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Search of the solution of a transport task by means of the software

The article is devoted to research of applied methods of mathematical modeling for the solution of economic tasks by means of the tabular processor. The solution of a transport task, that is finding of the minimum expenses of basic suppliers is provided under the set conditions. The tabular processor helps to find the optimal solution of an economic task.

Key words: purpose, optimum plan, MS Excel program.

The purpose of the work is learning to make the optimum plan of transportations of production taking into account limited providing with material reserves for the transport problem, to develop optimization of plans by mathematical computer methods of linear programming by means of the application Solver of the MS Excel program [1].

The plan of transportations is presented in the table form, including quantity of production reserves in warehouses of suppliers and necessary quantity of production for the consumer in natural expression. When developing the plan the production purpose is specified: minimization of transportation expenses[2].

Mathematical model for optimization algorithm

The general statement of the transport problem includes the determination of the optimum plan of transportations of some homogeneous cargo from m points of departure $A_1, A_2, ..., A_n$ to n destinations $B_1, B_2, ..., B_n$. As criterion of optimality we take either the minimum cost of transportations of all cargo, or the minimum time of its delivery [3].

Let c_{ij} $(i = \overline{1,m}, j = \overline{1,n})$ – tariffs of transportation of a unit of cargo from i point of departure to j destination; $a_i(\overline{1,m})$ – cargo reserves in i point of departure; b_j $(j = \overline{1,n}$)- requirement for cargo in j destination; x_{ij} $(i = \overline{1,m}, j = \overline{1,n})$ – quantity of cargo units, transported from i point of departure to j destination. Then the economic-mathematical problem definition concludes in determination of the minimum value of function

$$F_{min} = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}, \tag{1}$$

on conditions

$$\begin{cases} \sum_{j=1}^{n} x_{ij} = a_i, (i = \overline{1,m}); \\ \sum_{j=1}^{m} x_{ij} = b_j, (j = \overline{1,n}); \\ x_{ij} \geq 0 (i = \overline{1,m}; j = \overline{1,n}). \end{cases} \tag{2}$$

If needs for cargo destination points are equal to cargo reserves in the points of departure, i.e.

$$\sum_{j=1}^{n} b_j = \sum_{i=1}^{m} a_i, \tag{3}$$

then the model of a transport problem is called as closed, otherwise – as open.

In case of reserve excess over the requirement or the requirement over the reserve, the dummy destination or the dummy point of departure with zero tariffs is entered.

Problem setting

The homogeneous cargo in quantities equal to 50, 30 and 10 units arrived to three bases A_1, A_2, A_3. This cargo is required to be transported to four destinations B_1, B_2, B_3, B_4 respectively in quantities of 30, 20, 10 and 20 units. Tariffs of transportations of a unit of cargo are given in table 1. To find the optimum plan of transportations of a transport problem.

Table model

Let's make the plan in the form of the Table 1:

Table 1

Tariffs of transportations of a cargo unit

	A	B	C	D	E	F
1	Transport problem (minimum)					
2	Suppliers	Consumers				Reserve
3		B_1	B_2	B_3	B_4	
4	A_1	1	2	4	1	50
5	A_2	2	3	1	5	30
6	A_3	3	2	4	4	10
7	Requirements	30	20	10	20	

After drawing up the plan Tables 2, 3 it is necessary to connect indicators by formulas for calculations.

Formulas in the table

Table 2

Representation of formulas and numbers of input data is given

...	A	B	C	D
8				
9		B_1	B_2	B_3
10	A_1			
11	A_2			
12	A_3			
13	Imported	=SUM(B10:B12)	=SUM(„1¤710:„1¤712)	=SUM(D10:D12)

Table 3

Continuation

E	F	G
B_4	Exported	Remainder
	= SUM (B10:E10)	=F4-F10
	= SUM (B11:E11)	=F5-F11
	= SUM (B12:E12)	=F6-F12
= SUM (E10:E12)		

In the column F (planned transportations of goods on suppliers) formulas of calculation of the sum of planned quantity of production for each supplier are entered. In line 13 (planned transportations of goods on consumers) formulas of calculation of the sum of planned quantity of production for each consumer are entered. In the column G (remainder) formulas of calculation of the remainder of the store in warehouses of each supplier are entered.

Work realization order

At the first stages of work automation of planning the experiments and processing of results is inexpedient as a student receives ready results, without having shown activity, creativity, searching. After manual control the experiment when the comprehension and knowledge of the research object improved, it is possible to start automation of scheduling and management of experiment: changing the number of deliveries in cells $B10$: $E12$, reducing expenses in the cell $G13$. At the same time visually to control an expense of reserves in a column . The expense should not exceed reserves in a warehouse (column).

By means of the program of optimization we can facilitate realization of this task. After the selection the command Solution Search in the menu Service the dialog window in which we will set the following conditions will appear.

