

# Quantity Allocation Among the Source Group for Software Applications

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**ABSTRACT:** *MATLAB environment is tested on various occasions for the software applications. Many new software products are initially tested in MATLAB environment. In this work, we generated a linear optimization task which is termed the transport simplicity method. This task involves the quantities allocation among the source group and more groups to reduce the allocation of cost and energy. Finally, the authors can use MATLAB environment to apply the Transport Problem Solving Program in optimization methods.*

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## 1. Introduction

The solution for the transport task is based on a modified Simplex method for solving the Line Optimization Problem [1,2], called the transport simplicity method. The development of computer technology and the growth of its computing power, especially in the last decade, allows the study of complex objects and phenomena in real-time mode. The Matlab programming environment is a typical representative of this field [6]. In the MATLAB program environment [3, 4], commands are available to solve the classical linear limiting task with limitations: linprog, bintprog, but in this case for a transport task, there is no such command. Here is considered a method for solving a Transport task by reducing it to a task of linear optimization.

### Formulation of the transport task

The introduction of engineering design techniques into the engineering practice allows to move from the traditional method of creating a model of the developed equipment to modeling with the help of personal computers. [7]

Let  $m$  be given by sources  $A_i$ , which offer quantities  $a_i$ ,  $i = 1 \dots m$ , and the destinations  $B_j$  are  $n$  in number, need for quantities  $b_j$ ,  $j = 1 \dots n$ . Let matrix  $C$  be given for the transport cost of one distribution unit from the  $i$  source to  $j$  destination:

$$C = \begin{cases} c_{11} & c_{12} & \dots & c_{1n} \\ c_{21} & c_{22} & \dots & c_{2n} \\ c_{m1} & c_{m2} & \dots & c_{mn} \end{cases} \quad (1)$$

Let  $x_{ij}$  be unknown units of distribution from  $i$  source to  $j, i = 1, 2, \dots, m, j = 1, 2, \dots, n$ .

The goal is to minimize the total cost of allocating these quantities.

**Transport task:**

Minimize the function of total transport costs:

$$\min Z = \sum_{i=1}^m \sum_{j=1}^n c_{ij} x_{ij} \tag{2}$$

Subject to restrictions:

$$\sum_{j=1}^n x_{ij} = a_i, \quad i = 1, 2, \dots, m, \tag{3}$$

$$\sum_{i=1}^m x_{ij} = b_j, \quad j = 1, 2, \dots, n, \tag{4}$$

and limitations for the non-negative of the unknown variables  $x_{ij} > 0$ .

The matrix  $X$  of the Unknown is called a transport matrix.

$$X = \begin{pmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{pmatrix} \tag{5}$$

A transport matrix satisfying the system constraints (2) - (3) is called an acceptable solution to the transport task. For convenience, the prices, availability and needs of the transport The solution for the transport task is based on a modified task are given in Table 1:

	$B_1$	$B_2$	.....	$B_n$	$a_i$
$A_1$	$c_{11}$	$c_{12}$	.....	$c_{1n}$	$a_1$
$A_2$	$c_{21}$	$c_{22}$	.....	$c_{2n}$	$a_2$
$\vdots$					
$A_m$	$c_{m1}$	$c_{m2}$	.....	$c_{mn}$	$a_m$
$b_j$	$b_1$	$b_2$	.....	$b_n$	

Table 1. Availability and needs

**Specific features of the transport task**

If the unknown variables are treated as a pillar vector derived from the  $X$  matrix rows, then the Transport task is recorded as a Line Optimization task:

$$\min Z = C_{11}x_{11} + c_{12}x_{12} + \dots + c_{1n}x_{1n} + C_{21}x_{21} + C_{22}x_{22} + \dots + C_{m1}x_{m1} + C_{m2}x_{m2} + \dots + C_{mn}x_{mn} \tag{6}$$

