Explanation of Transshipment Problem using ASM Method

Raju Prajapati*, Gargi Akhoury#

*Amity University Jharkhand, Amity Institute of Applied Sciences, Ranchi, Jharkhand, Email: rprajapati@rnc.amity.edu

Amity University Jharkhand, Amity Institute of Applied Sciences, Ranchi, Jharkhand, Email: gakhoury@rnc.amity.edu

Abstract

A transshipment problem is an extension of a transportation problem. Several pieces of literature discuss the transshipment problem. The present paper deals with a particular type of transshipment problem and develops a strategy to solve it by Assigning the Shortest Mini-max (ASM) method which already exists in the literature. The above strategy is applied to a problem under consideration. Further for verification the same problem is solved by mathematical modeling. The results show that the ASM method gives an optimal solution, which is equal to the solution obtained by mathematical modeling for the considered problem.

Keywords: *Transportation Problem; Transshipment Problem; ASM method; Mathematical Modeling; Linear Programming*

Introduction

As operations research is coming into the picture, one cannot forget the transportation problem. It is a special class of linear programming problem and has huge applications in logistics. The main objective is to minimize the total shipping cost when commodities are shipped from source to destination without hampering the supply limit and the demand requirements, **Kalavathy (2018)**. As an extension of the transportation problem, we have the transshipment problem in literature. In the transshipment problem, we have either some mediator node in addition to the sources and destination nodes or some node from the source or destination itself can be the mediator nodes. Such nodes are called transient nodes. Further, there are various methods to solve a given transshipment problem. In most of the methods, the common thing is that we transform the transshipment problem into the corresponding transportation problem and then solve it by the available usual methods, **Agadaga and Akpan (2017)**.

Quddoos et al. (2012) introduced a method to find the optimal solution for the transportation problem. The beautiful part of this method is that it requires simple arithmetic and logical calculations which are easy and understandable. Many researchers used this method to get an optimal solution to the transportation problem, (**Kumar et al. 2017; Sudhakar et al 2012; Pandian; Natarajan 2010; Olsson 2019).**

Sen and Nandi (2013) tried to minimize the cost of rubber transportation. They developed a transportation model to minimize the cost of rubber transportation from Tripura to other regions. This was nothing but a case study of rubber transportation from Tripura to some destination centers in Bangladesh. In the meanwhile, some mediator points were also taken as the transient nodes, hence forming a transshipment problem. The paper deals with the problem by converting it to the corresponding transportation problem and then applying Vogel's approximation method (VAM). The research found that the method (VAM) works well and found the optimal solution for this case study.

Aini et al. (2021) use the ASM method and the Zero Suffix method for the Fuzzy transportation problem where no initial feasible solution was required. The results showed that the ASM method was best for Fuzzy transportation problems with triangular sets while the Zero Suffix method was good for the optimal solution. **Quddoos et al. (2012)** introduced a new method known as the ASM method to be used in transportation problems to get either an optimal solution or a solution closer to it. The best feature of this method is that it is easy for the layman to understand and anyone can use it as it contains very simple arithmetical and logical calculation. The method is profitable for decision-makers dealing with logistic and supply chain-related issues.

The ASM method is one of the methods to solve transportation problems and it produces the optimal direct solutions without determining the initial basic feasible solution first. Corresponding to this, a modified ASM method was introduced to obtain the optimal direct solution in a very simple way **Quddoos et.al. (2016)**. **Affandi and Lestia (2021)** use the same modified ASM method to obtain the optimal solutions for the transportation problem. They focused on the formation of a model of transportation problem and their types and used a modified ASM method to get a direct solution. Further, they concluded that this method successfully solves the balanced or unbalanced transportation problem.

A new algorithm was proposed by **Murugesan and Esakkiammal (2020)**, called the improved ASM method. This method was introduced to reduce the difficulty of recognizing and choosing an appropriate zero-entry cell for allocation from the reduced cost matrix (the case arises when there is a tie among the zero-entry cell when the sum of all the row and column elements considered have the same magnitude).

