



On Minimizing the Cost and Time of a Multi Objective Transportation Model - A Case Study

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ABSTRACT

In this paper, a Multi Objective Transportation problem to reduce the cost and time of transporting Urea through Truckloads has been studied. A solution procedure is developed for solving the problem and this method gives a better solution while compared with the existing ones. Moreover, a case study was made in the Ports of Tuticorin and Karaikal and a Multi Objective Transportation problem (MOTP) was formulated with the data and it was solved using the proposed method.

Keywords: *Transportation problem, optimal solution, Multi Objective Transportation problem, Efficient solution.*

1. INTRODUCTION

The transportation problem is a special type of linear programming problem which deals with the distribution of single product (raw or finished) from various sources of supply to various destinations of demand in such a way that the total transportation cost is minimized. Transportation problem was first introduced by F L Hitchcock in 1941 in his historic study, "The distribution of a product from several sources to numerous localities". This is the first important contribution for solution of transportation problem. In 1947 T C Koopmans also presented another important study, "Optimum utilization of the transportation problem study".

Until now, many researchers also have great interest in this field. Hammer (1969) introduced the time transportation problem for reducing time of distribution of goods from one source to another source; Chakrobarty & Chakrobarty (2010) presented method for Cost-Time minimizing for transportation problem for using linear membership function; Venkatasubbaiah and Acharyulu (2011) introduced Multi Objective Transportation problem as a special class of vector minimum linear programming problem, in which constraints are of inequality type and all the objectives are non commensurable and conflict with each other; Pandian and Natarajan (2011) introduced new method namely blocking method and blocking zero point method to solve bottleneck cost transportation problem; Abdul Quddoos, Shakeel Javaid and Khalid (2012) introduced new

method named ASM-Method which is proposed for finding an optimal solution for a wide range of transportation problems; Ahmed, Afaq Ahmad and Reshi (2014) proposed a set of efficient solutions for bi-objective transportation problems. Finally Gaurav Sharma, Abbas and Vijay Kumar Gupta (2015) also introduced multi objective transportation problem Procter & Gamble to reduce the transportation cost and time, of goods which is supply from one source to another source.

In this study, we have analyzed the transportation of Urea, which is used as a fertilizer in food grains production. The Urea is imported at Karaikal and Tuticorin ports in the state of Tamilnadu and stored in the warehouses at the ports. Later they are packed in bags and transported to multiple destinations across the state of Tamilnadu including Virudhachalam, Villupuram, Tiruvannamalai and Madurai through truck loads.

This paper is organized as follows: Section 2, preliminaries are given and its Mathematical formulation of MOTP also explained. In section 3, an ASM method for solving transportation problem is presented. An algorithm for solving MOTP is developed in section 4. An illustrative example to find the efficient solution of MOTP is explained in section 5. The last section gives conclusion.

2. PRELIMINARIES

Definition 1: A point (X, T) where $X = \{X_{ij} ; i=1,2,...,m \text{ and } j=1,2,...,n\}$ and T is a time, is said to be a feasible solution of (MP) if X satisfies the conditions

$$\sum_{j=1}^n x_{ij} = a_i, i=1, 2,...,m \quad (1)$$

$$\sum_{i=1}^m x_{ij} = b_j, j=1, 2,...,n \quad (2)$$

$$x_{ij} \geq 0, \text{ for all } i \text{ and } j \text{ are integers} \quad (3)$$

Definition 2: A feasible solution (X_0, T_0) is said to be efficient for (MP) if there exists no other feasible point (X, T) in (MP) such that $Z_1(x) \leq Z_1(X_0)$ and $Z_2(T) < Z_2(T_0)$ or $Z_1(x) < Z_1(X_0)$ and $Z_2(T) \leq Z_2(T_0)$.

Definition 3: A cost transportation problem of a MOTP is said to be active for any time M if the minimum time transportation corresponding to the cost transportation problem is M .

2.1 Mathematical formulation of MOTP

In general real life problems are modelled with multi objectives which are measured in different scales and at the same time in conflict. In actual transportation problem the multi objective functions are generally considered, which concludes average delivery time of the commodities, reliability of transportation, product deterioration and so on.

The mathematical model of Multi objective transportation problem can be stated as:

$$(MP) \text{ Minimize } Z_1 = \sum_{i=1}^m \sum_{j=1}^n c_{ij} x_{ij}$$

$$Z_2 = \sum_{i=1}^m \sum_{j=1}^n t_{ij} x_{ij}$$

Subject to (1), (2) and (3) are satisfied.

where a_i is the amount of the material available at i th source; b_j is the amount of the material required at j th destination; c_{ij} is the cost of transporting a unit from i th source to j th destination; t_{ij} is the time of a unit while transporting from i th source to j th destination; x_{ij} is the amount transported from i th source to j th destination.

3 ASM METHOD FOR SOLVING TRANSPORTATION PROBLEM

Now, the optimal solution of the transportation problem is obtained using ASM method which will be used in the proposed method.

The ASM method proceeds as follows:

Step 1: Construct the transportation table from given transportation problem.

