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Initial Basic Feasible Solution for Transportation Problem using TOCM with Zero Point Minimum Method

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Abstract: The effective distribution of commodities from several suppliers to numerous consumers while minimising transportation costs is the focus of the well-researched optimisation problem known as The Transportation Problem (TP) in operations research and logistics. A tactical tool for simulating the costs involved in moving commodities among sources and destinations is the Transportation Operation Cost Matrix (TOCM). In order to provide an initial basic feasible solution, the TOCM and the Zero Point Minimum Method (ZPMM) are employed in this study to present a novel technique to addressing the Transportation Problem. The ZPMM entails finding the least expensive cell in the TOCM that hasn't been allocated and giving it the greatest amount of stock. Iteratively repeating this approach until supply and demand restrictions are satisfied results in a fundamentally workable solution. The suggested approach tries to offer a quick and easy way to arrive at a preliminary answer to the Transportation Problem, which is a key first step for further optimisation methods like the Modified Distribution Method or the Vogel's Approximation Method. The Transportation Problem (TP) estimates minimum cost for the transportation of goods to different destinations from a number of different sources. This minimum cost is called the optimal solution of the transportation problem. Before finding optimal solution, one needs to find an Initial Basic Feasible Solution (IBFS). A new method Total Opportunity Cost Matrix-Zero Point Minimum Method for determining IBFS is developed in this paper. The results obtained in terms of transportation cost are compared with the Vogel`s Approximation Method (VAM) and the optimal solution. Several numerical tests are run on various transport scenarios to gauge the effectiveness of the suggested approach. The outcomes show that the developed initial basic feasible solutions are both feasible and optimal, opening the door for future improvement utilising cutting-edge optimisation methods.

Keywords: *Initial Basic Feasible Solution; Optimal Solution; Total Opportunity Cost Matrix; Transportation Problem; Zero Point Minimum Method;*

1. Introduction

One of the most traditional issues in operations research is called the Transportation Problem (TP), which aims to maximize profit or minimize overall transportation costs by finding the best way to move items from several sources to several destinations [1]. It occurs in a variety of sectors, including manufacturing, distribution, logistics, and supply chain management, where effective resource distribution and allocation are essential to the success of the organization [2]. The Transportation Problem is essentially about figuring out the most economical method to distribute available resources, which are usually represented as commodities or items, among many providers (sources) and several demand locations (destinations) [3]. With choice variables standing in for the quantity of cargo moved from each source to each destination, the issue is framed as a linear programming model. The goal is to fulfil supply and demand restrictions while minimising the overall cost of transportation [4]. The Transportation Problem (TP) is made up of a number of complex elements that are essential to understanding how to formulate and approach solutions [5]. To begin with, supply points are the places where commodities originate or are sourced; each has a limited amount of stock available. In order to prevent overuse and resource exhaustion, this capacity constraint makes sure that the entire shipment from each supply point stays within its resource restrictions [6]. Simultaneously, demand points, which specify particular requests or requirements, stand in for the locations or demand centres that need commodities delivered. Meeting these criteria is necessary to satisfy clients and keep operations running smoothly [7]. The second part of the matrix is the Transportation Costs, which shows the costs involved in delivering commodities from every supply location to every demand point. These costs, which are commonly stated as transportation charges per unit, take into account variables like as weight and distance conveyed. In order to evaluate the financial effects of various transport routes and direct decision-makers towards economically viable alternatives, a transport costs matrix is necessary [8]. Furthermore, the procedure for transport is made viable and feasible by supply and demand constraints. Supply limitations prevent resource depletion and logistical bottlenecks by limiting the amount of commodities that may be sent from each supply location [9]. In contrast, demand

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limitations guarantee that all of the demand is met at every destination, so averting shortages and guaranteeing client pleasure. It is crucial to strike a balance between these limitations when creating workable transport systems that satisfy demand and supply demands [10]. Minimising the overall cost of transportation is the main goal of TP optimisation. This objective function, which is determined by multiplying the total amount of transportation costs by the quantity of commodities moved from each supply point to each demand point, quantifies the total costs related to carrying goods along all routes [11]. Through the process of minimising this overall cost function, TP seeks to arrive at economical transportation solutions that maximise resource efficiency and operational effectiveness [12]. The complex relationship among supply and demand points, transportation costs, and limitations characterises the multidimensionality of the problem of transportation. Developing transportation plans and algorithms that optimise logistical processes and improve overall organizational performance requires a comprehensive approach to these components. The network of transportation issues is depicted in Fig 1.

