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МЕТОДОЛОГІЧНІ ПІДХОДИ ДО ОПТИМІЗАЦІЇ В ЕКОНОМІЦІ

Анотація. Запропоновано математичний апарат, який використовує векторний аналіз. Це дає нові можливості в аналізі економічних процесів. Зведення нелінійних задач до спрощеної лінійної форми може призвести до втрат коренів, або груп коренів, системних помилок та хибних рішень. Використання лінійних моделей для постановки та вирішення економічних задач можливо тільки для практичних потреб певного, обмеженого кола задач з малою кількістю параметрів. Тому постала необхідність змінити методологічні підходи до математичного оптимального моделювання в економіці. Уникнення надмірного спрощення дає можливість математично об'єктивно поставити задачу і більш точно вирішити її. Сучасна обчислювальна техніка і пакети прикладних програм дозволяють вирішити такі задачі в загальному вигляді – без надмірного спрощення.

Ключові слова: математична модель, векторний аналіз, системний критерій, нелінійні параметри, системи лінійних рівнянь, постановка задачі економічного моделювання

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METHODOLOGICAL APPROACHES TO THE OPTIMIZATION IN ECONOMY

Abstract. A mathematical apparatus which foresees the use of vector analysis is offered. It provides new possibilities for the analysis of economic processes.

The reduction of nonlinear tasks to the simplified linear form can result in the losses of roots, or groups of roots, system errors and solutions subject to errors. The use of linear models for the set up of and for the solutions for economic tasks is possible only in application to the practical needs of the certain, limited number of cases with a minimum set of parameters. Therefore, there was a need to change the methodological approaches to the mathematical optimal modeling in the economy.

The avoidance of oversimplification gives the possibility to set up he problem in a objective mathematical way and to find the solution more precisely. The modern computing engineering and application packages allow deciding such problems in a general view – without oversimplification.

Keywords: mathematical model, vector analysis, systemic criterion, nonlinear parameters, systems of linear equations, statement of the problem of economical modeling.

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МЕТОДОЛОГИЧЕСКИЕ ПОДХОДЫ К ОПТИМИЗАЦИИ В ЭКОНОМИКЕ

Аннотация. Предложено математический аппарат, использующий векторный анализ. Это дает новые возможности в анализе экономических процессов. Сведения нелинейных задач к упрощенной линейной формы может привести к потерям корней, или групп корней, системных ошибок и ошибочных решений. Использование линейных моделей для постановки и решения экономических задач возможно только для практических нужд определенного, ограниченного круга задач с малым количеством параметров. Поэтому возникла необходимость изменить методологические подходы к математическому оптимальному моделированию в экономике. Избежание чрезмерного упрощения дает возможность математически объективно поставить задачу и более точно решить ее. Современная вычислительная техника и пакеты прикладных программ позволяют решить такие задачи в общем виде – без чрезмерного упрощения.

Ключевые слова: математическая модель, векторный анализ, системный критерий, нелинейные параметры, системы линейных уравнений, постановка задачи экономического моделирования

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Introduction. The mathematical modeling of economic processes and business processes, in particular, guarantees the accuracy, objectivity, completeness of risk awareness and the use of resources in modern economic science.

The problem is that, in the fact, an extremely outdated apparatus of mathematical modeling is still used in this area. The use of such an apparatus was conditioned by the possibilities of computing technologies which did not allow applying more appropriate algorithms and methodologies. In those days problem set up was limited by the capabilities of the computers of that time. Therefore, the problem should've been set up in such a way that the computing machinery of early models, with limited capabilities, was able to calculate it in the reasonable timeframe. Therefore, linear models began to be used for modeling. Nowadays, these models are still offered for the purposes of economic problems' solving. Let's mention that most of the real problems of technical, and, even more, economic character, have a nonlinear nature. Economics is impossible without nonlinear variables, for example: the exchange rates for the planned period, the prices for fuel in the long run, and so on.

Analysis of the research and problem statement. In the context of this problem, we consider the fundamental question of the feasibility of linear models' use in modern mathematical modeling of economic processes and try to suggest on the algorithms for solving such problems in case their linearization is impossible.

In most cases the use of linear equation systems for modeling economic systems is an unjustified stylization of practical tasks. Modern methods of mathematical modeling used for technical tasks are also oriented on solving nonlinear problems [1-4]. In many cases, simplification leads to absurdity [5-6]. There are the following reasons for economic problems.

First. Under today's conditions of rapid dynamic changes in economic indicators, the assumption about their linear change seems to be unconvincing.

