Study Of Multi-Objective Linear Transportation Problem And Its Optimal Solution Using Maximum Divide And Minimum Allotment (MDMA) Method

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Abstract: Logistics, supply chain management, and resource allocation are just a few of the many real-world contexts in which the Multi-Objective Linear Transportation Problem presents itself as a formidable optimization issue. In this paper, we seek to solve a multi-objective, linear and non-linear transportation problem by suggesting the most efficient solution possible. The unique Maximum divide and minimum allotment (MDMA) approach was proposed to find a workable answer to a particular transportation issue. It also calculates the solution to the problem using a number of different transportation methods and compares the result to MDMA methods. It is determined that the MDMA approach offers a practical algorithm and solution for the designated transportation problem.

Keywords- Multi-Objective linear transportation problem, MDMA methods, Simplex method, Optimal solutions, Comparative analysis

1. INTRODUCTION

In the sphere of scientific investigation, optimization issues play a crucial role in resolving difficult decision-making scenarios in a variety of domains. The Multi-Objective Linear Transportation Problem (MOLTP) is a particularly intriguing area of study within the discipline of operations research, as it encompasses the complexities of resource allocation, logistics, and transportation optimization, all while taking into account multiple, frequently competing objectives. This introduction offers a scientific viewpoint on the difficulties and approaches involved in locating effective solutions for the MOLTP.

The MOLTP was developed in response to a basic difficulty faced by decision-makers in a variety of real-world contexts, including industrial production, urban planning, and disaster relief logistics. The standard Linear Transportation Problem (LTP) seeks to minimize a single criterion, often transportation costs. In contrast, the MOLTP incorporates a multi-objective dimension. It depicts a scenario in which multiple criteria must be maximized simultaneously. These criteria may include cost minimization, travel time reduction, energy efficiency, environmental impact reduction, or other pertinent goals.

Managing the MOLTP is a complex task requiring a sophisticated integration of mathematical models, optimization techniques, and decision analysis. It aims to offer decision-makers a comprehensive framework for making well-informed decisions that are consistent with their unique goals and restrictions, while taking into consideration the many and sometimes competing objectives at hand. This endeavor goes beyond the simple minimization of a cost function; it aims to find a balance between multiple objectives, reflecting the complexity of the modern decision-making landscape.

In contrast to single-objective problems, the MOLTP does not have a single optimal solution. This is one of the most difficult aspects of addressing this problem. Instead, it generates a collection of Pareto-optimal solutions that describe the tradeoffs between objectives. The decision-makers must next engage in a process of multi-criteria decision analysis to choose the optimal solution from this Pareto set, taking into account their preferences, constraints, and the specific problem situation.

2. Algorithm

Research has focused on developing more efficient algorithms to solve large-scale transportation problems. These improvements often involve specialized techniques, such as the network simplex method and column generation. The transportation problem was first formulated by Hitchcock in 1941, and it has since become a fundamental problem in operations research and optimization. Every search requires adequate supply to maintain equilibrium and develop the optimal shipping solution. This is an efficient method for offering a satisfactory transportation service. Supply and demand at a low price. It makes sense to investigate potential solutions to transportation issues. The proposed approach is the only method for achieving a viable solution (or the best current solution) without disrupting the attenuation state. The previously enumerated approaches like Least Cost Method, North-West Corner Method, Origin max-min method, Zero deduction method, Modified Distribution Method (MODI) and Vogel's approximation method are also examined when searching for viable solutions to the presented problem. In the paper, a novel and effective maximum divide minimum allotment (MDMA) method was proposed for a specific situation to discover a workable solution. In addition, it compares the practicable solution of MDMA to previous technique solutions. Table 1 displays the random transportation problem it aims to solve. The transportation issue is analyzed taking into account four supply sources and five demand sources.