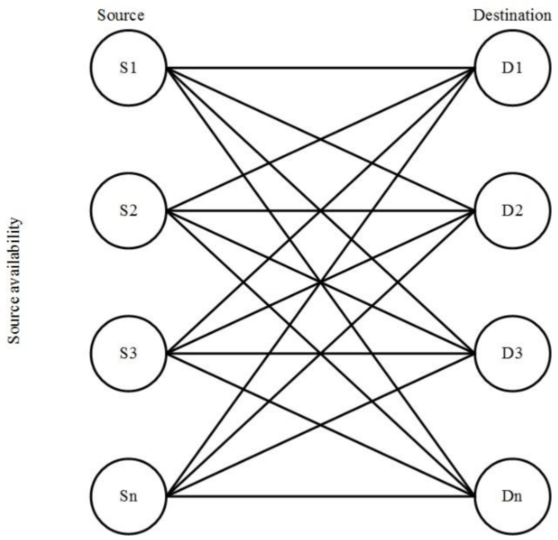

Fig 1. TP's Network representation

In order to maximise logistical processes and resource distribution inside organisations, the Transportation Problem (TP) must be solved. Finding the best, or almost best, solution that minimises transportation expenses and successfully balances supply and demand needs is the main goal. This means figuring out how to distribute and allocate items from various sources to various destinations in the most economical way. Numerous optimisation techniques and algorithms have been developed in order to effectively handle TP. Heuristic techniques like the LCM and the NWCM offer fast preliminary answers. Although these techniques are simple to implement, the most effective results could not always be obtained. Conversely, the MODI and VAM seek optimal solutions by repeatedly improving original answers in light of transportation costs and limitations. Even while these identical methods ensure optimality, it could need more processing power, particularly for bigger issue situations. The importance of TP solution goes beyond theoretical optimisation problems to practical applications in supply chain and logistics management. Businesses may increase overall efficiency, cut expenses, and optimise their transportation operations by effectively addressing TP. For example, better routes and means of transportation can result in shorter delivery times, less fuel used, and less wear and tear on the vehicles, which can save costs and increase customer satisfaction. Additionally, TP solutions provide distribution channel optimisation and inventory management, guaranteeing prompt product availability and lowering the cost of retaining inventory. Through increasing supply chain resilience and efficiency, this optimization helps businesses react quickly to changing market conditions and uncertainties. Furthermore, through providing insights into capacity planning, network architecture, and resource allocation, TP solutions assist in guiding strategic decision-making processes. Through the process of modelling various scenarios and optimising transportation routes, companies may make well-informed decisions that are consistent with their overall aims and objectives. This, in turn, increases their competitive advantage in the market. In today's complicated business environment, operational efficiency and competitive advantage are largely dependent on finding a solution to the Transportation Problem.

Efficiently solving transport problems (TPs) requires first identifying an IBFS. For optimisation algorithms, an initial base file system (IBFS) provides the groundwork for successive iterations to converge towards an optimal or nearly optimal solution. Optimisation techniques could speed up the convergence process and lower the amount of computing time and resources needed to arrive at a good solution by achieving an IBFS. Furthermore, an IBFS offers a workable beginning point that fulfils the fundamental specifications of the TP, guaranteeing that variations in the future respect supply and demand limitations. Organizations have the ability to find cost-effective transportation routes and resource allocations more rapidly because to this early feasibility, which speeds up the optimization process. Acquiring an IBFS additionally assists with decision-making as it gives information on the health of the transport network at the moment, enabling companies to plan ahead and solve logistical issues before they arise and run more efficiently. Two prominent methods for determining IBFS and optimising transportation networks in the field of TP optimisation are the Transportation Optimality Complementary Method (TOCM) and the Zero Point Minimum Method. The TOCM method effectively determines an initial viable solution by combining complementary pairs of variables. TOCM lowers computing complexity and speeds up convergence to an ideal solution by taking use of the complimentary nature of choice variables. Furthermore, TOCM's durability and adaptability make it appropriate for a range of TP situations with distinct features and limitations. A crucial element of TOCM is the

Zero Point Minimum Method, which focuses on finding the transportation cost matrix's minimum cost zero point. The cell with the lowest transportation cost, which might be a candidate for allocation in the IBFS, is located using a methodical evaluation of the cost matrix. The Zero Point Minimum Method helps to build an IBFS that minimises transportation costs while satisfying supply and demand needs by carefully choosing zero points and assigning appropriate amounts. Its effectiveness in determining the best allocation options is essential for quickening the convergence of optimization algorithms and raising the standard of the final result. The study's principal contributions are listed below:

- The study provides insights into the importance of finding an IBFS for efficient optimization of transportation problems, highlighting its role in expediting convergence towards optimal or near-optimal solutions.
- It elucidates the significance of the Transportation Optimality Complementary Method (TOCM) in solving transportation problems, showcasing its effectiveness in efficiently obtaining IBFS by leveraging complementary pairs of variables.
- Utilising TOCM and the Zero Point Minimum Method, the research quickens the convergence of optimisation algorithms, lowering the amount of computing time and resources needed to provide workable transportation solutions.
- Through the utilization of TOCM and the Zero Point Minimum Method, the study enhances the quality of transportation solutions by systematically identifying optimal allocation choices that minimize transportation costs while satisfying supply and demand constraints.

The remaining portions of the paper are arranged as follows: Related work is discussed in Section 2. In Section 3, the problem statement is covered. Part 4 delineates the suggested technique. The experimental findings are reported and compared in Section 5. The paper's conclusion and future research are discussed in Section 6.

2. Literature Review

The cost of moving items from one place to another is known as transportation expense. It is crucial to consider the expenses of moving goods in order to maximize earnings. In the current challenging global market, it is essential for businesses to strategically manage their transportation systems in order to cut costs. Determining the most efficient and budget-friendly way to transport a particular item is a choice that managers have to make. This modeling technique goes by the name of linear programming in transportation. When resolving a transportation problem, it is crucial to begin by identifying a basic solution before searching for the most effective one. Four commonly used techniques for determining a starting point in resolving transportation issues. This study proposes a fresh approach to finding initial solutions for transportation issues. An evaluation is made to determine the success of the new method through comparison with other methods. The updated technique is efficient in solving transportation problems. The suggested approach might face challenges when dealing with complex transportation networks or scenarios involving varied types of goods. Furthermore, the efficiency of this method may vary based on the unique transportation challenges. Moreover, the effectiveness of this solution may fluctuate according to the particular transport issue. Additionally, the success of this approach may be influenced by the specific transportation problem at hand [13].

