Jagannath University Journal of Science
Volume 12, Number II, Dec. 2025, pp. 143−158
https://jnu.ac.bd/journal/portal/archives/science.jsp
ISSN 3005-4486 (Online), ISSN 2224-1698 (Print)

A Heuristic Modification of the Zero Point Method for Solving Time-Minimizing Transportation Problem

Research Article

Farhana Rashid*, Naeem Hossain, Jannatul Ferdous Jeba, Rabindra Nath Mondal
Department of Mathematics, Jagannath University, Dhaka-1100, Bangladesh

DOI: https://doi.org/10.3329/jnujsci.v12i2.89567
Received: 25.01.2026, Accepted: 15.03.2026, Published: July 2026

ABSTRACT

Commonly used in math to discover the optimal solution to a problem with straight-line goals and limits is the technique of linear programming (LP). One of its first and most important applications is the Transport Problem (TP), which aims to find the best distribution strategy that meets supply and demand without sacrificing cost or time. The issue of transportation are balanced when supply meets demand and imbalanced otherwise. The Time-Minimizing Transportation Problem (TMTP) aims to reduce time spent on transportation. The literature suggests several ways to find an Initial Basic Feasible Solution. However, the quality of these solutions varies across methods and problem instances. Some approaches are computationally simple but often yield poor-quality solutions in terms of minimizing total transportation time. Others require slightly more effort yet provide better results, while a few methods can generate near-optimal or even optimal solutions but involve higher computational complexity. Importantly, no single method guarantees optimality for all transportation problems. In this research, we propose new, efficient algorithms for finding initial basic feasible solutions in both balanced and unbalanced transportation problems, with the primary objective of minimizing transportation time. A comparative study of results obtained by the proposed heuristics against existing methods demonstrates that our approach consistently achieves more efficient and reliable outcomes. The findings indicate that the proposed methods can serve as strong alternatives to traditional approaches, offering both computational efficiency and improved solution quality.

Keywords: *Balanced and Unbalanced Transportation Problem, Time Minimization, Supply and Demand*

* **Corresponding author:** Farhana Rashid
E-mail: farhana@math.jnu.ac.bd

1. Introduction

Optimization theory, known as operations research, is crucial to military, economic, and financial decisions. Main branch of Operations Research is Linear Programming (LP), which optimizes constrained resources. A single homogenous product is transported from multiple sources to numerous localities in a manner that minimizes the overall transportation cost while meeting all supply and demand constraints. This is known as the Distribution Problem or classical Transportation Problem or simply Transportation Problem (TP) branch of LPP, which aims to achieve the highest quality possible. We need to know how much is available, where it is, and how much is needed in order to attain this goal. We also need to be aware of the expenses involved in moving a single unit of a commodity from one location to another. The expense Reducing Shipping Problem is a unique class of LPP. In operations research, this model and its pertinent expansions are crucial for identifying the best answers to a variety of business and industrial planning issues.

In the procedure of transferring of urgent materials such as military operations where weapons need to reach in time, fresh food with short storage period or unpreserved foods where foods need to reach the market in time, rescue equipment's where the equipment's need to reach the locale very swiftly, rapid marketing to achieve the most turnover, people and medical treatment things etc. The cost of shipping is less significant than the shipping time. The goal of this kind of transport problem, which is called the Time Minimizing Transportation Problem (TMTP) and max-time interpretation of TMTP explain as Bottleneck Transportation Problem (BTP), is to reduce the length of time needed for transportation. Given the time aspect in the aforementioned situations, time reduction is also crucial to achieving an organization's goals. The publication that suggested a number of heuristics for usage with Vogel's Approximation Method (VAM) was represented by Shimshak et al. [1]. The process is carried out by computer or by hand, they lead to a decrease in the time and effort needed to obtain an initial answer utilizing VAM. Ramakrishnan [2] indicated that Goyal's adaptation of Vogel's approximation approach for the imbalanced transportation problem can be enhanced by appropriately subtracting or adding constants to the rows and columns of the cost matrix. The paper presented by Arora and Puri [3] examines a time minimizing assignment problem (TMAP). A lexi-search algorithm is proposed by Arora and Puri [4] to find the global optimal solution. Theoretical results are also provided to improve the efficiency of the search process.

