

# Solving Multi-Objective Transportation Problem by Row Maxima Method

\*Maulik Mukeshbhai Patel & \*\*Dr. Achyut C. Patel

\*National College of Commerce, Ahmedabad, Gujarat (India)

\*\*M.T. Dhamsania Commerce College, Rajkot, Gujarat (India)

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### \*Corresponding Author

Email: mady\_5231@yahoo.com

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## ABSTRACT

The transportation problem is the sub-classes of linear programming problems. The objective of transportation is to transport various quantities of single undifferentiated products. These are commodities stored at different origins to different places. These products are to be transported in such a way that the total transportation cost is least where the source parameter ( $e_i$ ) may be production facilities godowns etc. and the destination parameter ( $d_j$ ) may be ware house, sales depot etc. The penalty  $c_{ij}$  i.e. the coefficient of the objective function could show of transportation cost, delivery time, number of goods transported unfulfilled demand and many others. Thus the multi-objective transportation problem is multiple penalty criteria may present concurrently which leads to research work.

## INTRODUCTION

The transportation problem is the sub-classes of linear programming problems. The objective of transportation is to transport various quantities of a single undifferentiated product. These are commodities stored at different origins to different places. These products are to be transported in such a way that the total transportation cost is least where the source parameter ( $e_i$ ) may be production facilities godowns etc. and the destination parameter ( $d_j$ ) may be ware house, sales depot etc. The penalty  $c_{ij}$  i.e. the coefficient of the objective function could show of transportation cost, delivery time, number of goods transported unfulfilled demand and many others. Thus the multi-objective transportation problem is multiple penalty criteria may present concurrently which leads to research work.

Some of the researchers have shown their interests in multi-objective transportation problems and proposed also have some methods for solving it

## LITERATURE REVIEW

Gurupada Maity and Sankar Kumar Roy (2014) Solving multi-choice multi-objective transportation problem: a utility function approach. This paper explores the study of multi-choice multi-objective transportation problem (MCMTP) under the environment of utility function approach. MCMTP is converted to multi-objective transportation problems (MOTP) by transforming the multi-choice parameters like cost, demand, and supply to real-valued parameters. Transportation problem, Multi-choice programming, Multi-objective decision making. In this paper, we have considered MCMTP where the cost, demand, and supply coefficients are multi-choice type. Another important notion of this study is to give an impression of goal preferences of the DM. The approach of utility function is the most useful skill for representing the DM's preferences.

V.J. Sudhakar, V. Navaneetha Kumar (2010) Solving the Multi-objective Two Stage Fuzzy Transportation Problem by Zero Suffix Method. In this paper, Multi objective two stage

Fuzzy transportation problem is solved in a feasible method. For this solution zero suffix method is used in which the supplies and demands are trapezoidal fuzzy numbers and fuzzy membership of the objective function is defined. Transportation problem, Trapezoidal fuzzy numbers, Two stage fuzzy transportation problem, Multi-objective, Zero suffix method. In this paper zero suffix method is used to determine the optimal compromise solution for a multi-objective two stage fuzzy transportation problem, in which supplies, demands are trapezoidal fuzzy numbers and fuzzy membership of the objective function is defined.

Jignasha G. Patel ,Jayesh M. Dhodiya (2016) SOLVING MULTI-OBJECTIVE INTERVAL TRANSPORTATION PROBLEM USING GREY SITUATION DECISION-MAKING THEORY BASED ON GREY NUMBERS. An interval transportation problem constructs the data of supply, demand and objective functions such as cost, time etc in some intervals. This problem can be converted into a classical MOTP by using the concept of right limit, half-width, left limit, and center of an interval. Multi-objective interval transportation, effect measure, efficient solution, decision weight, grey situation. This paper present the compromise solution of multi-objective interval transportation problem obtained using grey situation decision making theory based method with objective weights. The comparison shows that the compromise solution is better and acceptable in real life situation when more than one objective available in transporting a product.

K. Bharathi and C. Vijayalakshmi (2016) Multi-Objective Transportation Problem Using Add On Algorithm. A linear based optimality with multi criteria in transportation model is termed as Multi-objective transportation problem. This type of Multi criteria problems are termed as hard NP problems and difficult to solve in real life problems. Here Add on Algorithm is introduced to find a best fit solution for Multi-objective problems. Transportation, optimization, Multi criteria, Best fit solution, Algorithm, Efficient solution. The results of the proposed algorithm are good enough to attain our optimal criteria. Based on the numerical calculations this model can be

considered as an appropriate model for multi objective travelling salesman problem.