**Subject to restrictions:**

$$\begin{pmatrix}
 1 & 1 & \dots & 1 & 0 & 0 & \dots & 0 & 0 & 0 & \dots & 0 \\
 0 & 0 & \dots & 0 & 1 & 1 & \dots & 1 & 0 & 0 & \dots & 0 \\
 \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\
 0 & 0 & \dots & 0 & 0 & 0 & \dots & 0 & 1 & 1 & \dots & 1 \\
 1 & 0 & \dots & 0 & 1 & 0 & \dots & 0 & 1 & 0 & \dots & 0 \\
 0 & 1 & \dots & 0 & 0 & 1 & \dots & 0 & 0 & 1 & \dots & 0 \\
 \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\
 0 & 0 & \dots & 0 & 0 & 0 & \dots & 0 & 0 & 0 & \dots & 0 \\
 0 & 0 & \dots & 1 & 0 & 0 & \dots & 1 & 0 & 0 & \dots & 1
 \end{pmatrix}
 \begin{pmatrix}
 x_{11} \\
 \cdot \\
 x_{1n} \\
 \cdot \\
 x_{m1} \\
 \cdot \\
 x_{mn}
 \end{pmatrix}
 =
 \begin{pmatrix}
 a_1 \\
 a_2 \\
 \cdot \\
 a_m \\
 b_1 \\
 b_2 \\
 \cdot \\
 b_n
 \end{pmatrix}
 \quad (7)$$

and limitations of non-negativity  $h_j \geq 0$ .

The transport task has the following specific features:

- The task is to minimize the target function;
- All restrictions are of the “equality” type;
- The matrix elements of the coefficients before the unknowns in the limitations are zeros or units;
- In each pillar of the matrix of coefficients in front of the unknown in the limits there are two units, ie each variable is involved only in two equations with a coefficient unit.

**Theorem 1:** The transport task (1) - (3) has an acceptable solution then and only when the class is fulfilled:

$$\sum_{i=1}^m a_i = \sum_{j=1}^n b_j \quad (8)$$

**Theorem 2:** The rank of the equation system (2) equals  $m + n - 1$ .

**Consequence:** Any acceptable solution  $X$  of the transport task contains at most  $m + n - 1$  positive components  $x_{ij}$ . The remaining components are zero.

**Definition 1:** An acceptable solution to the transport task, in which there are exactly  $m + n - 1$  positive components  $h_{ij}$ , is called unconditionally.

**Definition 2:** An acceptable solution to the transport task in which there are less than  $m + n - 1$  positive components  $h_{ij}$  is called degenerate.

### Types of transport tasks

- Balanced and unbalanced transport tasks

According to whether the condition of Theorem 1 is met, transport tasks are two types: balanced and unbalanced. If the condition (4) is met, the transport task is called a balanced one, or in the opposite case:

$$\sum_{i=1}^m a_i \neq \sum_{j=1}^n b_j \quad (9)$$

The task is unbalanced. There are two possible scenarios:

**1. Offering is greater than demand.** In this case, a fictitious destination (user) is entered, with zeros for transport costs and the required amount - the difference between total stocks and needs:

$$\sum_{i=1}^m a_i - \sum_{j=1}^n b_j \quad (10)$$

**2. Demand is greater than supply.** In this case, a fictitious source (manufacturer) is introduced, the transport costs are zero and the quantity produced - the difference between total needs and stocks:

$$\sum_{j=1}^n b_j - \sum_{i=1}^m a_i \quad (11)$$

• A blocked transport task (with bans)

When there is no transport link between a source and destination, the transport task is “blocked shipments”. In this case, a very positive number  $M \gg 0$  (large M method) is assumed for transport expense.

• Another case where the use of the M-method is required is when the Transport task is unbalanced and the user BK is required to obtain the requested amount in full. In this case, after introducing a fictitious source  $A_s$ ,  $M (M \gg 0)$  is applied to transport expense  $c_{sk}$  ensuring that  $B_k$  obtains the necessary quantities only from real sources.

• An analogous situation occurs when the task is unbalanced, and in addition a producer wants to distribute all of his available quantity. Then, after introducing a dummy user (destination)  $B_k$ ,  $M (M \gg 0)$  is applied for transport expense  $c_{sk}$  thus ensuring that  $A_s$  can distribute its available quantities only to real users (destinations).

