

SOLUTION OF THE OPEN TYPE TRANSPORT PROBLEM USING THE OPTIMAL 2 PROGRAM

S. KHAIDAROVA

Candidate of Technical Sciences, Associate Professor of Kokand, State Pedagogical Institute, Uzbekistan.
E-Mail: hay-vb1952@umail.uz

Annotation

This article discusses methods for solving an open-type transport problem using the Optimal 2 program.

Keywords and Expressions: Transport task of open type, transport task of closed type, Optimal 2 program.

Consider the following problem, called the transportation problem. There are m suppliers A_1, A_2, \dots, A_m , who have stocks of the same cargo in the amount of a_1, a_2, \dots, a_m units, respectively. This cargo needs to be delivered to n consumers B_1, B_2, \dots, B_n , who ordered b_1, b_2, \dots, b_n units of this cargo, respectively.

All tariffs for cargo transportation c_{ij} (the cost of transporting a unit of cargo) from supplier A_i to consumer B_j are also known. It is required to draw up such a transportation plan in which the total cost of all transportation would be minimal.

The condition of the transport problem is conveniently written in the form of the following transport table 1 (Таблица 1).

Let's designate the total stock of cargo from all suppliers by the symbol a , and the total need for cargo from all consumers - by the symbol b . Then

$$a = \sum_{i=1}^m a_i,$$

$$b = \sum_{j=1}^n b_j.$$

A transportation problem is called closed if $a = b$. If $a \neq b$, then the transport problem is called open.

Table 1

		Orders			
		B_1	B_2	...	B_n
Stocks		b_1	b_2	...	b_n
A_1	a_1	c_{11}	c_{12}	...	c_{1n}
A_2	a_2	c_{21}	c_{22}	...	c_{2n}
...
A_m	a_m	c_{m1}	c_{m2}	...	c_{mn}

Note that in the case of a closed task, all cargo stocks will be removed from suppliers, and all requests will be satisfied.

In the case of an open problem with $a < b$, the entire cargo will be exported, but there will be underdeliveries of the cargo to economically unprofitable consumers.

When $a > b$, on the contrary, all consumers will be satisfied, but part of the cargo will remain in the warehouses of economically unprofitable suppliers.

The solution of the transport problem begins with clarifying the question of whether the problem is open or closed.

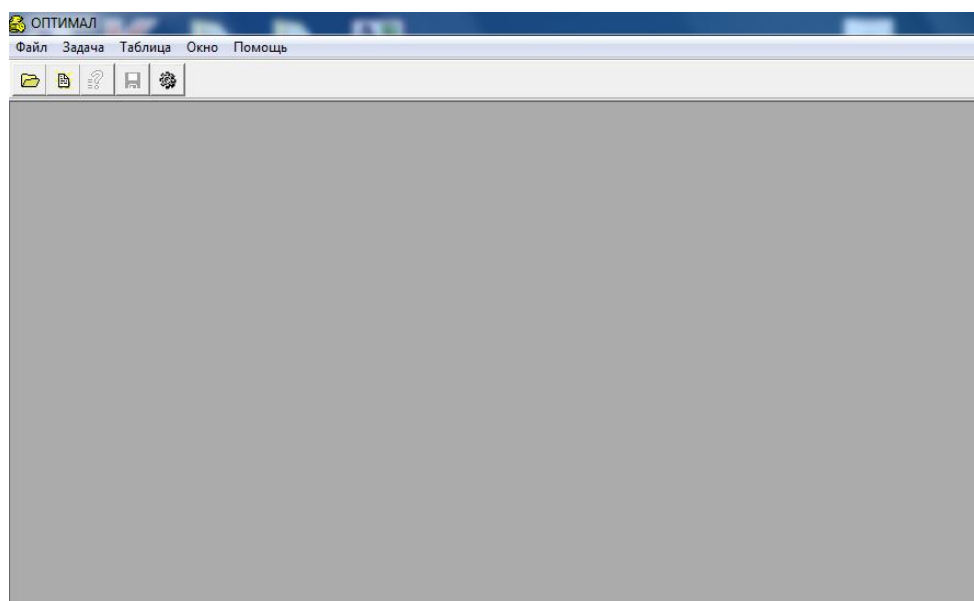
If the task is open, then it is necessary to carry out the procedure for closing the task. For this purpose, for $a < b$, we add a fictitious supplier A'_{m+1} with a cargo stock $a'_{m+1} = b - a$. If $a > b$, then we add a fictitious consumer B'_{n+1} with a cargo order $b'_{n+1} = a - b$.