Second. Prices for products, components, are not stable in the market conditions. Obviously, they will differ for different suppliers.

Third. The quality of the product and, accordingly, the consumer properties are different.

Fourth. Obviously, prices, quality, and consumer properties are not constant in time. Since the time intervals, when these parameters can be considered as stable, reduced significantly, the use of static systems became impossible. Dynamic systems are predominantly nonlinear.

This leads to the fact that, in practice, the use of classical mathematical interpretation is not expedient for a large number of real economic problems. We illustrate this on concrete examples.

Let's consider the first example of the classical widely known transportation problem [5].

Formulation of the problem. Let there be m suppliers of a certain product, which we will denote as $A_1, A_2,...,A_m$.. Each supplier has an absolutely identical load. Each of the suppliers ($A_1, A_2,...,A_m$) has, respectively, , $a_1, a_2, ..., a_m$ units of cargo. This is on the one hand. On the other hand, there are n consumers, which we denote $B_1, B_2,..., B_n$. Each consumer needs $b_1, b_2, ..., b_n$ of the specified product, respectively.

Obviously, real transportation is possible only when there are no obstacles for logistics operations of goods transportation from each supplier to each consumer [5]. In this case, the costs of transportation from the corresponding supplier A_i to the known consumer B_j ($i=1,m; j=1,n$) Cij for each transport should be known and fixed.

In addition to all this, there are still conditions that must be necessarily fulfilled [5].

First, the cargo from each supplier must be taken out all. Secondly, the needs of all consumers must be satisfied. It is desirable that the total quantity of goods shipped meets the total demand.

The problem requires the development of a transportation plan that will satisfy all these conditions [5].

Let's consider the real circumstances that the practitioner faces while performing such a task, even when there are objective factors that facilitate simplification of the problem. For example, the cargo is absolutely homogeneous (which is not necessary obligatory). Homogeneity in quality, size, price and types of goods in different delivery lots is extremely rare.

The second factor – the possibility and need to necessarily take out the entire cargo from each supplier- is also rarely available.

Nevertheless, the following decision is suggested for the transportation problem in the formulation from above [5]. In fact, the statement of the problem determines the algorithm for its solution. For this set up, the formulation of the mathematical equation for the objective function, namely, the total transportation costs, will have the form

$$\min F = \sum_{1}^{m.n} C_{\mathrm{ij}}\, x_{\mathrm{ij}} \tag{1}$$

For the transportation problem [5], the algorithm basis will be the mathematical equation of the objective function. And this equation will be linear.

Let's analyze the problem using the standard apparatus of the theory of graphs.

We illustrate this by the following drawing (see Figure 1).

Let's place the supply locations on the left, the destination nodes on the right.

These points are shown in the picture by circles (in the theory of graphs – nodes), the links between them – arcs (links).

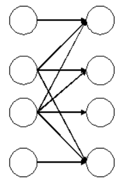

Fig.1. Graphical interpretation of the classical transportation problem statement

First. However, even for such idealized conditions - where, in current economic realities, one can assume the continuous function of transportation costs $\boldsymbol{S_{ij}}$? These costs are related to the delivery of a unit of cargo from supplier ***i*** to customer *j*.

Obviously, the function of transport costs is a piecewise-continuous function, that is a function that is continuous in each of the segments of which it consists, but at its segments has the gaps at their ends [7; 8].

The transportation cost function must have a piecewise continuous mathematical representation, since the cost of transportation will depend on many factors, for example, on the size of the batch. And the cost of transportation will vary according to the tariffs grid for the shipping of a unit of a particular cargo, for a certain distance, for a certain time, and the like.

Second. Does the product always go directly to the consumer? No. There are intermediate warehouses, there are railroad stations, there are resellers. That is, the real task should take into account not only suppliers and consumers but also intermediate entities, for example, intermediaries: dealers, transportation, logistics, other business intermediaries. If this factor is taken into account, it leads to the creation of new links within the system. And this makes the use of the traditional mathematical algorithm for solving transport problems impossible.

That is, the distribution scheme became too complicated, as illustrated on Fig. 2 [6].

On the left hand, again there are suppliers nodes, shown in circles, on the right there are consumer nodes. However, there are transit points where product flows are distributed, or even the part of the resources remains in place. Obviously, as a rule, it is not necessary to create separate routes from the production points to them. This provides the poly-dimensional system of consumers-suppliers and the real minimization of the total transportation cost which are unattainable in the classical formulation of the problem [7, 8].

