

Application of Mathematical Modeling to Solving Economic and Social Problems

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Abstract:

The article demonstrates the use of higher mathematics, specifically the theory of multivariable functions and their analysis, as well as systems of multivariable equations and inequalities, to solve economic problems. It shows how to create mathematical models, i.e., objective functions, and find optimal solutions for the unknowns of the function, that is, finding extremums, through real-life examples.

Keywords: mathematical model, social, economic, mine, raw material, objective function, maximum, minimum, optimal, cost function, income, resource, expenses incurred, total revenue, system of inequalities, optimal solutions.

We consider the application of mathematical modeling to economic and social problems. For this purpose, we will solve the following life problem. In our republic, we will consider the transport problem of delivering ores extracted from two ore mines to factories.

Let a_1, a_2 tons be extracted monthly from ore mines M_1, M_2 respectively. Let these raw materials be supplied monthly to factories (plants) P_1, P_2 , where P_1 factory requires b_1 tons for production output, and P_2 factory requires b_2 tons of raw materials (aluminum, copper or iron).

Let the cost of transporting one ton of aluminum from M_1 mine to P_1 factory be C_1 UZS. Let the cost of transporting one ton of copper from M_2 mine to P_1 factory be C_2 UZS. Similarly, let C_3, C_4 UZS be the costs of transporting from M_1, M_2 to P_2 factory.

It is required to develop a plan for transporting ore from mines to factories with the lowest total cost (minimum) at the cheapest price. To solve the problem, we will do the following. It is known to us that in order for the mines to be profitable from the sale of ores each month

$$a_1 + a_2 = b_1 + b_2 \quad (1)$$

The condition must be met, that is, the amount of extracted ore must be equal to the amount of sold ore or must match the purpose, because the factory needs a total of b_1 and b_2 tons of ore.

If we denote the ore transported from mine M_1 to factory P_1 as x_1 tons and from mine M_2 as x_2 tons, and similarly denote the ore transported to factory P_2 as y_1, y_2 , then for the amount of ore transported from mines M_1, M_2 to factories P_1, P_2 , we have these equations:

$$\begin{cases} x_1 + x_2 = b_1 \\ x_2 + y_2 = b_2 \end{cases} \quad (2)$$

and we obtain the system of equations (2) above. So, based on our notations, the cost spent on transporting x_1 tons of ore is c_1x_1 UZS, the cost for transporting x_2 tons of ore is c_2x_2 UZS, and in total, the cost of transporting y_1 tons is c_3y_1 for y_2 tons is c_4y_2 , and the total cost of ore transportation is

$$f = c_1x_1 + c_2x_2 + c_3y_1 + c_4y_2 \quad (3)$$

will be in UZS.

In the system of composed equations, x_1, x_2, y_1, y_2 are unknowns, and this equation has infinitely many solutions.

Thus, it is required to plan the transportation of ore from mines to the factory with the lowest total cost (the cheapest, minimum). The solution to this problem forms the mathematical model (3) formula.

Now the solution to this problem or the model of the decision-making life problem is as follows. It consists of finding the non-negative solutions of the system of equations (2) among which function (3) takes the smallest value.

Let's consider the mathematical model and its solution for the problem of resource utilization given in this exact way.

Let a factory (plant) have resources such as raw materials, equipment, and workers. For clarity, let's say this factory has resources P_1, P_2 , with their quantities measured in b_1, b_2 units respectively. The factory produces two types of products T_1, T_2 . Let one unit of T_1 product cost C_1 UZS and one unit of T_2 product cost C_2 UZS. To produce a unit of products T_1, T_2 , P_1 requires a_1, a_2 units of resources respectively. P_2 requires d_1, d_2 units of resources. The factory should maximize its profit from selling the products produced from the available resources, i.e., we compose a mathematical model of how much of products T_1, T_2 the factory should produce to gain the most profit.

Let's assume that x_1 amount of T_1 type product and x_2 amount of T_2 type product are produced. In this case, the factory's total income

$$f = c_1x_1 + c_2x_2 \quad (4)$$

will be in UZS.

For the factory to produce x_1, x_2 amount of products, P_1 uses

$$a_1x_1 + a_2x_2 \quad (5)$$

amount of resources. This (5) amount should not exceed the available b_1 amount in P_1 , that is

$$a_1x_1 + a_2x_2 \leq b_1 \quad (6)$$

condition is fulfilled. Similarly, the condition that it should not exceed the available b_2 amount in P_2 , that is

$$d_1x_1 + d_2x_2 \leq b_2 \quad (7)$$

From these equations (6) and (7), we obtain a system of inequalities with respect to the unknowns x_1 and x_2 , and we determine their infinitely many solutions. Now let's express this life problem from a mathematical point of view. The mathematical model of this problem consists of finding the largest value that function (4) takes among the non-negative solutions of the system of inequalities (6) and (7) composed above. Solving this involves finding the non-negative solutions of the system of 2 equations with 4 unknowns or inequalities, and finding the extreme (extremum) values of the objective function formed from this solution.

In the above problem 1, we considered the problem of transporting cargo from m – mines to n – factories. It's possible to use the same approach for transporting cargo from m mines to n factories. In this case, we obtain a system of equations with many unknowns and find its smallest (minimum) values.

Similarly, in problem 2, we can consider the production of different types of products from several types of raw materials and the resulting income problem. For this, we find the non-negative solutions of the system of inequalities with several unknowns, namely $x_1, x_2, x_3, \dots, x_n$, and find the extreme (extremum) values of the objective function formed from these solutions.

The mathematical models discussed above can be used in various types of production processes in other sectors of the national economy. The convenience of economic mathematical models is that each model has the property of expressing several economic processes. In general, mathematical models are widely used in various economic processes in content.

In summary, when solving economic problems, many essential functions, systems of equations and inequalities are used to solve transport problems, resource utilization problems, and many similar economic problems. We considered the problem of creating a mathematical model for the problem and finding the convenient (optimal) solution for us among the solutions in solving them.

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