The research explores diverse methods for initiating the resolution of a transportation challenge. It's crucial to determine the most effective starting point in order to find a viable solution. This investigation led to the identification of 23 novel solutions for a specific task, consisting of 18 entirely new approaches and 5 modified versions of existing methods. The effectiveness of 23 new methods, 11 older methods, and the best solution from linear programming was evaluated using 640 different problems. According to our findings, the new IBFS methods occupy the top six positions in terms of transportation cost, while the older IBFS methods take up positions 7 to 10. In addition, the best outcomes from the recently recommended IBFS approaches are very similar to the best possible solution, with just a slight deviation of 0% to 2%. These can be incorporated to tackle complex decision-making challenges such as logistics or supply chain management. Due to the limited paper size, we cannot include the results of the Wilcoxon Signed Rank test [14].

Transporting items from one location to another at a minimal expense is crucial for effectively controlling the movement of merchandise. In the transportation problem, the objective is to determine the most economical method of moving items between various destinations. When tackling a transportation problem, the IFS is used as the initial option for identifying the most optimal solution. The decrease in IFS means a reduction in the amount of effort required to find the most suitable solution. The paper outlines a fresh method for tackling transportation challenges, involving the application of a customized ant colony optimization algorithm known as MACOA. The recommended approach is user-friendly and provides optimal solutions with minimal trial and error. The algorithm performed effectively during tests with various examples, and extensive calculations were conducted to evaluate the effectiveness of our revised ant colony optimization algorithm. The evaluation indicates that both the MACOA and the existing JHM are successful in comparison to the approaches outlined in this paper for obtaining satisfactory results. When dealing with extensive transportation challenges, researchers and workers advise to opt for MACOA over JHM, as the latter requires a significant amount of time to calculate. This finding is significant as it could lead to time and cost savings through decreased transportation expenses and enhanced transportation procedures. This could also enhance the organization's competitiveness in the market. However, it doesn't always ensure the precise lowest possible price [15].

Identifying the most economical and effective means of moving commodities from their point of origin to their final destination is the core of the transportation issue. Although there are two steps involved in solving this problem—first finding the initial answer and then figuring out the best solution—it may be thought of as a linear programming framework. It's crucial to identify an effective initial solution, particularly for significant issues, as it will facilitate subsequent steps. Numerous techniques have been developed to discover the initial straightforward answer up to this point. This research suggests a fresh method for figuring out the initial fix for the problem with transportation. It goes by the name of the method for minimizing costs. This algorithm is effective due to its simplicity and user-friendly interface. Testing problems are done using the avoid maximum cost method and are compared with six other initial solution methods. The evidence suggests that the recommended technique produces a stable and highly effective starting point. Moreover, this technique can be utilized as a different approach for identifying a starting solution in instruction, as opposed to the customary methods. The variability in transportation costs can be a challenge when using the avoid maximum cost method, potentially leading to less-than-ideal starting solutions [16].

Efficiently moving goods from one location to another in the supply chain while minimizing transportation expenses is highly significant. It is commonly referred to as transportation-related challenges. In order to find the most effective solution to the problem, each individual begins by addressing it with a straightforward approach. With a solid initial solution, we can minimize the number of attempts needed to find the optimal solution with the lowest cost. This paper proposes a novel method for identifying the initial basic solution of a transportation problem. This is achieved by allocating items to the least costly option in the priciest position. The updated method outperforms the old methods in obtaining a better initial solution. This approach often leads to the most efficient solution in a short amount of time and with minimal steps. It is also effective for solving significant transportation problems. Furthermore, it has presented some thought-provoking contrasts to established methods. However, the suggested approach could be limited in situations when the capacity of transportation routes is restricted that could result in less-than-ideal outcomes [17].

The maximum flow problem is a commonly encountered problem in optimization theory. It involves determining the most effective means of transporting items through a network to minimize delivery time. According to the investigation, many ways have been devised by humans to manage the maximum volume of information that a network could sustain. The Dinic's algorithm and the Ford-Fulkerson technique are two important techniques for handling these kinds of issues. The Max-Flow Min-Cut Theorem, the Scaling technique, and the Push-relabel highest flow technique ought to all be employed to attain the maximum flow in a structure. Using the "max-flow" concept, the paper presents a fresh perspective on optimizing the flow within a network." There is a novel method for addressing transportation problems, which involves a new algorithm. This algorithm is designed to lower transportation expenses. It’s essential to understand that this technique is most effective after only a few attempts. The approach to problem-solving in this study is more straightforward than the techniques commonly found in books. It is difficult for researchers and practitioners to use conventional methods to solve major transportation problems because they involve tracing paths [18].