In both cases, the transportation tariffs c'_{ij} corresponding to fictitious objects are assumed to be equal to zero. As a result, the total cost of transportation z does not change.

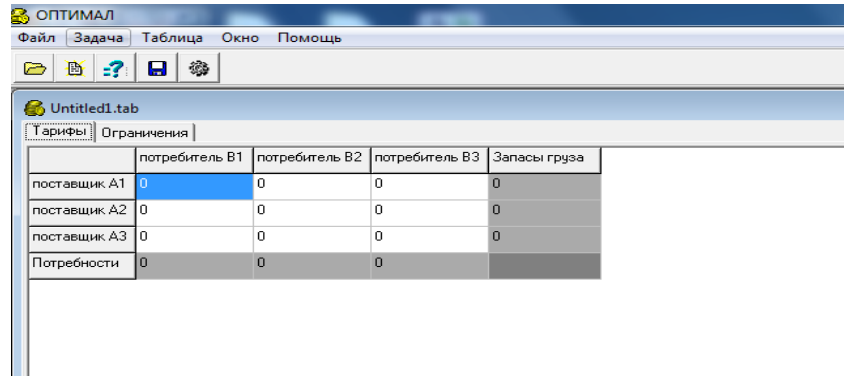
There are several analytical methods for solving the transport problem. The northwest corner method can be used to find the original plan, but this solution is not always optimal. The same can be said about the solution found by the minimum cost method. The potential method has the ability to find the optimal solution and check the optimality of each found solution, but it takes a lot of time.

Below is the automated method for solving the transport problem allows you to save time. One of these methods is the Optimal 2 program.

After starting the Optimal 2 program, the following window appears:



After selecting the “Создать” section the “Файл” menu, the following window appears:



In this window, the rows stand for suppliers A1, A2, A3, and the columns for consumers B1, B2, and B3. They form a 3x3 matrix. The last row and the last column show respectively the demand for the cargo and the stocks of the cargo.

The size of the matrix can be changed depending on the state of the task. To do this, select one of the “ Add line ”, “ Add column ”, “ Delete line ”, “ Delete column ” sections in the “ Table ” menu. They are used to add row and column respectively and also to remove row and column.

Consider an example for an open type of transport problem.

Let an open-type transport problem is given in the form of the following table (case $a < b$):

Source table

Supplier	Consumer			Cargo stocks
	B1	B2	B3	
A1	0 M	0 M	0 M	20
A2	4	8	2	45
A3	1	5	9	30
Need	74	40	36	

The transport task is open, since the stock of cargo is less than the requirements by 55 units.

Let's take some notation:

i – Row index

j – Column index

m – Number of suppliers

n – Number of consumers

x_{ij} – Transportation between supplier A_i and consumer B_j

M – Some number close to infinity

The red color shows the bandwidth limitations of communications between suppliers and consumers. Transportation costs (tariffs) are displayed in gray.

This transport task of an open type looks like this:

There are 3 suppliers A1, A2, A3, which have stocks of cargo in the amount of 20, 45, 30 units, respectively. This cargo needs to be delivered to four consumers B1, B2, B3, who ordered 74, 40, 36 units of this cargo, respectively. The cost of transportation is determined by the following matrix

$$C = \begin{pmatrix} 7 & 3 & 6 \\ 4 & 8 & 2 \\ 1 & 5 & 9 \end{pmatrix}$$

It is required to draw up such a transportation plan in which the total cost of all transportation would be minimal.

By the condition of the problem, the number of suppliers is $m = 3$, and the number of consumers is $n = 3$. Let's enter data:

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Тарифы		Ограничения		
	потребитель В1	потребитель В2	потребитель В3	Запасы груза
поставщик А1	7	3	6	20
поставщик А2	4	8	2	45
поставщик А3	1	5	9	30
Потребности	74	40	36	

Then we select the “Решить задачу” section in the “Задача” menu and at the 4th stage we will get the following solution.

Поставщик	Потребитель			Запасы груза
	В1	В2	В3	
A1	7 M	3 20 M	6 M	20
A2	4 9 M	8 M	2 36 M	45
A3	1 30 M	5 M	9 M	30
A4	0 35 M	0 20 M	0 M	55
Потребность	74	40	36	

Целевая функция F= 198
35 единиц груза потребителю В1 не поставлено.
20 единиц груза потребителю В2 не поставлено.