From simple combinations, producer – supplier, even within the same economy, where the production of the goods and their consumption are separated geographically, one switches to the allocation of resources on certain routes [8, 9, 10].

Sometimes the route alternately passes through a number of consumers, sometimes - through transit, split nodes. In separate nodes, the flow is divided into a group of arks. Some consumers can go through complex routes from several manufacturers. A group of routes is formed and the resource allocation follows these routes. Logistics needs to build a flexible network that is inertial to external factors and, most importantly, is adapting in time to changes in the consumers' needs for resources and changing supply options. It is precisely this statement of the transportation problem that ensures that additional logistical chains, not just consumers and suppliers, are taken into account which is not available in classic interpretation of the problem.

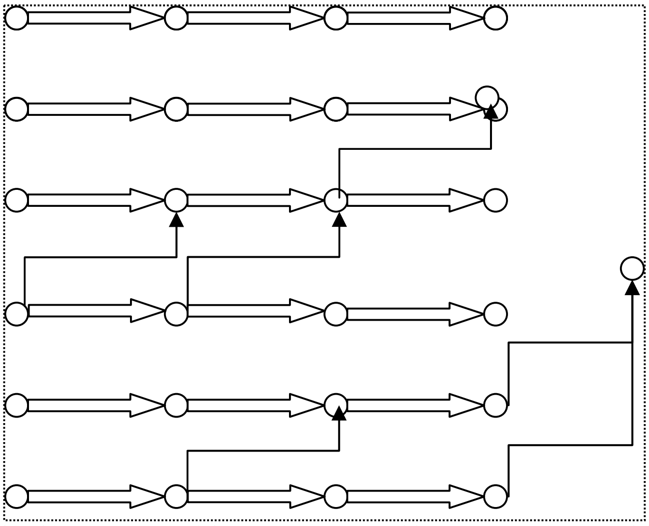

Fig. 2. Graphical interpretation of the transportation problem statement in general form

Let's consider the second example. The statement of the classical diet problem [6].

Some diet consists of ***n*** types of products. The unit cost of each product $c_j\left(j=\overline{1,n}\right)$, the amount of nutrients necessary for the body ***m*** and the need for each ***i***-th nutrient $b_i\left(i=\overline{1,m}\right)$ are known.

The unit of ***j***-th product should contain the $a_{ij}\left(i=\overline{1,m}; j=\overline{1,n}\right)$ of nutrient ***i***.

It is necessary to find the optimal ration ***X***= ***(x₁, x₂, ..., xₙ)***, which takes into account the requirements of providing the body with the right amount of all necessary nutrients.

The criterion of optimality for such a task, as a rule, is the minimum cost of a diet ***F***.

Formalization of the diet problem to mathematical formulation, as is known [7], looks like this. Let's denote by $X=(x_1, x_2, ..., x_n)$, – the quantity of the corresponding ***j***-th product type $\left(j=\overline{1,n}\right)$. The system of restrictions will describe the provision of each nutrient in the diet not lower than that of the specified level $b_i\left(i=\overline{1,m}\right)$. Then, the economic-mathematical model will look like [7].

$$\min F=\sum_{1}^{n} c_j x_j \tag{2}$$

under conditions:

$$\sum_{1}^{m,n} a_{ij} x_j \geq b_i \tag{3}$$

The requirement for the variables contained in expressions (2) and (3) is that they should be non-negative.

That is, the diet problem is artificially reduced to the solving of the system of linear equations, precisely linear ones.

Still this is a classic statement of the diet problem for a household that produces products for own consumption or a planned socialist economy. They do not pay attention to it. Why exactly for these households?

The answer is that only for such type of households and economy, the value of c_j of each ***j*** type of product will be constant. It is not true for market economies. Even in such a simplified problem setting, with a constant value of c_j, the unit of ***j***-th product will contain a different amount of ***i*** nutrient depending, for example, on the time of production and delivery of the product, on the producer and the batch of the product, etc. [7; 8].

This means that the mathematical form of the statement on the diet should be changed.

In the general case, we must consider each parameter as a vector or tensor, not a scalar.

The unit cost of each product should also be considered as a vector, or even as a tensor, because it is not a single value, but a set of prices, for example, of different suppliers, which, of course, can change even in time. Changes in time immediately transfer the problem to a class of nonlinear problems.

It is natural that, when there are such a number of vector or tensor variables, in this case, the mathematical statement of the problem of the diet should have a tensor form. Thus, when each parameter is a vector or tensor, and the unit cost of each product is a vector or tensor, the objective function is generally a tensor.