Step2: Subtract each row entries of the transportation table from the respective row minimum and then subtract each column entries of the resulting transportation table from respective column minimum.

Step3: Now there will be at least one zero in each row and in each column in the reduced cost matrix. Select the first zero (row-wise) occurring in the cost matrix. Suppose $(i, j)^{th}$ zero is selected, Count the total number of zeros (excluding the selected one) in the i^{th} row and j^{th} column. Now select the next zero and count the total number of zeros in the corresponding row and column the same manner. Continue it for all zeros in the cost matrix.

Step4: Now choose a zero for which the number of zeros counted in step 3 is minimum and supply maximum possible amount to that cell. If tie occurs for some zeros in step 3 then choose a $(k,l)^{th}$ zero breaking tie such that the total sum of all the elements in the k^{th} row and l^{th} column is maximum. Allocate maximum possible amount to that cell.

Step5: After performing step 4, delete the row or column for further calculation where the supply from a given source is depleted or the demand for a given destination is satisfied.

Step6: Check whether the resultant matrix possesses at least one zero in each row and in each column. If not, repeat step 2, otherwise go to step 7.

Step7: Repeat step 3 to step 6 until and unless all the demands are satisfied and all the supplies are exhausted.

4 PROPOSED ALGORITHM

In this section, a new algorithm is proposed for finding all efficient solutions to the MOTP which is based on ASM method proposed by Abdul Quddos et al [2].

The proposed method proceeds as follows:

Step 1: Construct the time transportation problem from the given MOTP.

Step 2: Obtain the time transportation problem using the ASM method. Let the optimal solution be T_0 .

Step 3: Construct the cost transportation problem from the given MOTP.

Step 4: Obtain the cost transportation problem using the ASM method and also, find the corresponding time transportation. Let it be T_m .

Step 5: For each time M in $[T_0, T_m]$, compute $\alpha = \left[\frac{T_c - M}{T_c - T_0} \right]$ which is the level of time satisfaction for the time M .

Step 6: Construct the active cost transportation problem for each time M in $[T_0, T_m]$ and solve it using the ASM method.

Step 7: For each time M , an optimal solution to the cost transportation problem, X is obtained from the Step 6 with the level of time satisfaction α . Then, the vector (X, M) is an efficient solution to MOTP.

Now, the proposed method illustrated by the following example.

5. ILLUSTRATIVE EXAMPLE

A supplier, supply a product (Urea) to different destinations from different sources. The supply (in Truckloads) and the demand (also in truckloads) together with the unit transportation cost is per Quintals per kilometre on the different routes and transportation time t_{ij} between source and destination are summarized in the transportation model in table 1

Destinations/Sources	W1	W2	W3	W4	Availability
S1	(3,460)	(4,520)	(5,692)	(5,400)	16
S2	(6,690)	(9,700)	(7,810)	(3,560)	28
Demand	8	10	8	18	

(Table-1)

Now the time transportation problem of MOTP is given below:

Destinations/Sources	W1	W2	W3	W4	Availability
S1	3	4	5	5	16
S2	6	9	7	3	28
Demand	8	10	8	18	

(Table-2)

Using the ASM method, we get the optimal solution of the time transportation problem to be 7

Now, the cost transportation problem of MOTP is given below:

Destinations/Sources	W1	W2	W3	W4	Availability
S1	460	520	692	400	16
S2	690	700	810	560	28

Demand	8	10	8	18	
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(Table-3)

By using ASM method, we get the optimal solution with allocations:

$X_{11}=8$; $X_{12}=8$; $X_{22}=2$; $X_{23}=8$; $X_{24}=18$ with the minimum transportation cost is Rs 25,800 and the minimum transportation time is 9.

Now, we have $T_0 = 7$; $T_m = 9$ and the time $M = \{7, 9\}$

Now the active cost transportation problem of MOTP for $M = 7$ is given below:

Destinations/Sources	W1	W2	W3	W4	Availability
S1	460	520	692	400	16
S2	690	-	810	560	28
Demand	8	10	8	18	

(Table-4)

Using ASM method, the optimal solution with allocations $X_{11} = 6$; $X_{12} = 10$; $X_{21} = 2$; $X_{23} = 8$; and $X_{24} = 18$ with the total minimum transportation cost is Rs 25,900.

Now, the efficient solution to the MOTP is given below:

S. No	Efficient solution of multi objective transportation problem	Objective value of MOTP	Satisfaction Level
1	$X_{11}=8$; $X_{12}=8$; $X_{22}=2$; $X_{23}=8$; and $X_{24}=18$	(25800 , 9)	0
2	$X_{11} = 6$; $X_{12} = 10$; $X_{21} = 2$; $X_{23} = 8$; and $X_{24} = 18$	(25900 , 7)	1

(Table-5)

CONCLUSION

In this paper, the proposed algorithm provides a set of efficient solution to a Multi Objective Transportation problem for a sequence of various time intervals. This proposed algorithm consumes less time and is very easy to understand and apply, it will be very helpful for the decision makers to select an appropriate transportation schedule, depending on his financial position. This will help the decision maker also to evaluate the economical activities and make the good managerial decisions.

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