The present paper is an approach to solving the transshipment problem by Assigning the Shortest Mini-max (ASM) method. In this paper, we directly use the converted transported problem and then check the application of the ASM method on this. This is the first part of our research. Secondly, we then find a mathematical model of the transportation problem and fit the problem into the LINDO software. The software directly gives the optimal solution to any optimization problem. We also compare the solution obtained by the ASM method to the one obtained by the software.

The paper has been organized as follows: a) introduction of the general form of the transshipment problem under study in the next section; b) solution of the transshipment problem by ASM method; c) solving the problem with the help of LINDO software; d) comparative study of the problem by the stated two methods i.e. ASM method and mathematical modeling method. Finally, the paper concludes with how the ASM method applies to all types of transshipment problems.

Transshipment Problem

Figure 1 represents a transshipment problem that is considered in the present paper. This may be treated as a type of general transshipment problem under consideration for this paper. The general transshipment problem consists of m source nodes and n destination nodes. Further, there are r transient nodes between the source and destination nodes. Goods are to be transported first from the source nodes to the transient nodes and then from transient nodes to the destination nodes minimizing the overall cost of transportation. The solution to such transshipment problems is still a good topic for exploration. The idea is to solve such problems and get closer to an optimal solution or optimal solution with minimum possible computational effort. Generally, we convert the transshipment problem to a transportation problem and then solve it by any method used to solve the transportation method like the North-West corner method, Least Cost method, or Vogel's Approximation method.

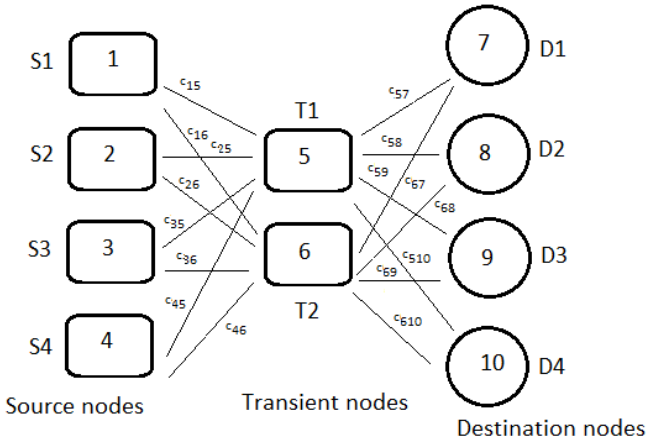


Fig 1. The Transshipment Problem.

ASM Method for the Transportation Problem

Apart from the traditional method of solving transportation problems, we have used the ASM method to solve transshipment problems. The ASM method was introduced by **Quddoos et al. (2012)**. This method gives either an optimal solution or closer to an optimal solution. This method has been used by many researchers to solve direct transportation problems. But in this research paper, this method is used in the transshipment problem to get an optimal solution. The steps of this method are very simple to use for transshipment problems as well. First, the transshipment problem is converted to a transportation problem before applying this method.

Following are the steps of the ASM method used for dealing with a balanced transportation problem:

Step 1: We construct a transportation table from the given transportation problem.

Step 2: In the transportation matrix, we subtract the minimum element of each row from all the elements of that row. Next, we subtract the minimum element of each column from all the elements of that column.

Step 3: We mark all the zeros from the matrix obtained after step 2. For each zero in the i^{th} row and j^{th} column, we count the additional total number of zeros available in the row i and column j. In that manner, we complete the counting of several zeros for all zeros in the transportation matrix.

Step 4: We choose a zero which has a minimum number of zeros count in the previous step and supply the maximum possible amount to this cell. In the case of tie, we take the zero for which the sum of elements of row and column is maximum. We allocate the maximum possible supply to that cell.

Step 5: We delete the column or row after the demand or supply gets exhausted.