In other words, the classical statement of the diet problem can be presented as a special case of the problem [6].

$$\max(\min)\ \boldsymbol{F} = \boldsymbol{CX} \tag{4}$$

under conditions:

$$\begin{aligned} \boldsymbol{AX} &= \boldsymbol{A_0}; \\ \boldsymbol{X} &\geq \boldsymbol{0}, \end{aligned} \tag{5}$$

where

$$A = \{a_{ij}\} = \begin{pmatrix} a_{11},\ a_{12},\ \ldots,\ a_{1n} \\ a_{21}, a_{22},\ \ldots, a_{2n} \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ a_{m1},\ a_{m2},\ \ldots, a_{mn} \end{pmatrix} \tag{6}$$

Vector $\boldsymbol{A}$ is represented by a matrix of coefficients for the vector of variables $\boldsymbol{X}$.

$\boldsymbol{F}$ is the tensor of objective function,

$X = \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{pmatrix}$ – vector (tensor) of variables;

$A_0 = \begin{pmatrix} b_1 \\ b_2 \\ \vdots \\ b_n \end{pmatrix}$ – vector (tensor) of free parameters of the system of equations;

$\boldsymbol{C = (c_1, c_2, \ldots, c_n)}$ is the vector (tensor) of the coefficients for variables (represented as the price matrix, in this case, the linear matrix) in the objective function

Obviously, the transition to the tensor form of the problem representation allows not discarding, at the stage of formulation, linearization, and solving the problem of groups of roots of the system of equations. In any case, one should be aware that these roots are available. This is not critical for a ration issue. But this problem is used only as an example of approach to the formation, construction and analysis of mathematical models of complex economic systems [9; 10]. In general, loss of a group of roots can be fatal.

Thus, the manager of this type of problems will need to return to the basics of linear programming. In the general case, there is an urgent need to change the methodology of mathematical modeling in the economics. Especially this is true for the cases while looking for and substantiating the best analytical solutions in this field.

The purpose of the article is to suggest on a new approach to mathematical optimal modeling in economics.

Research results. Which algorithm will help to solve these problems? For the above reasons, the objective function in the general case is not an additive function of the scalars, since each of the parameters $\boldsymbol{X}$ is the vector $\boldsymbol{x_1, x_2, \ldots, x_n}$. Moreover, each of $\boldsymbol{x_j}$ will be multiplied by its coefficient $\boldsymbol{c_i}$**.** Thus, not only each of the parameters $\boldsymbol{X}$ is a vector, but $\boldsymbol{C}$ – the delivery price will, in the general case, be a vector, not a scalar.

That is, for practical purposes, each kind of goods, even the same in terms of consumer qualities, can have its own delivery price.

For example, the manufacturer can get each ingredient of a poultry feed mix from different suppliers of different quality, different packaging, with different delivery prices. But as a result, a mixture consisting of components with a variation in the content of the nutrients should meet a certain regulatory standard.

We must also take into account that there are different types of product of two vectors: scalar product, vector product, tensor product (also called as dyadic product). Therefore, when a transportation problem is formulated in the general form, an algorithm for automatically selecting the type of product of the vectors ***X*** and ***C*** will be formed. In the general form, it will be a dyadic product.

Of course, there are still options of the use of classical methods of solving transportation problem. The use of such options greatly simplifies the solution procedure, reduces the amount of calculations, but the range of possibilities for the use of classical techniques dynamically reduces.

In a general form, the problem of linear programming looks like as follows.

We have a set of variables

$$x = (x_1, x_2, \dots, x_n) \tag{7}$$

and the function of these variables

$$f(x) = f(x_1, x_2, \dots, x_n) \tag{8}$$

Formula (8) is the so-called objective function. The task is: to find the extremum (the maximum or minimum) of the objective function on the condition that the variables belong to a certain domain of ***G***:

$$\begin{cases} f(x) \to extr \\ x \in G \\ x \geq 0 \end{cases} \tag{9}$$

Then, depending on the type of the objective function and the domain of G, one chooses the method and algorithm for solving the problem of mathematical programming.

This may be, for example, quadratic programming, convex programming, integer programming, or another one, under certain conditions.

That is, in the formation of automatic design programs to simplify the problem setting and its solution by a practitioner, it is necessary to implement a mechanism for selecting a type of programming so that practice does not stop this mathematical problem.