Ali Musaddak Delphi (2016) Heuristic Algorithms for Solving Multiobjective Transportation Problems. In this paper, we proposed three heuristic algorithms to solve multiobjective transportation problems, the first heuristic algorithm used to minimize two objective functions (total flow time and total late work), the second one used to minimize two objective functions (total flow time and total tardiness) and the last one used to minimize three objective functions (total flow time, total late work and total tardiness), where these heuristic algorithms which is different from to another existing algorithms and providing the support to decision markers for handing time oriented problems. Transportation problems, Heuristic algorithms, Feasible solutions, Multiobjective problems. In this paper, we conclude that the three heuristic algorithms found feasible solutions for the three problems optimality, these heuristic algorithms can be applied to different field such as military affair. It can be seen from the numerical examples that these heuristic algorithms provided in this paper is easier to compute and the results obtained are better.

**MATHEMATICAL FORMULATION OF THE PROBLEM**

Let there be m origins, i<sup>th</sup> origin possessing e<sub>i</sub> units of a certain product, whereas there will be n destinations (n may or may not be equal) with destination j<sup>th</sup> requiring d<sub>j</sub> units. Costs of shipping of an item from each of l sources to each of the m destinations are known either directly or indirectly in terms of mileage, shipping hours etc. Let c<sub>ij</sub> be the cost of shipping one unit product from i<sup>th</sup> source to j<sup>th</sup> destination. Let 'x<sub>ij</sub>' be the amount to be shipped from i<sup>th</sup> origin to j<sup>th</sup> destination.

Now the problem is to determine non-negative values of 'x<sub>ij</sub>' satisfying both, the availability constraint:

$$\sum_{i=1}^l X_{ij} = e_i, \text{ for } i = 1, 2, \dots, l.$$

as well as the requirement constraints:

$$\sum_{j=1}^m X_{ij} = d_j, \text{ for } j = 1, 2, \dots, m.$$

It is also assumed that total availabilities  $\sum e_i$  satisfy the total requirement  $\sum d_j$  i.e.

$$\sum e_i = \sum d_j \quad (i = 1, 2, \dots, l : j = 1, 2, \dots, m).$$

The problem now is to determine non-negative value of

X<sub>ij</sub> satisfying both, the availability constraints:

$$\sum_{j=1}^n X_{ij} = e_i, \text{ for } i = 1, 2, \dots, l.$$

as well as

$$\sum_{i=1}^m X_{ij} = d_j, \text{ for } j = 1, 2, \dots, m.$$

Now minimizing the total cost of shipping

$$z = \sum_{i=1}^l \sum_{j=1}^m x_{ij} C_{ij}$$

Here the constraints equations, and the objective function are all in linear in X<sub>ij</sub>, so it may be viewed as a linear programming problem.

**FUZZY PRELIMINARIES**

**Membership Function**

In this method, membership value presents penalties (cost, time, etc) and these penalties are defined by membership function. As membership value is higher it is closed to be optimal solution. The linear membership function which is defined as:

$$\mu_k(x_{ij}^k) = \begin{cases} 1 & x_{ij}^k \leq L_{2k} \\ \frac{L_{1k} - x_{ij}^k}{L_{1k} - L_{2k}} & L_{2k} \leq x_{ij}^k \leq L_{1k} \\ 0 & x_{ij}^k \geq L_{1k} \end{cases}$$

Where  $L_{1k} \neq L_{2k}$ ,  $k = 1, 2, \dots, p$

If  $L_{1k} = L_{2k}$  then membership value is 1 for any value of k.

**NEW ROW MAXIMA METHOD**

Step 1. For each cell and for each objective table obtain the membership value.

Step 2. Make a new table for having each cell average membership value of all objective tables.

Step 3. Take the first row and find maximum membership value, give this cell as much as possible either in supply or in demand or in both

Step 4. If condition in row, then go to next row and repeat step 3 and if condition is in column then search next maximum membership value in same row and allocate this cell as much as possible to get rim condition.

Step 5. Do the step 3 and 4 till supply and demand are empty.