In order to minimise costs, the research revealed a number of innovative techniques to effectively handle transportation-related issues. These techniques, which include the Avoid Maximum Cost Method, MACOA, and IBFS, showed encouraging outcomes in terms of cost reduction and the discovery of first solutions. Still, shortcomings were found in all of the methods. Certain techniques could fail to work well with intricate transportation systems or different kinds of commodities, which would restrict their utilisation. Furthermore, although several methods provided easy-to-use interfaces and prompt resolutions, it sometimes produced less-than-ideal outcomes because of variable transportation expenses or capacity constraints. Furthermore, certain techniques (e.g., JHM) could be computationally intensive, making them impractical for large-scale transportation problems. Although the Max-Flow Min-Cut Theorem and associated techniques provided novel insights into network flow optimization, its broad applicability could have been limited by the need to carefully evaluate certain circumstances for maximum performance.

3. Research Gap

The aim of the study is to examine and employ the Transportation Optimality Complementary Method (TOCM) with the Zero Point Minimum Method in order to tackle the problem of effectively optimizing transportation operations. The core of the issue statement is that companies need to optimize their transportation procedures in order to save expenses and guarantee prompt and effective delivery of goods. The intricacy of transportation issues and the computer power needed for optimisation, however, sometimes make it difficult to accomplish this aim. In order to effectively achieve IBFS for transportation challenges, the study aims to examine the effectiveness of TOCM in conjunction with the Zero Point Minimum Method. The goal is to follow supply and demand restrictions while increasing convergence towards optimum or nearly optimal solutions. The research study attempts to show the benefits and practical application of these approaches in real-world transportation settings through empirical analysis and testing. The primary objective of this endeavour is to provide significant methods and insights for raising operational efficiency and refining transportation optimization techniques across a range of sectors.

4. Research Framework

The TOCM was originally laid out by Kirca and Satir [19]. Through adding the row and column opportunity cost matrix structures, it transforms the original TP matrices into an initial vector. In order to solve the Transportation Problem—which has to do with estimating the costs of moving commodities from one place to another—the Initial Basic Feasible Answer (IBFS) is proposed. IBFS is crucial for achieving the best outcome. Each component in the row and column opportunity cost matrix is subtracted by the least expensive one. A workable solution to the transportation problem is found using the TOCM. Additionally, it helps VAM. The fundamental feasible solution (BFS) to the transportation problem may be found using the Total Opportunity Cost Table. The problem of transportation in the matrix is transformed from its initial state back into its original matrix employing TOCM by consist of both columns and rows of possibilities. The zero-point method provides a systematic approach to transportation problems that is simple to use and could be applied to every kind of transportation problems, regardless of whether the optimization problem is maximised or minimised. It serves as a crucial contrivance for decision-makers when they are dealing with numerous logistical problems. For a lowered transportation cost of transportation problem as well as a shortened transportation time, correspondingly, the Zero Point approach and TOCM are employed to discover the best solution. In order to solve for cost and time minimising transportation to decrease the transportation time and cost, we are adopting TOCM - Zero-point approach. Here, the goal is to compare the zero-point approach with TOCM in order to find a workable clarification to the transportation challenges while reducing the amount of time it takes.

4.1 Mathematics Formulation of TOCM-Zero Point Method

In order to minimise the overall expense of Transportation Problem, as demonstrated in Equation 1 the goal of TP is to identify the unknown variable y_{uv}. The following is a formulation of TP's goal:

$$Minimum\ T = \sum_{u=1}^{r}\sum_{v=1}^{s} r_{uv} y_{uv}$$

$$\left.\begin{array}{l} With\ regards\ to\ \sum_{v=1}^{s} y_{uv} = P_u\ \ for\ u = 1, 2, 3, \dots \dots r \\ \sum_{u=1}^{r} y_{uv} = Q_v\ for\ v = 1, 2, 3, \dots \dots s \end{array}\right\}$$

$$y_{uv} \geq 0 \quad for\ all\ u, v$$

Where,

u Overall supply nodes

v Overall request nodes

P_u Sourcing quantity at Supply u

Q_v Need for Destinations Quantity v

r_{uv} Expense of moving a unit from origin u to endpoint v

y_{uv} Quantity of units that will be transported from origin u to destinations v

In a time, transportation problem, the amount of time it takes to move items from p origins to q destinations are reduced while fulfilling specific constraints for source availability and destination needs. Consequently, the transportation problem that minimises time is:

$$Min\ T' = \left[Maximum^{(a,b)}\ s^{ab} : i^{ab} > 0\ \right]$$

$$Subject\ to\ \sum_{b=1}^{q} i^{ab} = x^{a} \quad a = 1,2,3, \dots \dots \dots p$$

$$\sum_{a=1}^{p} i^{ab} = y^{b} \quad b = 1,2,3, \dots \dots \dots q$$

$$i^{ab} \geq 0$$

Transporting commodities from the a-th origin, where they are available, at time s^{a}, to the b-th destination, where they are needed, at time s^{ab}, takes place. The time of transportation for each specified viable solution, $I = [i^{ab}]$, fulfilling (1) is the maximum of s^{ab}'s among the cells in which there are positive allocates, i.e., the time of transportation for the solution I is:

$$\left[Maximum^{(a,b)}\ s^{ab} : i^{ab} > 0\ \right]$$

The goal is to cut down on travelling time. These problems emerge when perishable products must be transported during times of conflict, when food and armaments must be transported in the smallest amount of time, and in a variety of other scenarios. The suggested method for solving the transportation problem is depicted in Figure 2.