The field **Set Target Cell** serves for the indication of the target cell which value needs to be maximized, minimized or established equal to the given number. This cell has to contain the formula. In our problem it is cell $G13$ (the common expenses) (Fig. 1).
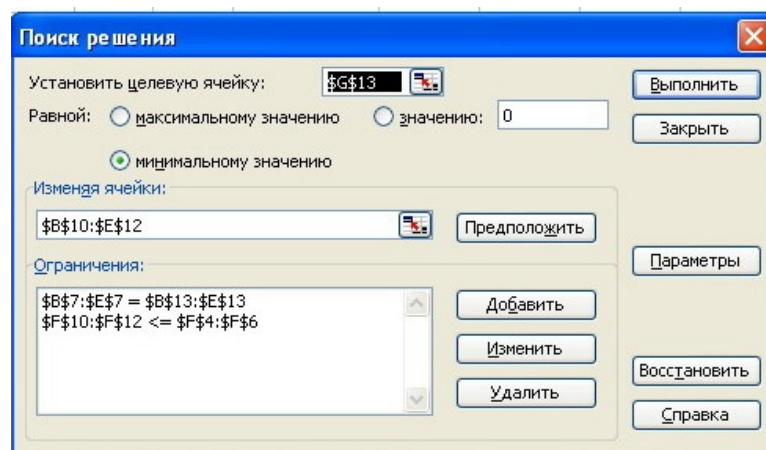

Figure 1. Dialog window Solution Search

The button **Equal** serves for the choice of option with the preset value of the target cell. To determine the given number, it is necessary to enter it in the field. In our problem for maximizing profit we press the button **Maximal value**.

The field **Change Cells** serves for the indication the cells which values change in the course of searching of the solution until the imposed restrictions are executed and the condition of optimization of cell value specified in the field **Establish Target Cell**. In the field **Change Cells** names or addresses of changeable cells are entered, dividing them by commas. In our problem we will enter the range of cells $B10 : E12$ containing required values of the optimum plan of production transportations. Changeable cells have to be directly or indirectly connected to the target cell. The setting up to 200 changeable cells is allowed.

The field **Assume** is used for automatic search of the cells influencing the formula, the reference to which is given in the field **Establish Target Cell**. The search result is displayed in the field

Change Cells.

The fields **Restrictions** serve for display of the list of boundary conditions of the set problem. The field **Restrictions** serve for display of the list of boundary conditions of the problem.

In our case these are values:

$B13$: $E13=B7$: $E7$.

$F10$: $F12 \leq F4$: $F6$.

The command **Add** serves for display of the dialog window **Add Restriction**.

The command **Change** serves for display of the dialog window **Restriction Change**.

The command **Remove** serves for removal of the restriction specified by the cursor.

The command **Operate** serves for start of problem solution search.

The command **Close** serves for escaping dialogue window without start of problem solution search. The settings made in the dialogue windows appearing after pressing the buttons **Parameters** to **Add**, **Change or Remove** are reserved.

The button **Parameters** serves for display the dialog window **Parameters of Problem Solution Search** in which it is possible to load or keep the optimized model and to specify the provided options of solution search.

The **Restore** button serves for cleaning the fields of dialogue windows and restoring the values of the parameters of problem solution search used by default.

In the field **Reference to Cell** we enter the cell address, name or cell range on which values restrictions are imposed.

Let's select the conditional operator from the opened list that it is necessary to place between the reference and its restriction. These are signs of operators: not greater, not less, equal etc.

In the field **Restrictions** the number, formula or name of cell or range containing or calculating the restricting values is entered.

To start a set of a new condition, press **Add** button.

To return to the dialog window **Solution Search**, press OK button.

The conditional operators of the whole and binary type are possible to be applied only when imposing restrictions on changeable cells.

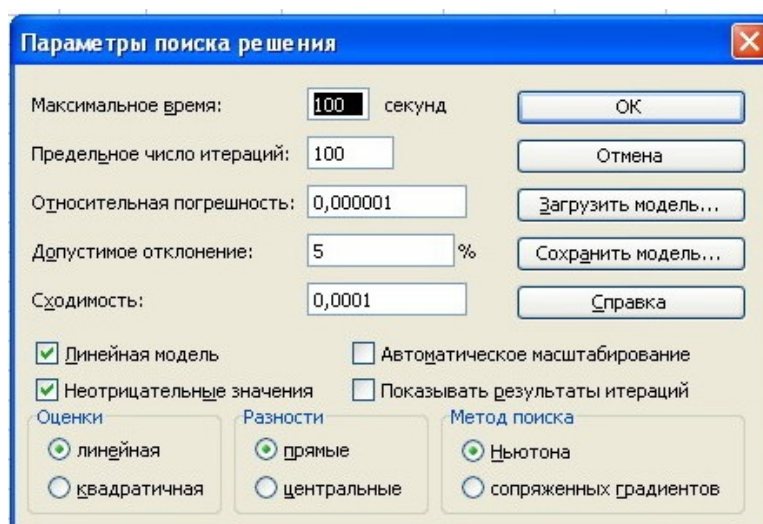We accept the model as linear one, according to Figure 2:

Figure 2. Dialog window «Parameters of Solution Search»

After pressing the button Operate, we receive the result given in Table 4.