Table 1: Cost table of a transportation problem

	D_1	D_2	D_3	D_4	D_5	*Supply*
S_1	11	5	10	6	8	*54*
S_2	9	1	8	7	6	*40*
S_3	3	10	3	8	6	*35*
S_4	9	17	7	7	2	*52*
Demand	*45*	*25*	*45*	*31*	*35*	*181*

We now present a novel approach that we have dubbed the MDMA method in an effort to find viable solutions to a problem involving transportation. The following is an outline of how the MDMA method's algorithm works:

To begin, write out the TT for the made-up Pay-Off Matrix (POM). Second, using the selected element as a divisor, divide all POM items by the selected element to obtain the Constructed Transportation Table (CTT). Third, meet the minimum elemental CTT requirement by increasing supply. Then, for the subsequent groups, choose the CTT maximum that comes next.

3. Maximum Divide and Minimum Allotment (MDMA) Method

The choice of method to solve the transportation problem depends on the specific requirements of the problem at hand, and advancements in algorithms to enhance the efficiency and effectiveness of solutions. 3. Maximum Divide and Minimum Allotment (MDMA) approach that were taken to solve the transportation problem using this tactic will be discussed in the following section.

3.1. Step 1 of MDMA algorithm

We reach this conclusion by consulting the Transportation Table that was presented above, and it tells us that there can be no more than 17 components. Therefore, in order to derive the new table below using the MDMA method, we would first divide the entire table by 17, which is the Maximum of all the costs given in table 1.

Table 2: Initial step of MDMA algorithm

	D_1	D_2	D_3	D_4	D_5	*Supply*
S_1	$\frac{11}{17}$	$\frac{5}{17}$	$\frac{10}{17}$	$\frac{6}{17}$	$\frac{8}{17}$	*54*
S_2	$\frac{9}{17}$	$\frac{1}{17}$ **(25)**	$\frac{8}{17}$	$\frac{7}{17}$	$\frac{6}{17}$	*40* ***(15)***
S_3	$\frac{3}{17}$	$\frac{10}{17}$	$\frac{3}{17}$	$\frac{8}{17}$	$\frac{6}{17}$	*35*
S_4	$\frac{9}{17}$	1	$\frac{7}{17}$	$\frac{7}{17}$	$\frac{2}{17}$	*52*
Demand	*45*	*25* ***(0)***	*45*	*31*	*35*	*181*

Now, we have chosen the smallest element possible, which is the value (1/17) that appears in cell (2, 2) of the $S_2 \times D_2$ table, and we are looking for the lowest possible cost (demand or supply). Then, we will allot the minimal demand i.e., minimum of (25, 40), which equals 25, into the cell (2, 2), and the entire column is going to be cancelled out.

3.2. Step 2 of MDMA algorithm

According to the updated Transportation Matrix (Table 2), we discover that the maximum element equals 11/17 in the cell (1, 1). Therefore, in order to obtain a new table in accordance with the MDMA approach, Each cell's value must be divided by the Maximum Element (12/15), which is the largest value in the table.

Table 3: Second step of MDMA algorithm

	D_1	D_3	D_4	D_5	Supply
S_1	1	$\frac{10}{11}$	$\frac{6}{11}$	$\frac{8}{11}$	54
S_2	$\frac{9}{11}$	$\frac{8}{11}$	$\frac{7}{11}$	$\frac{6}{11}$	15
S_3	$\frac{3}{11}$	$\frac{3}{11}$	$\frac{8}{11}$	$\frac{6}{11}$	35
S_4	$\frac{9}{11}$	$\frac{7}{11}$	$\frac{7}{11}$	$\frac{2}{11}$ **(35)**	52 ***(17)***
Demand	*45*	*45*	*31*	*35 (0)*	*156*

To find the most affordable demand and supply, we've settled on the absolute minimum, which is the value (2/11) in cell (4, 4) of the $S_4 \times D_5$ table. Next, we'll apply cancellation to the full row after allocating the minimum demand of 35 units and then allocating min(35,52) =35 units in cell (4,4). Also, we remove column D_5 in the next table.

3.3. *Step 3 of MDMA algorithm*

At this point, we discover that the largest element is equal to 10/11. Therefore, in order to obtain the new table shown below, we must, in accordance with the MDMA technique, divide each member of the table by the maximum element, which is equal to 10/11.