### Program implementation

• The Transport Troubleshooting Program is a MATLAB function with the following arguments:

#### 1. Entry arguments:

- Matrix C of transport costs
- Vector a - quantities offered
- Vector b - Queries

#### 2. Output arguments:

- Z - value of the target function
- X - matrix of the solution of the Transport task.

• After input values are entered, the command is set :  $[Z, X] = transport (C, a, b)$

• In the event of an unbalanced transport task, the program automatically balances it. When solving a blocked transport task (Figure 1, Figure 2), the corresponding element in transport matrix C is assigned a large enough number, of the order of  $1e+009$ .

```
function [Z, X] = transport (C, a, b)

(m, n)=size (C);

[ma, na) = size (a);

[mb, nb) = size (b);

if ma < na
    a = a';
    [ma, na) = size (a);
end

if mb < nb
    b = b';
    [mb, nb) = size (b);
end
```

```

if (ma~=m) | (mb~=n)
    error('некоректен брой елементи на a или b')
end

suma = sum(a);

sumb = sum(b);

Iflag = 0;

if sumb>suma

```

Figure 1. Blocked transport task

```

    Iflag=1;

        nula=zeros (1, length (b));

        C=[C; nula];

        a= [a; sumb-suma];

    end

    if sumb<suma
        Iflag=2;
        nula=zeros (length (a),1);
        C= [C, nula];
        b= [b;suma-sumb];
    end

    B = [a;b];
    [m, n]=size (C);
    f = reshape (C',m*n, 1);
    A1 = zeros (m,m*n);
    A2 = eye (n);
    A3 = eye (n);

    for k =1:m
        A1 (k, ((k-1)*n+1): (k*n))=1;
    end

    for k =1: (m-1)
        A2 = [A2, A3];
    end

    A = [A1; A2];

    lb = zeros (m*n, 1);

    options = optimset ('LargeScale', 'off', 'Simplex', 'on');

    [X, Z] = linprog (f, [], [], A, B, lb, [], [], options);

```

```

X=reshape (X, n, m); X=X';
if Iflag==1
    X(end, :)=[];
elseif Iflag==2
    X(:, end)= [];
end

```

Figure 2. Blocked transport task

**Numerical Experiments**

•The program for solving a transport task has been tested multiple times with different numerical data. Here are three examples of balanced, unbalanced tasks and a Transport task with blocked shipments (Figure 3, Figure 4).

No.1	$B_1$	$B_2$	$B_3$	$a_i$
$A_1$	4	4	2	30
$A_2$	5	3	1	20
$A_3$	3	6	4	40
$b_j$	45	35	10	

No.2	$B_1$	$B_2$	$B_3$	$a_i$
$A_1$	1	2	4	80
$A_2$	4	2	6	70
$A_3$	6	1	3	50
$b_j$	50	80	50	

No.3	$B_1$	$B_2$	$B_3$	$a_i$
$A_1$	20	45	40	60
$A_2$	-	30	25	60
$A_3$	-	15	20	30
$b_j$	20	10	30	

```

>> балансирана транспортна задача
>> C [4 4 2:5 3 1:3 6 4];
>>a = [30 20 40];
>>b = [45 35 10];
>> [Z, X]-transport (C, a, b)
Z =
    280
X =
    5    25    0

```

Figure 3. Transport task with blocked shipments

0	10	10
40	0	0

```

>> Пример 2: небалансирана транспортна задача
>> C = 1 2 4; 4 2 6; 6 1 3);

```

```

>> a=[80 70 50];
>> b=[50 80 50];
>>[Z, X]=transport (C,a,b)
Z=
    360

X=
    50    10    0
    0    70    0
    0    0    50

>> Пример 3: небалансирана транспортна задача с блокирани превози
>> C [20 45 40: 1e9 30 25; 1e9 15 20];
>> a=[60 60 30];
>> b=[20 10 30];
>> [Z, X]-transport (C, a, b)
Z=
    1200

X=
    20    0    0
    0    0    10
    0    10    20

```

Figure 4. Transport task with blocked shipments

## 2. Conclusion

The Transport Problem Solving Program is widely applied in science and practice and is successfully applied to the study of Optimization Methods.

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