



FINDING A BASIC ALLOWABLE SOLUTION OF THE TRANSPORTATION PROBLEM BY THE DIAGONAL METHOD IN THE FUNCTION OF INDUSTRIAL LOGISTICS USING GNU OCTAVE SOFTWARE

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Abstract:

Knowledge of internal operations, system analysis, and scientific methods, has a significant role in the functioning of the logistics system.

This paper presents the solution to the transportation problem, i.e. finding a basic admissible solution using the Diagonal method (North West Corner Rule) and creating a software solution in GNU Octave to solve it, which can also be used in Matlab.

The developed software solution especially has a significant role for situations in practice where the dimensions of the problems are significantly larger than the example presented in this paper.

Keywords:

Industrial logistics, Transportation problem, Diagonal method, GNU Octave software.

INTRODUCTION

Today, we have several definitions for the term logistics. One of them is the definition of the International Society of Logistics (SOLE), according to which, in a broader sense, logistics represents a strategic process by which a business organization organizes and supports its activity in terms of managing all activities that contribute to the circulation of products and the coordination of supply and demand, and we can also say about logistics that it represents the process of managing the procurement, movement, and storage of materials and semi-finished products/products through the organization and its marketing channels, and in the most cost-effective, appropriate and profitable way for organization and customer [1].

For industrial logistics, we can say that it represents project management where the team works to meet the criteria for the material and semi-finished product to be in place at a certain time, using:

- supply chains,
- storage,
- transportation,
- information system,
- planning.

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Industrial logistics systems consist of:

- human resources,
- information technology,
- management of incoming and outgoing logistics,

and all to reduce the time and costs required for the material and semi-finished products/products to reach their destination.

Logistics is considered one of the important elements in modern business and solving problems in the field of engineering. Although science itself dates back to before, it still has a very significant and irreplaceable role in solving the problems of today and the future [2], [3].

In this paper, we will present the transportation problem, which represents one of the most common problems solved in engineering logistics [4]. Two ways of solving the transportation problem will be presented, the classic way and the approach through the application of computer technologies. The computer technologies approach and solution of transportation problems will be accented, considering that the real problems in logistics could be rather large, concerning their dimensions and the use of computer technologies, that is, appropriate software tools are inevitable in this case.

For the purpose of this paper, we have chosen the GNU Octave software, because it has great potential for use in engineering, due to its features and the possibilities it offers.

2. TRANSPORTATION PROBLEM

The transportation problem is an optimization problem typical for operational research and management science. It involves determining the most cost-effective way to transport products from multiple sources (such as production plants or warehouses) to multiple destinations (such as retailers or customers), satisfying the demand constraints. The objective is typically to minimize transportation costs while meeting demand requirements and respecting the capacity limitations of both sources and destinations.

By solving the transportation problem at Industrial Logistics, we deal most intensively with solving the problem of optimizing transportation from the source (e.g. warehouse) to the destination (e.g. production plant, store) and minimizing transport costs.

There are two types of transportation problems, balanced transportation problem (the total supply equals the total demand), and unbalanced (the total supply is not equal to the total demand). In this paper, the balanced transportation problem will be presented and explained.

Also, concerning the solving of the transportation problem, there are several algorithms [5]. Some of the better-known among them are North West Corner Rule (NWCR), Least Cost Method, and Vogle's Approximation Method (VAM). In this paper, we will demonstrate the application of the North West Corner Rule otherwise called the Diagonal method.

2.1. FINDING A BASIC ADMISSIBLE SOLUTION TO THE TRANSPORTATION PROBLEM USING THE DIAGONAL METHOD

The basic admissible solution (initial solution) is obtained by applying the diagonal method as follows: we start the distribution of resources from the upper left corner of the table (matrix) of values, by satisfying the maximum needs of the first destination or completely emptying the first source. The field with the newly defined value in the table (matrix) represents the field through which we carry out the transport and it represents the basic solution of the transport problem. With this procedure, we eliminate from the further calculation and/or the first row and/or the first column of the table (matrix) [6].

We have found a basic acceptable solution when all available quantities from the source have been shipped and the needs of all destinations have been met. For the basic admissible solution to be non-degenerate, we need to define a total of r basic admissible solutions ($r=m+n-1$) in the final table (matrix), through which we carry out transport, whereby: m – number of rows of the table (matrix) of values, and n – number of columns of the table (matrix) of values.