Table 4: Third step of MDMA algorithm

	D_1	D_3	D_4	Supply
S_1	$\frac{11}{10}$	1	$\frac{6}{10}$	54
S_2	$\frac{9}{10}$	$\frac{8}{10}$	$\frac{7}{10}$	15
S_3	$\frac{3}{10}$	$\frac{3}{10}$ **(35)**	$\frac{8}{10}$	35 (0)
S_4	$\frac{9}{10}$	$\frac{7}{10}$	$\frac{7}{10}$	17
Demand	*45*	*45* ***(10)***	*31*	*121*

Now, we've narrowed our search for the lowest possible demand and supply to the number (3/10), which appears in cell (3,2) of $S_3 \times D_3$. Note that here we have two choices to assign the cost to the lowest demand, we can select any one of them. Further, cancelling the entire third row and assigning 35 units to the cell (3, 2) based on the minimum demand.

3.4. *Step 4 of MDMA algorithm*

The highest possible element is 11/10 at the place (1, 1). According to the MDMA technique, we must divide the entire table by the Maximum Element (11/10), which yields the following result:

Table 5: Fourth step of MDMA algorithm

	D_1	D_3	D_4	Supply
S_1	1	$\frac{10}{11}$	$\frac{6}{11}$	54
S_2	$\frac{9}{11}$	$\frac{8}{11}$	$\frac{7}{11}$	15
S_4	$\frac{9}{11}$	$\frac{7}{11}$ **(10)**	$\frac{7}{11}$	17 ***(7)***
Demand	*45*	*10* ***(0)***	*31*	*86*

Now, we're looking for the minimal demand compared to supply by picking the minimum element, which is the (7/11) in cell (3, 2) of,$S_4 \times D_3$. Then, assigning units in the cell (3, 2) and applying cancellation of the entire second column to meet the minimal requirement (10, 17) = 10.

3.5. *Step 5 of MDMA algorithm*

To get a new table with the following structure, we divide everything by the largest member, which is 9/11. We get the following table 6.

Table 6: Fifth step of MDMA algorithm

	D_1	D_4	*Supply*
S_1	$\frac{11}{9}$	$\frac{6}{9}$ **(31)**	*54* ***(23)***
S_2	1	$\frac{7}{9}$	*15*
S_4	1	$\frac{7}{9}$	*7*
Demand	*45*	*31* ***(0)***	*76*

Now we've narrowed our search for the lowest possible demand and supply by selecting the minimal element, which is the (6/9) in cell (1,2) of $S_1 \times D_4$. Then, in cell (3,2) we'll allot min (31, 54) = 31 units, and we'll remove the entire second column.

3.6. *Step 6 of MDMA algorithm*

As we have only one column, we assign the remaining cost in the respective all remaining cells of the following table 7.

Table 7: Sixth step of MDMA algorithm

	D_1	*Supply*
S_1	$\frac{11}{9}$**(23)**	*23*
S_2	1**(15)**	*15*
S_4	1**(7)**	*7*
Demand	*45*	*45*

In the above matrix, the cell at the coordinates (1,1) receives 23 units, whereas the cell at the coordinates (2,1) receives 15 units and the cell (3, 1) receives 7 units. The table below shows all the assigned values to find the optimal solution for the given transportation problem.

Table 8: Optimal Distribution Table for the MDMA Method

	D_1	D_2	D_3	D_4	D_5	*Supply*
S_1	11 **(23)**	5	10	6 **(31)**	8	*54*
S_2	9 **(15)**	1 **(25)**	8	7	6	*40*
S_3	3	10	3 **(35)**	8	6	*35*
S_4	9 **(7)**	17	7 **(10)**	7	2 **(35)**	*52*
Demand	*45*	*25*	*45*	*31*	*35*	*181*

In addition, the goal is to arrive at the following minimally viable solution: 12 × 10 = 120 units at S1 minus D1 price.