Ramakrishnan [2] indicated that Goyal's adaptation of Vogel's approximation approach for the imbalanced transportation problem can be enhanced by appropriately subtracting or adding constants to the rows and columns of the cost matrix. Samuel and Venkatachalapathy [6], Pandian and Anuradha [7] proposed a novel algorithm for addressing the fuzzy transportation problem. This algorithm is more efficient than other existing algorithms. The procedure for the solution is illustrated with a numerical example. Further, comparative study among the new algorithm and the other existing algorithms is established by means of sample problem. Pandian and Anuradha [7] have presented an unconventional approach utilizing the zero-point principle for solid transportation problems. The proposed method immediately produces an optimal solution for the specified solid transportation problem. It is straightforward to comprehend and use, offering administrators the ideal resolution to various distribution challenges involving three products. The suggested approach is shown by using a numerical example. Samuel [8] highlights the potential modifications to the zero-point technique for crisp or fuzzy transport issues proposed by Pandian and Anuradha [7]. Sharma et al. [9] presented a modified Zero Suffix Method for determining an optimal solution to transportation challenges. Juman et al. [10] submitted a paper detailing the successful implementation of VAM coding in C++ and its analogy with the existing VAM coding. Giramy and Sharma [11] proposed a heuristic method to address the imbalanced transport issue and enhance the Vogel's Approximation Method, aiming to obtain a superior initial solution for the unbalanced transit problem compared to the conventional VAM.

An iterative technique with polynomial time complexity to address the two-level hierarchical time minimization transportation problem as proposed by Sharma et al. [12]. Alkubaisi [13], Juman and Hoque [14] and Ahmed et al. [15]. Akpan et al. [16] proposed method and illustrated with a numerical example for the transportation problem. The paper by Sonia and Chidambaran [17] studies a time minimization transportation problem (TMTP) in the context of e-commerce delivery, focusing on reducing delivery times. It introduces the concept of a time paradox, where unusual or counterintuitive results can occur in minimizing time. Niluminda and Ekanayake [18] represented direct method to find an optimal or near-optimal solution to profit maximization TPs. Babu [19] reviews transportation problems**,** which aim to minimize the cost of shipping goods from supply centers to demand centers using optimization techniques. It discusses different types of transportation problems, including those with mixed constraints, bottlenecks**,** uncertainty, and multiple objectives**.** The study summarizes exact, heuristic, and meta-heuristic methods used to find feasible and optimal solutions. Overall, it highlights the importance of transportation models in solving real-world business and distribution problems. Memon [20] addresses a time-optimized transportation problem that considers both the transportation time and cost simultaneously. New algorithm for minimizing time proposed by many researcher [21,22,23] to while keeping costs as low as possible. The approach improves upon traditional methods by handling dual objectives in a single framework. The study offers a practical and flexible solution for real-world transportation planning problems. I would like to say in this regard, that the transportation problem was first formulated by the French Mathematician Monge [24]. Significant contributions to this field have been made by the Russian Mathematician and Economist Kantorovich during World War II [25]. The standard transportation problem was first described by Hitchcock [26].

This study proposes efficient heuristic algorithms based on a modified Zero Point approach to generate high-quality IBFS for both balanced and unbalanced TMTPs. The main objectives of the proposed research project are to discuss the time so that our manpower/labor uses properly. As a developing country like Bangladesh, we use our resources in systematic way in various sections such as Garments, Furniture Company, Electrical Company, lather industry etc. Perform a comparative study of our numerical results with that of other investigations obtained so far.