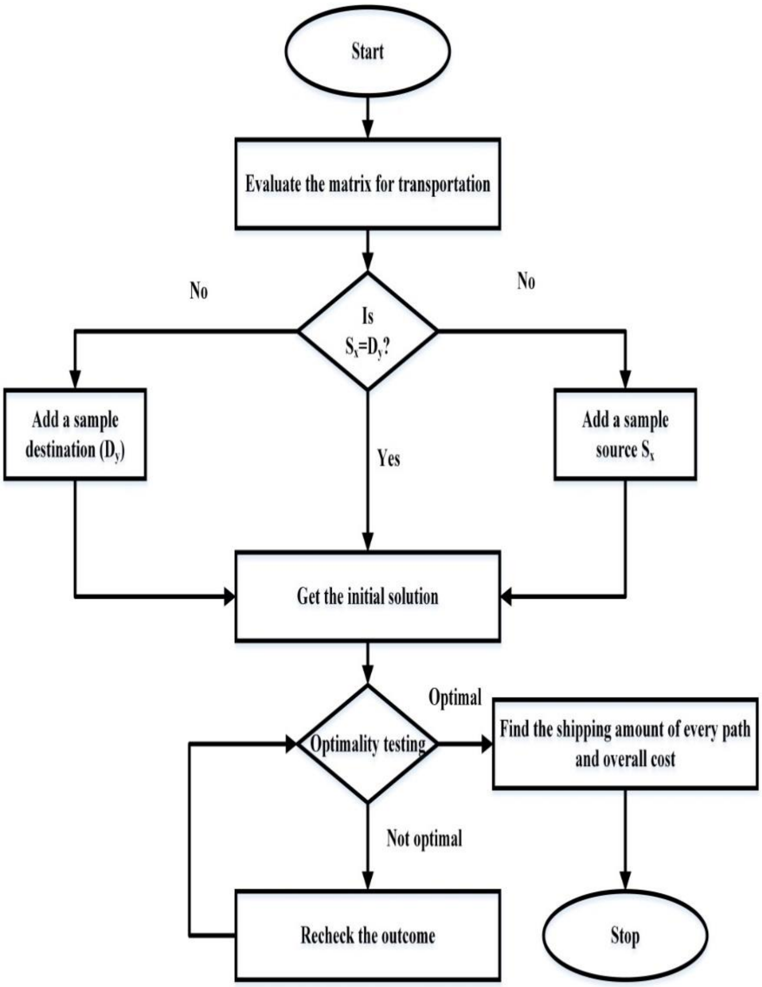

Fig 2. Workflow of the proposed work

4.2 Total Opportunity-Cost Matrix (TOCM)

Kirca and Satir [20] is the first to present the Total Opportunity-Cost Matrix (TOCM). By including the row opportunity-cost matrix (ROCM) as well as column opportunity-cost matrix (COCM), TOCM converts the primary matrix into in the Total Opportunity-Cost Matrix (TOCM).

- **Row Opportunity-Cost Matrix (ROCM):** The cheapest price of each row in the supplied balanced TP has been deducted from each component in that similar row. The ROCM seems to be the name given to the ensuing matrix.
- **Column Opportunity-Cost Matrix (COCM):** The cheapest price of each column in the supplied balanced TP has been deducted from each component in that similar column. The COCM seems to be the name given to the ensuing matrix.

The Matrix Minima Method (MMM) is then effectively used by Kirca and Satir, along with certain tie-breaking criteria on the TOCM, to come up with a workable resolution to the TP. The integration of TOCM as well as modified Total Difference Method-1 TDM1 has been known as TOCM - Minimal Total (TOCM-MT). The following list is a description of the TOCM-MT steps:

Step 1: Generate a distinctive matrix for the Transportation Problem (TP) encompassing costs, suppliers, and demands. Introduce placeholder rows or columns if the total supply falls short of meeting the entire demand.

Step 2: Create a row opportunity matrix by determining the lowest cost in each row of the initial TP, and then subtracting this cost from all other costs in the same row.

Step 3: Create a column opportunity matrix from the initial TP by identifying each column's lowest cost and then deducting all other costs from that column.

Step 4: Create the TOCM with the rows and columns opportunity matrices included as entries.

Step 5: Determine the punishment for each row. The overall discrepancy between the least expensive cost and the remaining expenses in the row seems to be the penalty.

Step 6: Choose the Highest Penalty (HP). Apply the appropriate tie-breakers in the correct sequence in the event of a tie (i.e., equivalent HP):

i. Pick HP well with lowest price.
ii. If (i) is tied, choose the penalty only with highest total cost.
iii. Choose the maximum allocation of penalties if there is a tie in (ii).

Step 7: From the greatest penalty, choose the least cost (LC) option. In the event of a tie (i.e., equivalent LC), choose the LC well with highest unit allotment.

Step 8: Verify the LC values. Step 9 becomes the next step if LC has been not equivalent to zero; otherwise, choose the HP from the initial HP (HP1) or secondary HP (HP2). By contrasting every cost cell in HP1 as well as HP2, choose the HP.

Step 9: Give the HP cell with the lowest cost the largest number of units.

Step 10: Make any adjustments to supply as well as desire, and then mark the fulfilled rows or columns.

Step 11: Recalibrate the fine without taking the crossed-out columns as well as rows into account.

Step 12: Continue doing steps 6 through 11 till all columns as well as rows have been satisfied.

Step 13: After integrating TOCM-MT, the fine, and the initial TP, determines the Total Cost TP (TCTP).