In case the problem formulation is not an excessive simplification, and there is no need to weigh the lack of computing resources, there is a possibility of using such a response function, which will take into account the real economic system characteristics. This inevitably leads to the fact that the response surface will be multiconvex and therefore the problem of finding a global extremum on the area with local extrema will be raised.

Recall that in the general form, this problem is still considered to be not resolved [1-4]. What does this mean in practice? From the point of view of the user, and from the point of view of the task manager?

The task manager must have an exact algorithm for determining which type of the extremum is reached at the intermediate stage – local or global. It is the achievement of the global extremum that will mean the final stage of the problem solution. But, not knowing the surface of the response, not having the idea of the presence of other extrema, except of those that are found, it is extremely difficult. The only way is to pass through the whole area of domain with a small iteration step and to determine the presence or absence of an extremum (or its features). The sign of an extremum, in this case, may even be a small but steady gradient of growth of the objective function during iteration, in the case of finding its maximum, or a decrease in the case of finding its minimum. Then one of the tried and tested methods of finding an extremum, for example, a steep climb (or steep descent) can be used.

Passing all over areas of definition of variables with a small iteration step and finding out whether or not there is an extremum (or its features). Signs of an extremum, in this case, may even be a small but steady gradient of growth of the objective function during iteration in the case of finding its maximum, or a decrease in the case of finding its minimum. Then one of the tried and tested methods of finding an extremum, for example, a steep climb (or steep descent) can be used.

The passage of the entire domain with a small step of iterations will inevitably lead to the loss of time and technology resources for solving the problem and for a large number of variables. Thus, it is not possible to solve the problem in a short time with the available technology.

For the practice user, this means that without a special programmer, he will not be able not only to solve the task, but even will not be able to set it. In addition, he can not be sure that in the case of a difficult task, another practitioner will be able to repeat or even confirm its result.

Linearization of the formulation of nonlinear problems leads, in general, to the problems, which importance and significance, in our opinion, is not mentioned by the scientific environment.

First, the accuracy of the calculation is underestimated. Let's examine this in more detail. When, instead of a complex curve that geometrically interprets a nonlinear function, we draw a straight line (chord) between two points, which geometrically shows a linear function, the distance between the curve and the chord can reach significant size. This is a deviation, inaccuracy, the linearization of nonlinear problems leads to. What does this mean in practice? For example, the calculation of the profit of a possible transaction that changes with a change in the exchange rate, may deviate from the true by certain percentage points. How much will it cost in cash terms of lost profit for a significant amount of transactions? Lost profits can be evaluated as large amounts of money.

Second, the linearization of nonlinear problems can lead to loss of roots and groups of roots in solving systems of algebraic equations, by which economic problems are represented in mathematical formulation.

That is, practitioner can even not know a possible success or even a loss, in result of this calculation, since the problem statement hide from him some results or group of results that are possible in economic and business realities.

Thus, the conclusion from the above thesis is that the use of linear models for the formulation and solution of economic problems is possible only for the practical needs of a certain, limited range of applications. Moreover, considering the possibility of loss of results or results' groups, the use of linear models for modern economic problems is, in general, not desirable.

Recent trends in the methods of optimizing more complex systems (which have significantly more variables than the examples given) have led to the use of HEN / MEN – technology of systems representation. This methodology is already used in solving predominantly technical problems. According to this methodology, the mathematical programming structure formulates HEN / MEN as a problem of mixed integer nonlinear programming – MINLP simulation [3].

Without prejudice to the successes of this methodology, we will also indicate its shortcomings. For this methodology (as well as for most existing methodologies), the most vulnerable stage is the formalization of the design of optimization task.

When designing the model, one should use the "principle of optimal inaccuracy": the model should be as detailed as it is necessary for the purpose for which it was created. However, achieving this goal is always difficult [2], especially since the limit of detailing is subjective. Experts with the same level of training, while detailing one system, will offer different models. But none of these models, regardless of its level of detail or complexity, can be considered as the only "correct" one. Models can only be arranged according to the degree of adequacy in describing the behavior of the real system in the area of practical use. The quality of the model can not be evaluated either on the base of its structure or form. The only criterion for the evaluation can be the relevance of the data received. However, in this case what can serve as a criterion for data relevance?

In [2] it was mentioned that complex systems are difficult to formalize, and the models constructed for them are difficult to investigate with the use of numerical methods. Then one has to use simplified models.

We emphasize that the use of MINLP simulation [3] threatens to subjective the statement and, accordingly, to solve the problem, can lead to the loss of results' objectivity, which is not desirable, especially while talking about economic problems.