Thus, for $X_{\min} = \begin{pmatrix} 0 & 20 & 0 \\ 9 & 0 & 36 \\ 30 & 0 & 0 \\ 35 & 20 & 0 \end{pmatrix}$ the objective function F takes its minimum value, i.e. $F=198$.

The solution has a matrix form, we can write it in the following form:

$$x_{12} = 20, x_{21} = 9, x_{23} = 36, x_{31} = 30, x_{41} = 35, x_{42} = 20$$

In this open problem, for $a < b$, the entire cargo was taken out, but there were underdeliveries of the cargo to economically unprofitable consumers:

35 units of cargo were not delivered to consumer B1;

20 units of cargo were not delivered to consumer B2.

Now consider the case $a > b$. Let the transport problem of an open type be given in the form of the following table:

Исходная таблица:

Поставщик	Потребитель				Запасы груза
	В1	В2	В3	В4	
A1	8 0 м	11 0 м	1 0 м	4 0 м	120
A2	5 0 м	2 0 м	7 0 м	3 0 м	97
A3	10 0 м	4 0 м	3 0 м	5 0 м	69
Потребность	54	32	25	15	

Транспортная задача является открытой, так как запас груза больше потребностей на 160 единиц.

This transport task of an open type looks like this:

There are 3 suppliers A1, A2, A3, which have stocks of cargo in the amount of 120, 97, 69 units, respectively. This cargo needs to be delivered to four consumers B1, B2, B3, B4, who ordered 54, 32, 25, 15 units of this cargo, respectively. The cost of transportation is determined by the following matrix

$$C = \begin{pmatrix} 8 & 11 & 1 & 4 \\ 5 & 2 & 7 & 3 \\ 10 & 4 & 3 & 5 \end{pmatrix}$$

It is required to draw up such a transportation plan in which the total cost of all transportation would be minimal.

By the condition of the problem, the number of suppliers is $m = 3$, and the number of consumers is $n = 4$. Select the “Добавить колонку” section in the “Таблица” menu and enter the data:

	потребитель В1	потребитель В2	потребитель В3	потребитель В4	Запасы груза
поставщик А1	8	11	1	4	120
поставщик А2	5	2	7	3	97
поставщик А3	10	4	3	5	69
Потребности	54	32	25	15	

Then we select the “Решить задачу” section in the “Задача” menu and at the 5th stage we will get the following solution.

Поставщик	Потребитель					Запасы груза
	В1	В2	В3	В4	В5	
A1	8 <i>М</i>	11 <i>М</i>	1 25 <i>М</i>	4 4 <i>М</i>	0 91 <i>М</i>	120
A2	5 54 <i>М</i>	2 32 <i>М</i>	7 <i>М</i>	3 11 <i>М</i>	0 <i>М</i>	97
A3	10 <i>М</i>	4 <i>М</i>	3 <i>М</i>	5 <i>М</i>	0 69 <i>М</i>	69
Потребность	54	32	25	15	160	

Целевая функция F= 408

91 единиц груза из хранилища А1 осталось нераспределенным.
69 единиц груза из хранилища А3 осталось нераспределенным.

Thus, for $X_{\min} = \begin{pmatrix} 0 & 0 & 25 & 4 & 91 \\ 54 & 32 & 0 & 11 & 0 \\ 0 & 0 & 0 & 0 & 69 \end{pmatrix}$ the objective function F takes its minimum value, i.e. F=408.

The solution has a matrix form, we can write it in the following form:

$$x_{13} = 25, x_{14} = 4, x_{15} = 91, x_{21} = 54, x_{22} = 32, x_{24} = 11, x_{35} = 69$$

In this open problem, for $a > b$, all consumers are satisfied, but part of the cargo remains in the warehouses of economically unprofitable suppliers:

91 cargo items from storage A1 remained unallocated;

69 units of cargo from storage A3 remained unallocated.

The transport problem belongs to linear programming problems and can be solved by the potential method or by the simplex method. But automated methods for solving linear programming problems are more convenient and can be used instead of using potentials and bulky simplex tables.

With the help of the Optimal 2 program, you can quickly and conveniently solve open type transport problems.

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