4.3 Zero Point Minimum Approach procedure

The zero-point method [6] is an efficient and effective method in finding the IBFS and the solution is near to optimal of transportation problem, whether the problems are balanced or unbalanced, and its effectiveness has been proven in many researches when compared to other methods. The following steps outline the zero point minimum approach.

Step 1: Create a table for the specified transportation issue. After that, determine if it is equal or not. If the transportation issue has been not equal, then resolve it into an equal problem.

Step 2: From each row value of the relevant row, deduct the row minimal.

Step 3: Each value in the relevant column should have the column minimal subtracted from it.

Step 4: If the conditions are met, go on to step 7 right away.

i. Desire for every column falls below the total supply of columns whose decreased cost remains zero.
ii. The total of the requests for the rows whose decreased cost has been zero is fewer than the number of rows available.

If not, proceed to step 5.

Step 5: By creating the least number of horizontal and vertical lines possible, every one of the zeros in the shortened transportation table have been covered, but certain values in the table's rows or columns, which do not comply with step 4 have been left unaffected.

Step 6: The following seems to be a new, decreased TP that has been changed.

i. The decreased cost matrices' lowest entry that isn't surrounded by a line was discovered.
ii. All entries located at the junction of any second line have been added to, and the uncovered values are removed with these lowest entries.

Next, proceed to step 4.

Step 7: A cell was chosen in the decreased transportation table where decreased cost seems to be the minimal cost, which is shown as (h, k). If the three have been greater than one unit, any among them is chosen.

Step 8: The smallest amount feasible is allotted to a cell in the k column or h row of the decreased transport table that seems to be the sole one where decreased cost remains zero. Determine the cell having the following lowest number if the minimal value isn't really present there. Choose any entry from the decreased transportation table where decreased cost seems to be zero if the following minimal value does not also appear.

Step 9: The decreased transportation table has been modified by adding the demand and supply point that are not fully employed after the completely employed demand and supply point have been removed.

Step 10: Repeat steps 7 through 9 until all supply points have been used and all request points have been satisfied.

Step 11: This results in the transportation issue being resolved.

4.4 Integrating TOCM and Zero Point Minimum Method

Kirca and Satir [1] propose the Total Opportunity Cost Matrix (TOCM). Introducing column or row opportunities transforms the matrix transportation problem into an initial matrix from the original matrix. The matrix of the original TP is shown in step 3. In every row, a row opportunity is found by subtracting minimum cost from each element in that particular row. Similarly in each column, the column opportunity is found by subtracting minimum cost from each element in that particular column. TOCM is the total of the column and row opportunities mentioned in the TOCM table.

Algorithm 1: TOC Matrix & Zero Point Minimum Method

Step 1: Verify if the taken into consideration TP is balanced. If it isn't balanced, add a dummy row or dummy column to make it balanced.

Step 2: Calculate the TOCM:

(i) The row opportunity is obtained by deducting each element in the row by its lowest cost and put it on right top of that element.

(ii) The column opportunity is obtained by deducting each element in the column by its lowest cost and put it on right bottom of that element.

(iii) TOCM is obtained by the addition of column and row opportunity cost matrices.

Step 3: Apply Zero Point Minimum Method on TOCM obtained in step 2.

Steps of Zero Point Minimum Method:

(i): Subtract row minimum from each row entry of the corresponding row.

(ii): Subtract column minimum from each column entry of the corresponding column.

(iii): Directly go to step 3 (vi), if the following are satisfied

a) Every column's demand is equivalent to or lower than the total supply of the columns whose lowered costs are zero

b) Every row's supply will be equal to or fewer than the total of the requests of the rows for which the lower cost is zero.

Otherwise go to step 3 (iv).

(iv): The reduced transportation table's zeros are all covered by creating the fewest possible horizontal and vertical lines, leaving certain entries in the table uncovered if they don't meet step 3 (iii).

(v): The following is the development of the significantly redesigned decreased transportation problem.

a. The smallest entry of the reduced cost matrices is found which is not covered by any line

b. The uncovered entries are subtracted with these smallest entries and add the same to all the entries lying at the intersection of any two lines. Next, go to step 3 (iii).

(vi): In the reduced transportation table a cell is selected, whose reduced cost is the minimum cost which is represented as (h, k). Any one of the cells is selected if there are more than one cell.

(vii): The reduced transportation table's h row or k column is chosen because it contains the single cell with a reduced cost of 0 and the smallest feasible amount is allotted to it. Locate the cell containing the next minimal value if the minimum value does not appear in that cell. If the subsequent minimum amount does not also occur, choose any cell in the lowered transportation table with a reduced cost of zero.

(viii): The simplified transportation database is modified by adding the supply point and demand point that are not fully utilized, after the fully utilized supply and demand points have been deleted. This changes the transportation problem.

Step 3 (ix): Until all supply points have been utilised and all demand points are received, steps 3 (vi) through 3 (viii) are repeated.

Step 3 (x): Performing this, the transportation issue is resolved.

A transportation table for a particular transportation problem is shown in Table 1 and shows the expenses of transportation from five supply stations $(S1, S2, S3, S4, S5)$ to three demand points $(D1, D2, D3)$. A unit of commodities' transportation costs from a given supply site to a given demand point are shown in each cell of the table. For instance, moving commodities from supply point S1 to demand point D1 costs 10, whereas moving goods from S3 to D2 costs 8. The total supply required at each demand location and the total supply available at each supply point are shown in the table's last row and column, respectively. For example, there are 8 units of total supply available at supply point S1, and 5 units of total demand at demand point D1. To effectively solve the transportation problem, this transportation table offers a thorough understanding of the expenditures associated with transportation as well as the needs of supply and demand.