**EXAMPLES**

**Example 1:**

A supplier, supply a product to different destinations from different sources. Here take decision in this transportation problem so that cost and time should be minimum. The data for the cost and time is as follows:

**Data for time (Table 1)**

Destination → Sources ↓	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Supply
N <sub>1</sub>	18	21	14	16
N <sub>2</sub>	24	15	21	18
N <sub>3</sub>	16	30	10	14
Demand	12	17	19	48

Data for cost (Table 2)

Destination → Sources ↓	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Supply
N <sub>1</sub>	11	16	14	16
N <sub>2</sub>	18	12	16	18
N <sub>3</sub>	10	22	08	14
Demand	12	17	19	48

Now, The first step we calculate membership value for time, Here  $L_{1k} = 30$  and  $L_{2k} = 10$  Then membership values are as follows

Membership value for time (Table 3)

Destination → Sources ↓	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Supply
N <sub>1</sub>	0.6	0.45	0.08	16
N <sub>2</sub>	0.3	0.75	0.45	18
N <sub>3</sub>	0.7	0	1	14
Demand	12	17	19	48

Membership value for cost, Here  $L_{1k} = 22$  and  $L_{2k} = 8$ :

Membership value for cost (Table 4)

Destination → Sources ↓	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Supply
N <sub>1</sub>	0.79	0.43	0.57	16
N <sub>2</sub>	0.29	0.71	0.43	18
N <sub>3</sub>	0.86	0	1	14
Demand	12	17	19	48

Now calculate average membership value.

Average membership value (Table 5)

Destination → Sources ↓	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	Supply
N <sub>1</sub>	0.695	0.44	0.685	16
N <sub>2</sub>	0.395	0.73	0.44	18
N <sub>3</sub>	0.78	0	1	14
Demand	12	17	19	48

After applying the new raw maxima method we get the solution as follows:

$$X = \{ X_{11} = 12, X_{13} = 4, X_{22} = 17, X_{23} = 1, X_{33} = 14 \}$$

The corresponding objective function values are

$$f^1(x) = 716 \text{ and } f^2(x) = 520$$

Example 2: Let us consider another example having the following characteristics.

Penalties (Table 1)

Destination → Sources ↓	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	M <sub>4</sub>	Supply
N <sub>1</sub>	2	3	8	8	10
N <sub>2</sub>	2	10	4	5	20
N <sub>3</sub>	9	10	5	7	18
Demand	12	4	15	17	48

Penalties (Table 2)

Destination → Sources ↓	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	M <sub>4</sub>	Supply
N <sub>1</sub>	5	5	4	5	10
N <sub>2</sub>	6	9	10	11	20
N <sub>3</sub>	7	3	6	2	18
Demand	12	4	15	17	48

Now we calculate membership value for table (1), here  $L_{1k} = 10$  and  $L_{2k} = 2$ , then membership values are as follows:

Membership value for penalties (Table 3)

Destination → Sources ↓	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	M <sub>4</sub>	Supply
N <sub>1</sub>	1	0.875	0.25	0.25	10
N <sub>2</sub>	1	0	0.75	0.625	20
N <sub>3</sub>	0.125	0	0.625	0.375	18
Demand	12	4	15	17	48

We calculate membership value for table (2), here  $L_{1k} = 11$  and  $L_{2k} = 2$ , then membership values are as follows:

Membership value for penalties table (Table 4)

Destination → Sources ↓	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	M <sub>4</sub>	Supply
N <sub>1</sub>	0.67	0.67	0.78	0.67	10
N <sub>2</sub>	0.56	0.22	0.11	0	20
N <sub>3</sub>	0.45	0.89	0.56	1	18
Demand	12	4	15	17	48

Now we calculate average membership value

Average membership value (Table 5)

Destination → Sources ↓	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	M <sub>4</sub>	Supply
N <sub>1</sub>	0.835	0.7725	0.515	0.47	10
N <sub>2</sub>	0.78	0.11	0.44	0.30	20
N <sub>3</sub>	0.28	0.454	0.60	0.70	18
Demand	12	4	15	17	48

Now we get the solution by applying the new row maxima method.

$$X = \{ X_{11} = 10, X_{21} = 2, X_{23} = 15, X_{24} = 3, X_{32} = 4, X_{34} = 14 \}$$

The corresponding objective function values are

$$f^1(x) = 237 \text{ and } f^2(x) = 285.$$

**FINALIZED RESULTS AND SUGGESTION**

The finalized result of above three examples with suggestion is as follow:

**Table Comparison between different approaches**

Name of the approach	$f^1(x)$	$f^2(x)$
Fuzzy goal programming method	715	520
New Row maxima method	716	520
Ideal solution	715	520

**Table Comparison between different approaches**

Name of the approach	$f^1(x)$	$f^2(x)$
Fuzzy goal programming method	228	267
New Row maxima method	237	285
Ideal solution	210	239

**CONCLUSION**

For the above examples new row maxima method is used and answer is obtained. The ideal solutions in all other method examples are obtained using the appropriate software. For first example ideal solution and solution by new row maxima method give almost equal answer for both criterions. But In second example new row maxima method does not give solution equal to the ideal solution for all the penalty criterions. But when this method is compared with other method in literature some of the objective gives better solution and for some objective it gives same solution.

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