, production profile and market requirements.

The life-cycle concept of long-term investment projects largely determines both the maximum volume of output, sales and profits, and the life cycle of specific technological innovations [3].

The implementation of long-term large-scale investment projects and the introduction of new equipment and production technologies with their subsequent commercialization, in contrast to the deterministic production and economic current processes, are stochastic in nature. This determines the need to analyze their impact on financial results, taking into account situational and simulation modeling, as well as multiple regression analysis [4,5].

In the conditions of actively developing digital economy it is necessary to introduce simulation modeling and augmented reality mechanisms into the production process. This will allow to check the production process for the absence of a conflict of interest, ensuring the optimal time of the production cycle and the definition of the necessary tools [6,7].
The digital economy is closely linked to the investment climate, optimizes costs and increases the profitability of production systems. In such circumstances, manufacturing enterprises must quickly adapt and implement technological advances in active cooperation with the scientific and technological community, as well as correlating their own interests with the needs and preferences of consumers and external partners [8]. It should be borne in mind that the purpose of the use of digital economy is to obtain understanding and refinement of the results of computer processing, and not in their multiplicity. Moreover, each specific task arising from a common goal should be solved both in an isolated state, and then, in the aggregate synergetic interaction. In accordance with this, the main purpose of modeling the main parameters of production projects is their optimization and improvement of economic efficiency.

2. Model and methods
The main problem in the creation of model structures and algorithms is their complementarity, that is, the strict interdependence of the subordinate units of the modeling system. The solution to this problem can be a flexible adaptation of different variations and combinations of models and the possibility of their restructuring, additions and integration depending on industry, technological, fundamental and methodological features [9].

For the system, solution of problems concerning the increase in the economic efficiency of production use of various models, which combine information, methodological, technological and technical software, is supposed.

Thus, the main concept of modeling algorithmization is a multi-aspect study of the target base center of the dynamic model system structure. Such model will make it possible to move this center vertically and horizontally with a flexible change of research directions and trends with an aggregated description of the project environment [10].

Alternately modeled, analyzed and supplemented basic units of the system can act as such center. These include:

- block of space-time resources of the project;
- block of information resources of the project;
- block of technological and technical resources of the project;
- block of project personnel resources;
- unit of cost formation and pricing;
- block of organizational modeling;
- block of financial resources of the project;
- unit of evaluation of economic efficiency of the project (Figure 1).

We briefly describe the content of each block. Eight blocks can be divided into two parts, four blocks each: four blocks of resource modeling and four blocks of organizational and economic modeling.

Block modeling of space-time resources determines the optimal geographical, geological, geophysical, geometric and temporal indicators. The block of modeling of technological and technical resources is focused on the optimization of the production process in terms of ease of labor, reducing the time of the production cycle, the effective use of the enterprise. At the same time, it is necessary to take into account the current state of scientific and technical development and satisfaction of the consumer market. Block modeling of information resources is associated with the timely receipt of the necessary data and their processing with the help of modern information software. The main tasks of the human resources modeling unit are:

- provision of the production process with the optimal number of employees of the relevant specialty and qualification;
- rationing and rational use of human resources;
- organization of the remuneration system;
- creation of a system of stimulation and motivation of employees.
Figure 1. The modelling of the production of the project.

The unit of cost and pricing modeling is responsible for the optimal value of each element of the formed cost price, and then the price taking into account production and market factors, as well as in accordance with the requirements of the tax system. The block of organizational modeling includes all aspects of the organization of management structuring, production process, financial, legal mechanisms, as well as the administration system. The block of modeling of financial resources is designed to reveal issues related to the sources of capital for the project, as well as to the provision of this capital. The economic efficiency modeling unit determines the feasibility of investments at each stage of the project.

In each block of modeling efficiency criteria on the basis of normative, statistical, methodological and expert positions are established. And in the moving target base center of the model there is a cognitive system for determining the optimal parameters, based on the stochastic Monte Carlo method and the deterministic Nelder-Mead method. Communication between the blocks of the model is carried out through this center, which makes it possible to solve the tasks without establishing a strict interdependence of the elements of the system.

3. Forming a target base of center ppm project

The definition of the Monte-Carlo method is to model a random variable whose purpose is to find the characteristics of their distributions.

The main advantage of the method is its simplicity and generality. A disadvantage that is slow convergence is eliminated by modifying the method. Random variables are of three types: random number generators, tables of random variables and pseudo-random number method, which is used on a computer. Pseudo-random numbers are obtained as a result of the work of some developed algorithm designed to generate these numbers. A minor drawback of this method is a limited number of pseudo-random numbers, but the periodic sequence is so large that in practice this is enough.

The basis of the developed algorithm based on the Monte Carlo method is the use of models of possible results. When these models are created, any parameter that is uncertain is replaced by a range of some values, i.e. probability distribution. Variable parameters can have different probabilities of consequences. For this algorithm, the distribution of a random variable with a uniform probability density within the range of acceptable values was accepted.