Table 1. Consideration of transpiration table of the given transpiration problem

	S1	***S2***	***S3***	***S4***	***S5***	***Supply***
D1	10	15	10	12	20	8
D2	5	10	8	15	10	7
D3	15	10	12	12	10	10
Demand	5	9	2	4	5	

Solution by using TOCM with Zero Point Method

Solution

Step 1:

Consider TP is balanced $\sum S_u$=$\sum D_v$ =25.

Step 2: Obtain TOCM.

The row opportunity is calculated by subtracting each component in that row with its lowest cost.

The column opportunity is calculated by deducting each element in the column by its lowest cost.

Table 2

$\mathbf{10_5^0}$	$\mathbf{15_5^5}$	$\mathbf{10_2^0}$	$\mathbf{12_0^2}$	$\mathbf{20_{10}^{10}}$
5_0^0	10_0^5	8_0^3	15_3^{10}	10_0^5
15_{10}^5	10_0^0	12_4^2	12_0^2	10_0^0

TOCM

Table 3

	S_1	S_2	S_3	S_4	S_5	Supply
D_1	5	10	2	2	20	8
D_2	0	5	3	13	5	7
D_3	15	0	6	2	0	10
Demand	5	9	2	4	5	

Step3: by applying Zero Point minimum method, we get

Table 4

	S_1	S_2	S_3	S_4	S_5	Supply
D_1	3	8	0	0	18	8
D_2	0	5	3	13	5	7
D_3	15	0	6	2	0	10
Demand	5	9	2	4	5	

Here, using Step 3(iii) (a) and 3(iii) (b) the condition is not satisfied in the first row and second row, so we will again process it by drawing the smallest number of vertical and horizontal lines.

Table 5

	S_1	S_2	S_3	S_4	S_5	Supply
D_1	6	8	0	0	18	8
D_2	0	2	0	10	2	7
D_3	18	0	6	2	0	10
Demand	5	9	2	4	5	

Here, using Step 3(iii) (a) and 3(iii) (b) the condition is not satisfied in the first row and second row, so we will again process it by drawing the smallest number of vertical and horizontal lines.

Table 6

	S_1	S_2	S_3	S_4	S_5	Supply
D_1	6	6	0	0	16	8
D_2	0	0	0	10	0	7
D_3	20	0	8	4	0	10
Demand	5	9	2	4	5	

Here, using step 3(iii) (a) and 3(iii) (b) the condition is not satisfied in the first row, so we will again process it by drawing the smallest number of vertical and horizontal lines.

Table 7

	S_1	S_2	S_3	S_4	S_5	Supply
D_1	0	0	0	0	10	8
D_2	0	0	6	16	0	7
D_3	20	0	14	10	0	10
Demand	5	9	2	4	5	

Using Step 3(iii) (a) and 3(iii) (b) the condition is satisfied, so I using steps 3 (vi) to 3 (x) of zero point minimum method, the transportation table is computing total transportation cost for the feasible allocations.

Table 8

	S_1	S_2	S_3	S_4	S_5	Supply
D_1	0	0 / 2	0 / 2	0 / 4	10	8
D_2	0 / 5	0 / 2	6	16	0	7
D_3	20	0 / 5	14	10	0 / 5	10
Demand	5	9	2	4	5	

The original TP table is

Table 9

	S_1	S_2	S_3	S_4	S_5	Supply
D_1	10	15 / 2	10 / 2	12 / 4	20	8
D_2	5 / 5	10 / 2	8	15	10	7
D_3	15	10 / 5	12	12	10 / 5	10
Demand	5	9	2	4	5	

The amount of products carried from each supply location to each demand point is multiplied by the associated transportation cost, and the results are added up to determine the total transportation cost (TC). This time, the entire cost of transportation could be determined via the formula below:

$$TC = (15\times2) + (10\times2) + (12\times4) + (5\times5) + (10\times2) + (10\times5) + (10\times5)$$

$$=243$$

The expenses of moving items from five supply sites (S1, S2, S3, S4, S5) to three demand points (D1, D2, D3) in a transportation problem are shown in the transportation table 9. The expenses associated with moving one unit of products from a given supply site to a given demand point are shown in each cell of the table. For instance, moving commodities from supply point S1 to demand point D1 costs 10, whereas moving goods from S3 to D2 costs 8. Additionally, the table shows the entire demand needed at each demand point and the total supply available at each supply location, correspondingly, in rows and columns. According to the provided transportation chart, the total cost of transportation for moving products is thus 243 units. This computation provides an overall estimate of the cost associated with satisfying demand requirements while taking supply constraints and transportation efficiency into account. It does this by accounting for all transportation expenses incurred from each supply point to each demand location. This total cost is a crucial indicator for assessing the efficacy and affordability of various transport plans. It may also guide the process of making decisions that maximise transport operations while reducing expenses.