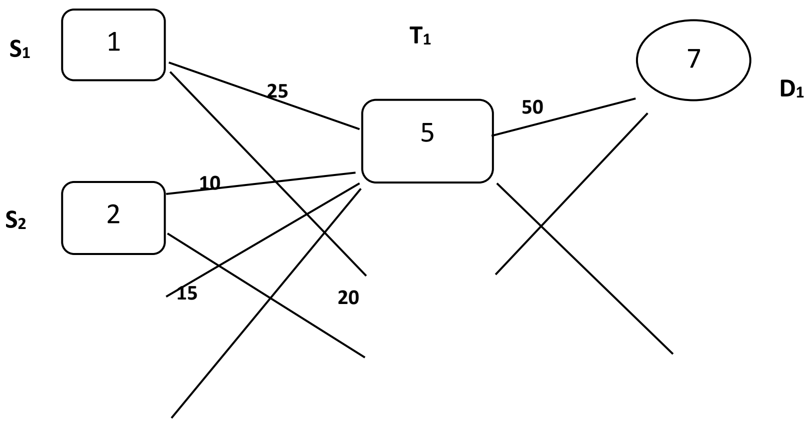
Step 6: We again check that at least one zero is present in each row and in each column. In case some zero is lacking in any row or column, we repeat step 2 again

Step 7: We repeat steps 3 to 6 until all the demand at destinations is meet and supply is exhausted.

We'll be directly applying the above steps to the transportation matrix obtained from the given transshipment problem.

The Problem under Study

Figure 2 represents the transshipment problem considered in this research. There are four source nodes, two transient nodes, and two destination nodes. Goods are to be transported from source points to destination points using some intermediate nodes. With the presence of these intermediate nodes, the problem is easily categorized as a transshipment problem. The whole problem is transformed into a transportation problem and is mentioned in Table 1. We solve this transportation matrix by the ASM method.



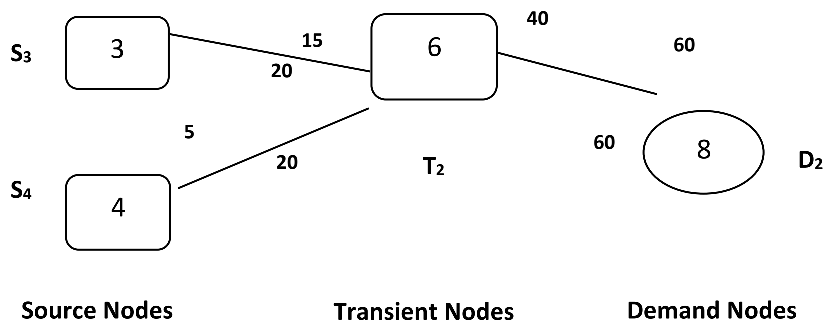


Fig 2. The Stated Transshipment Problem.

Table 1: The Converted Transportation Problem table from the given Transshipment Problem

	T1	T2	D1	D2	Supply
S1	25	20	M	M	100
S2	10	15	M	M	200
S3	15	20	M	M	400
S4	5	20	M	M	100
T1	0	40	50	60	800
T2	M	0	40	60	800
D1	M	M	0	20	800
Demand	800	800	1200	400	3200

The steps of the ASM method are applied to the data given in Table 1. After applying the row column subtraction in the above transportation matrix, we have the following matrix as in Table 2.

Table 2: The First Iteration of the Converted Transportation Problem (I)

	T1	T2	D1	D2	Supply
S1	5	0	M	M	100
S2	0	5	M	M	200
S3	0	5	M	M	400

S4	0	15	M	M	100
T1	0	40	50	40	800
T2	M	0	40	40	800
D1	M	M	$\mathbf{0_{800}}$	0	800
Demand	800	800	1200	400	3200

We have our first allocation of 800 as per the remaining steps of the ASM method. We delete the row and replace the column remaining demand as 400 only. Table 3 shows the first iteration of the transportation problem.