Let us consider the block diagram of the algorithm shown in Figure 2.
The first step is to set the number of parameters to be optimized \((n)\). This is followed by setting restrictions \((a_{1\text{min}}, a_{1\text{max}}, a_{2\text{min}}, \ldots, a_{n\text{max}})\). Then, after setting the initial conditions, you should determine the number of random throws \((\text{NumCalc})\). According to the developed algorithm, the random number generator starts its work, which performs random stuffing of parameter values in the given constraints according to:

\[
a = a_{\text{min}} + (a_{\text{max}} - a_{\text{min}}) \cdot \text{rand},
\]

\(\text{rand} \) – random number between 0 and 1.

The next step is to find the target function depending on the values of the parameters: \(OF_t = f(a_1, \ldots, a_n)\). The iterative calculation process will be repeated until the counter \(t\) is greater than \(\text{NumCalc}\): \(t > \text{NumCalc}\).

The result of optimization will be the numerical values of \(a\), which are extremes of \(OF\).

In this paper, we propose a combined approach to solving the optimization problem: at the first stage, the Monte-Carlo method is used, and then in the vicinity of the best solution, it is advisable to optimize by the Nelder – Mead method. This sequence of methods is necessary to clarify the result.

*Figure 2.* A block diagram of Monte-Carlo method.
The Nelder–Mead method refers to deterministic methods of unconditional optimization of a function from several zero-order variables \[6\]. As it is known, deterministic methods are based on the idea of locally optimal choice at each step, which generates the main drawback of the method—a low probability of finding a global extremum. The advantages include the following: applicability to nonsmooth and/or noisy functions and efficiency and compactness in the calculation. The principle of operation of the method is to compare the values of the function at the vertices of the triangle lying in the domain of the desired solution, and then move this simplex in the direction of the optimal value. In an iterative calculation, the worst vertex is replaced by a new vertex, where the function values take the «best» values. Thus, there is a formation of a new simplex, which tends to come to the extremum of the function.

Let us consider in more detail the operation of the algorithm based on the Nelder–Mead method. As an example, we use the \(k\)-th iteration. For each \(k \geq 0\) there is a non-degenerate simplex \(\Delta k\) consisting of \((n + 1)\)-th vertex, each of which is a point in \(R^n\).

For example, find the maximum of function \(f(x, y)\) from three variables.

To start the optimization according to the flowchart shown in Figure 3, you must specify the initial simplex \(V_n = (x_n, y_n), n = 1, 2, 3\). Next, you need to calculate the values of the function \(f(x, y)\) at each point \(z_n = f(x_n, y_n), n = 1, 2, 3\). Each \(k\)-th iteration begins by ordering the points as follows: \(z_1 \leq z_2 \leq z_3\).

![Figure 3. Block diagram of the Nelder–Mead method.](image-url)
We introduce notation: in $B$ (best) – «best» vertex, $G$ (good) – «good» vertex and $W$ (worst) – «worst» vertex. As a result, we have:

$$B = (x_1, y_1), \ G = (x_2, y_2), \ W = (x_3, y_3).$$

The method uses generally accepted coefficients:

- $\rho = 1$ – reflection coefficient;
- $\chi = 2$ – coefficient of tension;
- $\gamma = 0.5$ – truncation coefficient (reduction);
- $\sigma = 0.5$ – compression ratio.

Such values of coefficients were recommended by the creators of the method – Nelder and Mead. This recommendation is based on experiments with different combinations of values. These values allow the method to be efficient in both calculation time and convergence rate.

The principle of finding the best point $B$ two-dimensional space is shown in Figure. 4.

![Figure 4. Explanations for finding the optimal point.](image)

1 The initial triangle with vertices in $BGW$ (a) is given.
2 The construction of the following triangle (simplex) uses the middle point of the segment of the best side $(b, h)$: $M = \frac{B + G}{2} = \left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$. The formula for the point $R$ is: $R = M + (M - W) = 2M - W$.

3 Then, after finding the values of the function at points $C_1, C_2$ and the result is no better than at point $W$, the points $G$ and $W$ should be «pulled» to point $B$, using the truncation constant $(f)$. Let us replace $G$ with $G'$ and $W$ with $W'$. The obtained points are the midpoints of the segments.

The simplex after each iteration is constantly reduced to point $B$, discarding the worst point. The result is the coordinates of the extremum of the function.

4. Conclusion

Thus, in view of the advantages and disadvantages of the considered methods, it is advisable to combine deterministic algorithms with random search methods and situational modeling to correctly solve the problem of optimization of the production project separately and the production process as a whole.

The dynamic model of parameters of the production project with elements of their optimization allows one to react flexibly to changes of both external and internal environment. This happens by means
of the reconstructed and supplemented cognitive system of optimization of the target basic center. It, on the one hand, acts stochastically, and, on the other hand, is deterministic that smooths strict interdependence of production factors in coordination with the established values of efficiency of the project, and does not allow going beyond them.

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