3. THE GNU OCTAVE SOFTWARE

GNU Octave software serves as a powerful tool for complex numerical computations and analyses, essentially encompassing mathematical operations. It operates as a high-level programming language primarily made for mathematical tasks, including analysis, data processing, visualization (including 2D and 3D graphics), algorithm development, prototyping, and addressing various scientific challenges [7], [8].

In contrast to languages like C, GNU Octave employs an interpreter that directly executes user-provided instructions without requiring separate compilation. It can be accessed through a graphical user interface (GUI) or a command-line interface (CLI), offering a user-friendly environment that integrates calculations, programming, and result visualization seamlessly.



Notably, GNU Octave stands as an open-source alternative to the commercial software Matlab, sharing substantial compatibility with minimal syntax discrepancies. It is compatible with various operating systems such as GNU/Linux, macOS, BSD, and MS Windows, and is available for free download from its official website [9].

4. AN EXAMPLE OF FINDING A BASIC ADMISSIBLE SOLUTION USING THE DIAGONAL METHOD

Let's say for example that we have warehouses as sources and production plants as destinations. Warehouses and production facilities are located in different locations, so the transportation costs per unit of raw material transported from warehouses to production facilities are different, and we will present them in Table 1.

We will present the available quantities in warehouses and the required quantities for production facilities in Table 2.

4.1. FINDING A BASIC ADMISSIBLE SOLUTION TO THE TRANSPORT PROBLEM USING THE DIAGONAL METHOD WITHOUT THE USE OF THE SOFTWARE

We obtain the basic admissible solution in the following way: we start from the upper left corner of the value table (matrix) so that the warehouse S1 satisfies the demand of all production plants in order until it exhausts its stocks. We repeat the further procedure according to the same principle of the upper left corner for the remaining part of the unfilled elements of the table (matrix) of values, which is presented from table 3 to table 5.

The criteria function that presents the costs of this solution is:

$$T_o = 3 \cdot 20 + 3 \cdot 10 + 11 \cdot 25 + 13 \cdot 35 + 6 \cdot 10 + 8 \cdot 80 = 1520 \text{ [n.j.]}$$

Table 1. Transportation costs from the warehouse to the production plant.

Warehouses	Production plants			
	P 1	P 2	P 3	P 4
S1	3	3	5	7
S2	9	11	13	15
S3	2	4	6	8

Table 2. Available quantities in warehouses and required quantities for production facilities.

Warehouses	Production plants				Available quantities in warehouses
	P 1	P 2	P 3	P 4	
S1	3	3	5	7	30
S2	9	11	13	15	60
S3	2	4	6	8	90
Required quantities in warehouses	20	35	45	80	180

Table 3. Application of the Diagonal method - step 1.

Warehouses	Production plants				Available quantities in warehouses	
	P 1	P 2	P 3	P 4		
S1	20 → 3	10	3	5	7	30
S2	9	11	13	15	60	
S3	2	4	6	8	90	
Required quantities in warehouses	20	35	45	80	180	



Table 4. Application of the Diagonal method - step 2.

Warehouses \ Production plants	Production plants				Available quantities in warehouses
	P 1	P 2	P 3	P 4	
S1	20 → ³	10 ³	5	7	30
S2	9	↓ ¹¹ 25 →	13	15	60
S3	2	4	6	8	90
Required quantities in warehouses	20	35	45	80	180
					180

Table 5. Application of the Diagonal method - step 3.

Warehouses \ Production plants	Production plants				Available quantities in warehouses
	P 1	P 2	P 3	P 4	
S1	20 → ³	10 ³	5	7	30
S2	9	↓ ¹¹ 25 →	35	13	15
S3	2	4	↓ ⁶ 10 →	80	8
Required quantities in warehouses	20	35	45	80	180
					180

4.2. FINDING THE BASIC ADMISSIBLE SOLUTION BY THE DIAGONAL METHOD USING GNU OCTAVE SOFTWARE

Now we will present solving the same problem using a computer, ie. of GNU Octave software. In the Editor window, create an m-script file (Listing 1), save it under the desired name and run it, e.g. by pressing the icon Save File and Run / Continue. The result will be shown in the second window called Command Window (Listing 2). An m-script file created in GNU Octave can also be run in the Matlab software.