2. Precise Invention of Classical Transportation Problem (TP):

With m suppliers and n destinations, the distribution problem is an allocation problem. At a unit carrying cost c_{ij}, any of the m sources can assign to any of the n destinations. Each source supplies S_i units ($1\leq i\leq m$) while each destination demands d_j units ($1\leq j\leq n$). The goal is to create routes and size shipments to minimize the total transportation cost of satisfying demand given supply restrictions.

2.1 The Decision Variables

With the help of a distribution challenge, you can pi npoint exactly how many product units need to be sent from one location to another.

As a result, the variables that drive the decision are:

x_{ij} = The total value of the shipment going from point i to point j,

Where $i = 1,2,\ldots\ldots,m$ and $j = 1,2,\ldots\ldots,n$

2.2 The Objective Function

Consider warehouse i to destination j shipment. Transportation cost per unit is c_{ij}, and shipment size is x_{ij} for any i and j. Since we assume the cost function is linear, the total cost of this cargo is $c_{ij}\, x_{ij}$. Summing over all i and j gets the transportation cost for all source-destination pairings.

Our objective function is:

$$\text{Min: } z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}$$

2.3 The Constraints

Simultaneously, the total supply from warehouse i is denoted as S_i, and the total outbound shipment must not surpass S_i. We must mandate

$$\sum_{j=1}^{n} x_{ij} \le S_i \;; \qquad i = 1,2,\ldots\ldots,m$$

And the request at outlet j is d_j, the total incoming shipment should not be less than d_j. That is, we must require

$$\sum_{i=1}^{m} x_{ij} \ge d_j \;; \qquad j = 1,2,\ldots\ldots,n$$

Naturally, the x_{ij}*'s* should be non-negative, in other words, $x_{ij} \ge 0$, as they are tangible dispatches. The linear programming model that represents the transportation problem is typically presented as

$$\text{Minimize } z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}.$$

$$\text{subject to } \sum_{j=1}^{n} x_{ij} \le S_i \;; \qquad i = 1,2,\ldots\ldots,m$$

$$\sum_{i=1}^{m} x_{ij} \ge d_j \;; \qquad j = 1,2,\ldots\ldots,n$$

$$x_{ij} \ge 0. \quad \text{for all } i \text{ and } j.$$

In mathematical terms, the aforementioned problem may be articulated as identifying a set of x_{ij} 's, $i = 1,2,\ldots\ldots,m$; $j = 1,2,\ldots\ldots,n$ to

$$\text{Min. } z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}.$$

$$\text{subject to } \sum_{j=1}^{n} x_{ij} = S_i \;; \qquad i = 1,2,\ldots\ldots,m$$

$$\sum_{i=1}^{m} x_{ij} = d_j \;; \qquad j = 1,2,\ldots\ldots,n$$

$$x_{ij} \ge 0. \qquad \text{for all } i \text{ and } j.$$

To illustrate the formulation of the problem, a network representation of the transportation problem from source to destination is shown in Figure1.