Table 3: The First Iteration of the Converted Transportation Problem (II)

	T1	**T2**	**D1**	**D2**	**Supply**
S1	5	0	M	M	100
S2	0	5	M	M	200
S3	0	5	M	M	400
S4	0	15	M	M	100
T1	0	40	50	40	800
T2	M	0	40	40	800
Demand	800	800	400	400	2400

Table 4: The Final Table after all the Iterations were performed.

	T1	**T2**	**D1**	**D2**	**Supply**
S1	5	0_{100}	M	M	100
S2	0_{200}	5	M	M	200
S3	0_{100}	5_{300}	M	M	400
S4	0_{100}	15	M	M	100
T1	0_{400}	40	50	40_{400}	800
T2	M	0_{400}	40_{400}	40	800

D1	M	M	0_{800}	0	800
Demand	800	800	1200	400	3200

Table 5: The Optimal Allocation of the Defined Problem

	T1	**T2**	**D1**	**D2**	**Supply**
S1	25	20_{100}	M	M	100
S2	10_{200}	15	M	M	200
S3	15_{100}	20_{300}	M	M	400
S4	5_{100}	20	M	M	100
T1	0_{400}	40	50	60_{400}	800
T2	M	0_{400}	40_{400}	60	800
D1	M	M	0_{800}	0	800
Demand	800	800	1200	400	3200

Table 4 shows the final iterations of the problem and Table 5 shows the optimal allocation. The total cost of optimal allocation obtained is 52000. Further, the number of allocations is 10 for this problem which means the problem is non-degenerate. The allocation of the final table gives the following transshipment figure.

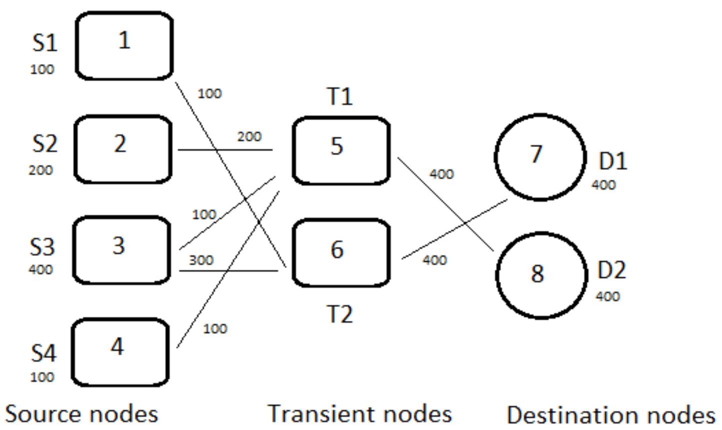


Fig 3. Final Solution of the Problem by ASM Method.

Figure 3 shows the final solution to the problem by the ASM method. The above problem is also verified by the mathematical modeling approach with the help of LINDO software. The optimal solution was the same as that obtained by the ASM method, and the result was satisfied. Thus we can say that the ASM method can also be used for Transshipment Problem as well.

Conclusion

In the present paper, we have considered a transshipment problem and solved the same using the ASM method existing in the literature. We further write the mathematical model of the corresponding transportation problem and solve it by the mathematical model using LINDO software. The ASM method gives the optimal solution when compared with the solution of a mathematical model. The paper, therefore concludes that the ASM method gives the optimal solution when applied to the said transshipment problem. We have applied the ASM method to a particular version of the transshipment problem, which consists of independent transient nodes. The future scope of this research includes the application of the ASM method on all variants of transshipment problems, i.e. the problems where the transient nodes are some nodes from the sources or destination itself, etc. The mathematical model always gives an optimal solution. However, the present paper proves the effectiveness of the ASM method concerning one problem under consideration.

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Conflicts of interest/Competing interests - "The authors declare that they have no competing interests".

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