In the m-script, the costs of transportation are first defined and available and required quantities in warehouses. From the m-script realized in GNU Octave (Listing 1), it can be seen that it follows the algorithm of the Diagonal method, starting from the upper left corner (north-west corner) of the value table (counters i and j are set to 1 in the m-script). The algorithm of the diagonal method is repeated by comparison of the stocks and demand, until the stocks are exhausted, as it was shown in the tables above.

The results are displayed in the Command window of the GNU Octave software (Listing 2).

The proposed solution to the transportation problem using the GNU Octave software is one solution that uses suitable software tools and can be used for teaching and learning, but it has great potential to be used in real practice.

The new applications of the technologies in logistics and transportation, especially the “smart” ones, are already in development, and open new fields where they can be used [10].



```

clc;
clear all;
troskovi=[3 3 5 7; 9 11 13 15; 2 4 6 8];           % definisanje troškova transporta
izvori=[30 60 90];                               % definisanje količina na izvoru
odredista=[20 35 45 80];                         % definisanje količina na odredištu
x=zeros(size(troskovi));
[m,n]=size(troskovi);                           % m - broj redova matrice, n - broj kolona
matrice
r=m+n-1;                                         % r - izračunat broj bazno dopustivih
rešenja, tj.                                     % broj elemenata u završnoj tabeli preko kojih
                                                % se vrši transport
i=1;                                             % brojač redova
j=1;                                             % brojač kolona
k=0;                                             % brojač bazno dopustivih rešenja
while(k<r)
if izvori(i)<=odredista(j);
    x(i,j)=izvori(i);
    odredista(j)=odredista(j)-izvori(i);
    i=i+1;                                       % brojač redova
    k=k+1;                                       % brojač bazno dopustivih rešenja
elseif odredista(j)<=izvori(i)
    x(i,j)=odredista(j);
    izvori(i)=izvori(i)-odredista(j);
    j=j+1;                                       % brojač kolona
    k=k+1;                                       % brojač bazno dopustivih rešenja
else
    break;
end
end
printf('Bazno dopustivo rešenje: \n');--
disp(x)
Ukupno_r=length(nonzeros(x));
if Ukupno_r==r
    printf('\n Bazno dopustivo rešenje je nedegenerisano. \n');
else
    printf('\n Bazno dopustivo rešenje je degenerisano. \n');
end
Ukupni_troskovi=sum(sum(troskovi.*x));
printf('\n Funkcija kriterijuma koja prezentuje troškove ovog rešenja iznosi: %d/n.j./.\n',
Ukupni_troskovi);

```

Listing 1. M-script file created in GNU Octave.

```

Bazno dopustivo rešenje:
  20  10   0   0
   0  25  35   0
   0   0  10  80

Bazno dopustivo rešenje je nedegenerisano.
Funkcija kriterijuma koja prezentuje troškove ovog rešenja iznosi: 1520/n.j./.
>>

```

Listing 2. Display of the results in the GNU Octave Command Window.



5. CONCLUSION

Finding a basic admissible solution to the transportation problem using the diagonal method in the function of industrial logistics, as we can see, is a relatively easy method for determining the initial solution. The basic permissible solution, i.e. we defined the initial when we shipped the available quantities from all sources and satisfied the needs of all destinations.

This method is applicable only in case we have chosen i.e., a balanced model when the sum of the available quantities at the sources is equal to the sum of the required quantities at the destinations. If this is not the case, then we have an open i.e., unbalanced model in which we will have to add one new row or new column to the table due to the expansion of the existing model to translate it into a closed model.

Solving practical examples of larger dimensions, unlike the example we presented in this paper, requires the mandatory application of software solutions, such as the software solution developed in this paper using GNU Octave or Matlab.

Concerning that in the real logistics practice dimensions of the problems are quite large, and the software tools are necessary for solving that kind of problem. The GNU Octave software can be successfully applied to various problems in logistics, which makes it a useful tool available to a wide range of experts.

6. REFERENCES

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