5. Result and Discussion

A thorough evaluation of three methods for resolving transportation-related issues in nine distinct circumstances is shown in Table 10. Every instance is distinguished by its size, which is represented by the number of sources and destinations (**P_{Size}**), and is uniquely recognized by a number (Transportation Problem). The total transportation cost obtained through each strategy for each instance is calculated in the table to assess the efficacy of the novel approach, Vogel's Approximation Method (VAM), and the MODI (Modified Distribution) technique. The widely utilised heuristic method Vogel's Approximation Method (VAM) is employed to identify preliminary workable solutions for transportation-related issues. It compares the differences among the two lowest prices for each row and column in the cost matrix to determine how it operates. With larger or more complicated transportation challenges, in particular, VAM could occasionally not be able to provide the best answer. As stated previously, the Zero Point Minimum way is one possible alternative strategy or algorithm that is meant to be referred to as the "new method" in the table. Through resolving some of the shortcomings of current algorithms, this approach could be superior to more established methods. An optimisation technique called the MODI (Modified Distribution) method is frequently employed to enhance the first workable solutions that come from approaches such as VAM. To further reduce transportation costs, iterative adjustments are made to the allocations inside the solution. MODI is a useful tool in the optimisation of transportation problems because of its reputation for improving solutions and maybe achieving optimality. Analysis of Table 10's data reveals that the new approach and MODI consistently yield the same total transportation costs in every case. This indicates that their performance is comparable in terms of the quality of the answers, suggesting that the new approach may be useful in producing optimum or nearly ideal solutions similar to MODI.

Table 10. Comparison of various techniques in solving transportation problem

Transportation Problem	P_{Size}	VAM	new method	MODI
1	3×5	249	243	243
2	3×4	781	776	776
3	4×4	199	197	197
4	4×5	829	829	829
5	5×5	94	94	93
6	5×6	318	319	315
7	4×4	262	262	262
8	3×3	365	365	365
9	4×5	374	374	374

In contrast, VAM occasionally leads to somewhat higher overall transportation costs than the other approaches, suggesting that it might not always identify the most economical course of action. However, when comparing VAM to more intricate optimisation techniques like MODI and the new approach, it is crucial to take into account the computational effectiveness and ease of implementation. For example, (5×5), the new technique achieves a transportation cost total of 93, whereas the cost of combined VAM and MODI is 94. This shows that by obtaining a reduced overall cost, the novel technique performs better in this particular situation than VAM and MODI. These findings point to the novel method's possible benefits over more conventional approaches in terms of solution quality and cost effectiveness.

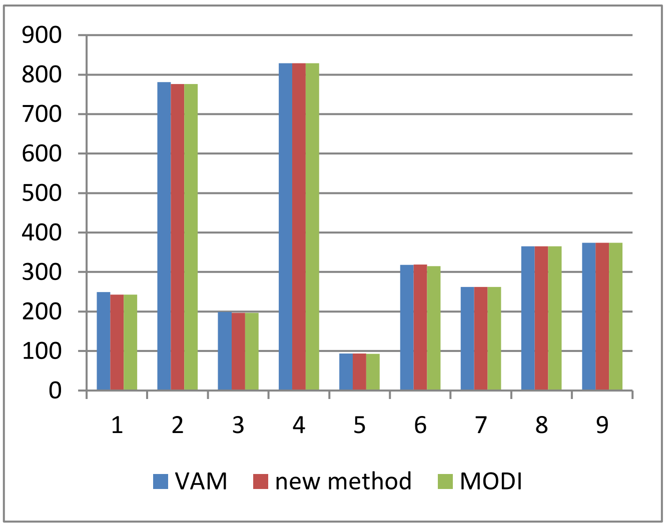

Fig 3. Comparison of various techniques in solving transportation problem

In order to solve transportation issues of different sizes, Fig 3 presents a thorough comparison between VAM, the novel technique, and MODI. In order to possibly increase solution quality and gain cost savings in transportation issue optimization, it emphasizes the need of investigating other methodologies, such as the new method. Extensive research and validation of the novel approach's performance in various issue scenarios could provide significant insights into its efficacy and practicality.

6. Conclusion

The optimisation of transport problems (TP) by concentrating on locating the Initial Basic Feasible Solution (IBFS) has yielded numerous important conclusions in this study. The effectiveness of the Zero Point Minimum Method in quickly determining IBFS has been shown via practical research and testing, which speeds up the optimisation process in the direction of optimal or nearly optimal transportation costs. The Zero Point Minimum Method is important because it may be used to systematically find the best allocation options inside the transportation cost matrix. Through deliberate zero point selection and matching quantity allocation, this approach helps build an IBFS that minimises transportation costs while meeting supply and demand needs. The effectiveness of this approach lies in its ability to identify the best allocation options quickly, which in turn speeds up the convergence of optimisation algorithms. This enhances the quality of transportation solutions and helps make educated decisions. There are several directions that future study in this field may go. The Zero Point Minimum Method has the potential to become more efficacious in addressing intricate and sizable transportation issues through more investigation and improvement. Furthermore, researching the incorporation of artificial intelligence or machine learning methods into transportation optimisation algorithms may provide fresh perspectives and methods for handling unpredictable and dynamic transportation problems. Additionally, investigating the implementation of this technique in particular sectors or domains, such humanitarian logistics or healthcare, may offer insightful information about how to handle particular requirements and limitations associated with transportation optimisation. Subsequent research initiatives in this field hold promise for enhancing transportation optimisation techniques and augmenting logistical operations and resource distribution across diverse scenarios.

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