The received results

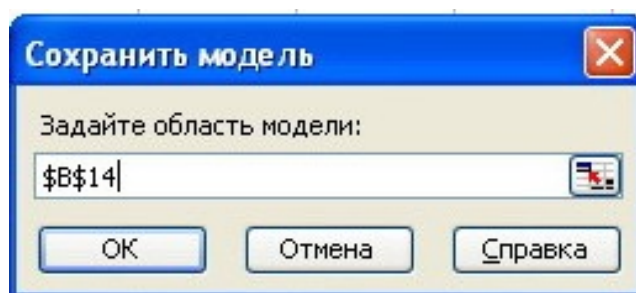|	A	B	C	D		F	G
8							
9		B_1	B_2	B_3	B_4	Exported	Remainder
10	A_1	20	10	0	20	50	0
11	A_2	10	0	10	0	20	10
12	A_3	0	10	0	0	10	0
13	Imported	30	20	10	20	Total expenses	110

Figure 3. Dialog window Save Model

After that, in the field **Set model area** enter the reference to the top cell of a column in which it is necessary to place optimization model(Fig. 3).

The values of management elements of dialog window Solution Search and Parameters of Solution Search are registered on the sheet. To use several models of optimization on the sheet, it is necessary to save them in the different ranges (columns). The offered range contains a cell for each restriction, and also three more cells. It is also possible to enter the reference only to the top cell of the column in which it is necessary to save the model.

The dialog window Load Model is used for reference setting to the area of the loaded optimization model. The reference has to address area of the model entirely; it is not enough to specify only the first cell.

For the start of the optimizer we press the button Operate in the window Solution Search.

The program will start working, in the line of messages (on the left at the bottom of the sheet) the message Problem Setting „1¤7 will appear. The table with model and parameters of algorithm will automatically be provided to standards of setting the problems of mathematical programming. This is the advantage of Excel. After the stage of setting, the problem is being solved.

Upon the end of calculation the dialog window Solution Search Results appears.

Having pressed the corresponding button, it is possible to save the found solution in the influencing cells of model or to restore original values.

Therefore, minimum expenses at restrictions of reserves in warehouses of suppliers are achieved. Having simplified and accelerated the search of profit, the program of optimization Solver rationalized the solution of this economic problem [4].

Summing up the result on the solution of our problem, it is possible to allocate, at least, four aspects of application mathematical methods in the solution of practical problems:

1. Perfecting the system of economic information. Mathematical methods allow ordering the system of economic information, to reveal shortcomings of the available information and to develop requirements for preparation of new information or its adjustment. Development and application of economic-mathematical models specify the ways of perfecting the economic information focused on the solution

of particular system of problems in scheduling and management. Progress in information support of scheduling and management bases on rapidly developing technical means and software of informatics.

2. Intensification and increase of accuracy of economic calculations. Formalization of economic problems and use of PC multiply accelerate standard, mass calculations, increase accuracy and reduce labor input, allow carrying out the multioptional economic justifications of difficult actions inaccessible at domination of «manual» technology.

3. Deepening of the quantitative analysis of economic problems. Thanks to application of the method of model operation possibilities of concrete quantitative analysis, studying of many factors affecting on economic processes, the quantitative assessment of consequences of changing conditions of economic objects development, etc. considerably amplify.

4. Solution of new economic problems. By means of mathematical model operation it is possible to solve such economic problems which cannot be solved by other means, for example: finding the optimal variant of the economic plan, imitation of economic actions, control automation of the composite economic objects functioning.

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Программалық жабдықтар көмегімен транспорттық есепті шешудің жолы

Мақалада кестелік процессор көмегімен экономикалық есептерді шешуде математикалық модельдеу әдістерін қолдану сұрақтары зерттелді. Авторлар транспорттық есептің шешімін көрсетті. Сатушылардың қоймаларындағы өнімдердің шектеулі жағдайларында минималдық шығындар есептелді. Кестелік процесс экономикалық есептің оңтайлы шешімін табуға көмектеседі.

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Поиски решения транспортной задачи средствами программного обеспечения

Статья посвящена исследованию прикладных методов математического моделирования для решения экономических задач с помощью табличного процессора. Приводится решение транспортной задачи, то есть нахождение минимальных затрат базовых поставщиков при заданных условиях. Табличный процессор помогает найти оптимальное решение экономической задачи.

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