Table 9: Optimal solution of the given problem using MDMA algorithm

Allotment Cell	***Unit Cost (INR)***
$S_1 \times D_1$	11 x 23 = 253
$S_2 \times D_1$	9 x 15 = 135
$S_4 \times D_1$	9 x 7 = 63
$S_2 \times D_2$	1 x 25 = 25
$S_3 \times D_3$	3 x 35 = 105
$S_4 \times D_3$	7 x 10 = 70
$S_1 \times D_4$	6 x 31 = 186
$S_4 \times D_5$	2 x 35 = 70
Total cost	**Rs 679**

The MDMA strategy for solving the transport problem results in a candidate value for the aim function when it is used in this manner. The algorithm that has been suggested adheres to a straightforward and logical technique. It is flexible enough to be adapted to discover the best solution to any situation that may be faced by itinerant merchants. When dealing with a wide variety of types of logistics in real time, decision-makers can use the tools that are provided by explanatory approaches to good use.

4. Analyzing Several Solutions to the Transportation Crisis

After discovering a solution to the transportation problem using the MDMA approach, the same problem was also solved using the many other ways that were already in existence, and the solutions found using each method were compared. Here, we will discuss comparison research of several different methods, and after conducting the analysis, we have come to the conclusions presented in the following result table:

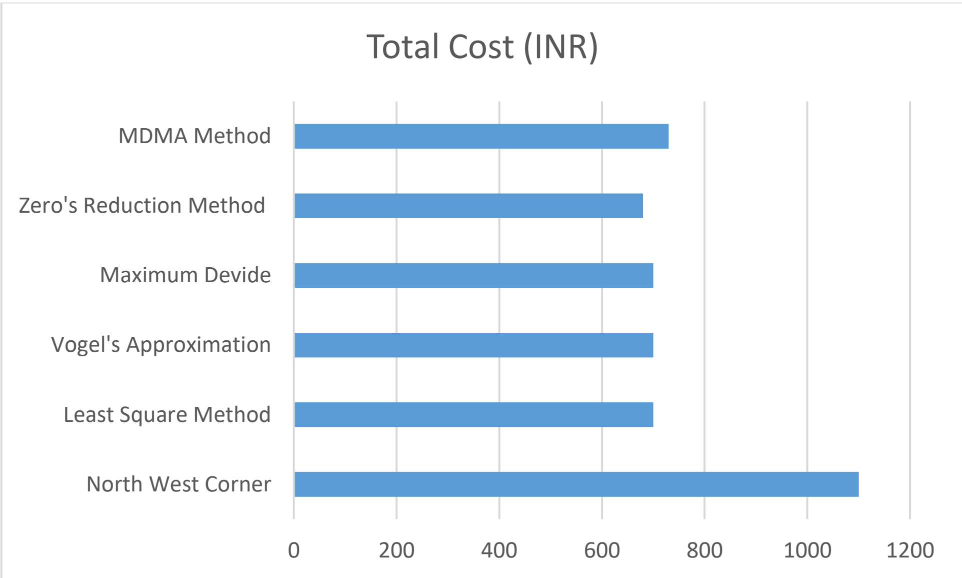

Figure 1: Value of overall transportation costs calculated using various techniques.

CONCLUSION

Finding an allocation strategy that reduces transportation costs is a top priority for solving the transportation challenge. The objective function connected with the transportation problem has the potential to benefit from the MDMA approach. The suggested approach follows a procedure that is well-organized and uncomplicated, which makes it simple to understand. It is expandable to deal with the challenges and issues posed by travelling merchants in order to gain the best solution that is attainable. When there are several logistical difficulties that need to be solved to make solid decisions, the proposed technique is a crucial instrument for decision makers to employ, and the MDMA comparison finally results in the best effective solution of all possible ways. A comparative analysis is performed, in which the results obtained from the various research approaches are contrasted with one another and summed up. This helps determine which approach offers the most effective solution to the challenges that have been outlined in this section. These techniques are a crucial instrument for decision makers since they allow them to cope with a variety of different types of logistics and arrive at the most accurate judgments possible.

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