Another existing problem is the complexity of tasks for complex systems. The increase in the number of elements and links between them leads to a shortage of technical resources of the computer technology generally used for solving such problems. For example, the designed network was tested for the adequacy of the LP model in order to check the system's functions performance. The task was divided into 100 periods, 41509 equations and 32409 variables [8].

The next disadvantage is that mathematical formulation of algorithms for solving economic problems for complex systems is often based on a large number of small intervals of iterations. As it has already been noted, such intervals is a compulsory measure, because the use of large intervals can lead to the fact that the extremum of the objective function will be unnoticed, that is, its presence will not even be known, because it will be on the interval of iteration. The iteration step can be so large that it will pass over the extremum, without noticing it.

Even for optimization problems with moderate dimensionality (the number of variables), the number of intervals can be significant, thus creating a problem in solving a tasks that increases to the unmanaged size [3], that is, the time of its solution becomes practically unachievable.

Increase in the size also leads to difficulties in the analysis of the objective function. In the analysis, you need to be sure that the solution exists, and the numerical methods are robust.

According to [3], the next disadvantage of MINLP models is that the objective function is not linear and not convex, and therefore the solution will usually be a local extremum. This is one of the key problems for these tasks. So, for example, in the NLP models, one finds a global extremum when the objective function and constraint are convex. For non-convex objective function [3], NLP models do not guarantee finding a global optimum.

Almost all experts point to the dependence of the NLP model solutions on the initial conditions (reference plans). For example, nonlinear optimization methods require good initial approximations, often not guaranteeing convergence to the global optimum.

Experts note the generally support plans, that can simplify the task, are difficult to access.

That is, the success of a task depends on either the experience of the expert or the good luck. This leads to uncertainty in the outcome and uncertainty about the ability to replicate the result. This indicates the subjectivity of the solution methods. The latter is unacceptable for mathematically objective statements of tasks.

In this case, the most radical approach is to change the methodology for solving optimization problems, which implements the system approach and guarantees the global extremum.

In brief, this methodology can be formalized as a sequence of following steps:

Step 1. Designation of the object from the environment.

Step 2. Defining the design object as a system.

Step 3. Decomposition of the system to the elements.

Step 4. Application of the methodology of thermodynamics of systems to the design object.

Step 5. Defining the objective function of this system design.

Step 6. Definition of set of constraints and parameters of this system.

Step 7. Definition of known and unknown parameters of this system.

Step 8. Formation of a closed mathematical system of equations. For the formation of a system of equations, on should use only the laws of thermodynamics.

Step 9. Solving this mathematical system of equations in a symbolic form.

Step 10. Analysis of the solution. Finding a global extremum.

For the system that already exists (designing a "system upgrade" or "improving system performance").

Step 11. Positioning the real state of the existing system in relation to the global extremum.

Step 12. Formation of such a set of points in the phase space to which the phase trajectories of the system coincide (the path along the surface of the response), so that the transition to the desired state has been achieved.

Another option.

Step 10. The expert determines the desired value of the objective function of the system, and, under the available preconditions, the input variables to the system.

Step 11. The programming tool delivers the necessary parameters of the inputs and outputs of the elements with the required level of their effectiveness. At the same time, the global extremum of efficiency is definitely and without fail achieved.

The suggested algorithm was tested to minimize the cost of the produced feed for birds. The use of the algorithm to minimize the costs in the production of forages also showed such characteristics as flexibility and convenience and the speed while choosing solutions in terms of time availability.

As a whole, as it was demonstrated by the experience of annual use of the algorithm, in 68% of cases the use of the solution algorithm coincided with the solution acquired according to the method (2)-(3) with a discrepancy in parameters at 8%. The use of this algorithm allowed reducing the cost of feed by 23% annually.

Conclusions. First, for economic problems one has to deviate from the classical methods of their mathematical formalization.

Secondly, the use of linear models for the formulation and solution of economic problems is possible only for the practical needs of a certain, limited range of non-parametric tasks. Given the possibility of loss of roots or groups of roots of linear models, it is not generally desirable.

Many-parameter tasks, in particular, economic, require other approaches. Avoiding excessive simplicity makes it possible mathematically to objectively put the task and to solve it more precisely. Modern computer technology and application software packages allow us solving such problems in a general way – without excessive simplification.

Third. For real multiparametric problems, in particular, economic ones, the use of a variant of the methodology of systems thermodynamics is suggested. An algorithm for solving this problem is given in this article.

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