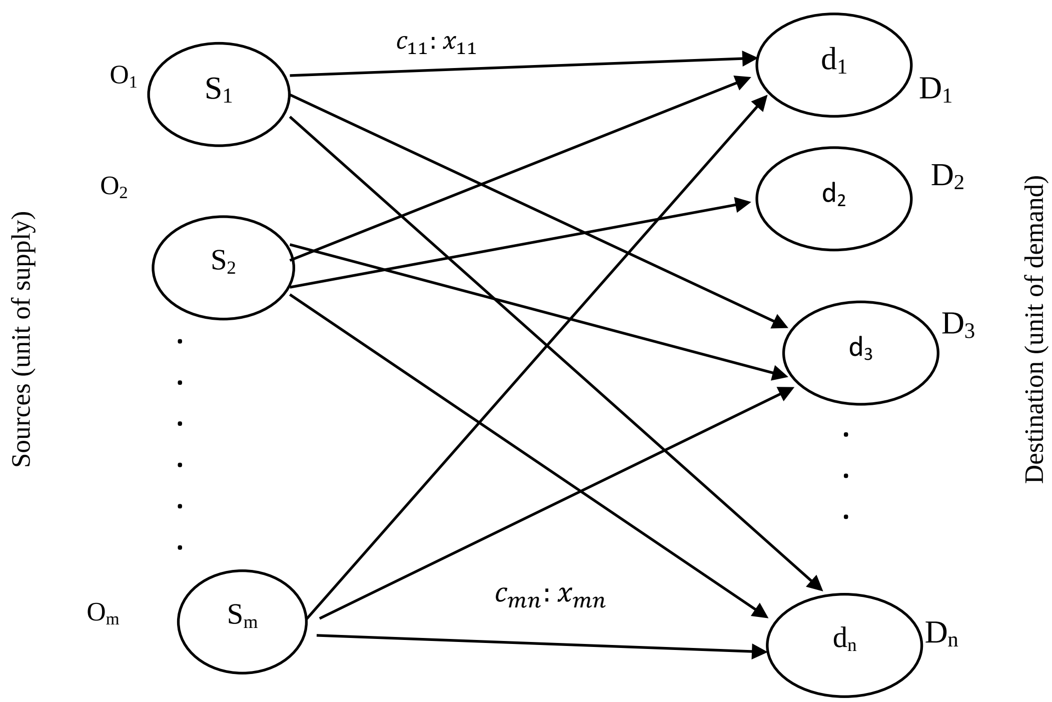


Figure 1. Network Representation of Transportation Problem

3. Bottleneck Transport Problem (BTP):

Here is a mathematical expression for the bottleneck transport problem:

$$\text{Minimize} = [Maximize_{(i,j)} t_{ij} / x_{ij} > 0]$$

Subject to the constraints

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

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

$$\text{and } x_{ij} \geq 0 \text{ for all i and j.}$$

The number of supply points is *m*, the number of demand points is *n*, the number of units shipped from supply point *i* to demand point *j* is x_{ij}, the time of transporting goods is t_{ij}, and a_i and b_j are the supply and demand at supply and demand points, respectively. In a BTP, the time matrix $[t_{ij}]$ represents the time spent carrying items from the i^{th} origin to the j^{th} destination. Time transportation is the maximum of t_{ij}'s across cells with positive allocations for each possible solution $X=\{x_{ij} : i=1,2,..., m$ and $j=1,2,..., n\}$ of the problem . As long as $x_{ij} > 0$, transportation time is independent of commodity quantity.

4. Proposed Algorithm

The Proposed algorithm for finding the minimum time consists of the following steps:

Step 01: Develop the distribution table for the specified issue with transport.

Step 02: Transform the shipping problem into a balanced one if it is not already balanced.

Step 03: Deduct the minimum value in each row from every element in that row, followed by subtracting the minimum value in each column from every element in that column.

Step 04: Repeatedly examine the row and column until a row or column with a single zero is identified.

Step 05: Choose the row or column that contains the greatest number of zeros.

Step 06: Allocate the maximum quantity possible to the specified row or column. Modify the supply and demand requirements in the appropriate rows or columns.

Step 07: Continue with the reduced distribution table procedure until all supply and demand constraints have been satisfied.

Step 08: Finally allocate total supply and demand unit to the original transportation table.

Step 09: Determine the optimal transportation time *t* as the largest transportation time corresponding to basic cells.

Step 10: With this allocation, the issue of transportation may be resolved.

4.1 Theoretical Justification of the Proposed Method

4.1.1 Proposition 1: Feasibility Preservation

At each iteration of the proposed algorithm, the allocation satisfies the supply and demand constraints of the transportation problem.

Proof: Allocation is always performed as min(supply, demand) which ensures: supply never becomes negative and demand is satisfied progressively. Rows/columns are removed only after full allocation. Therefore, all constraints remain satisfied → feasibility preserved.

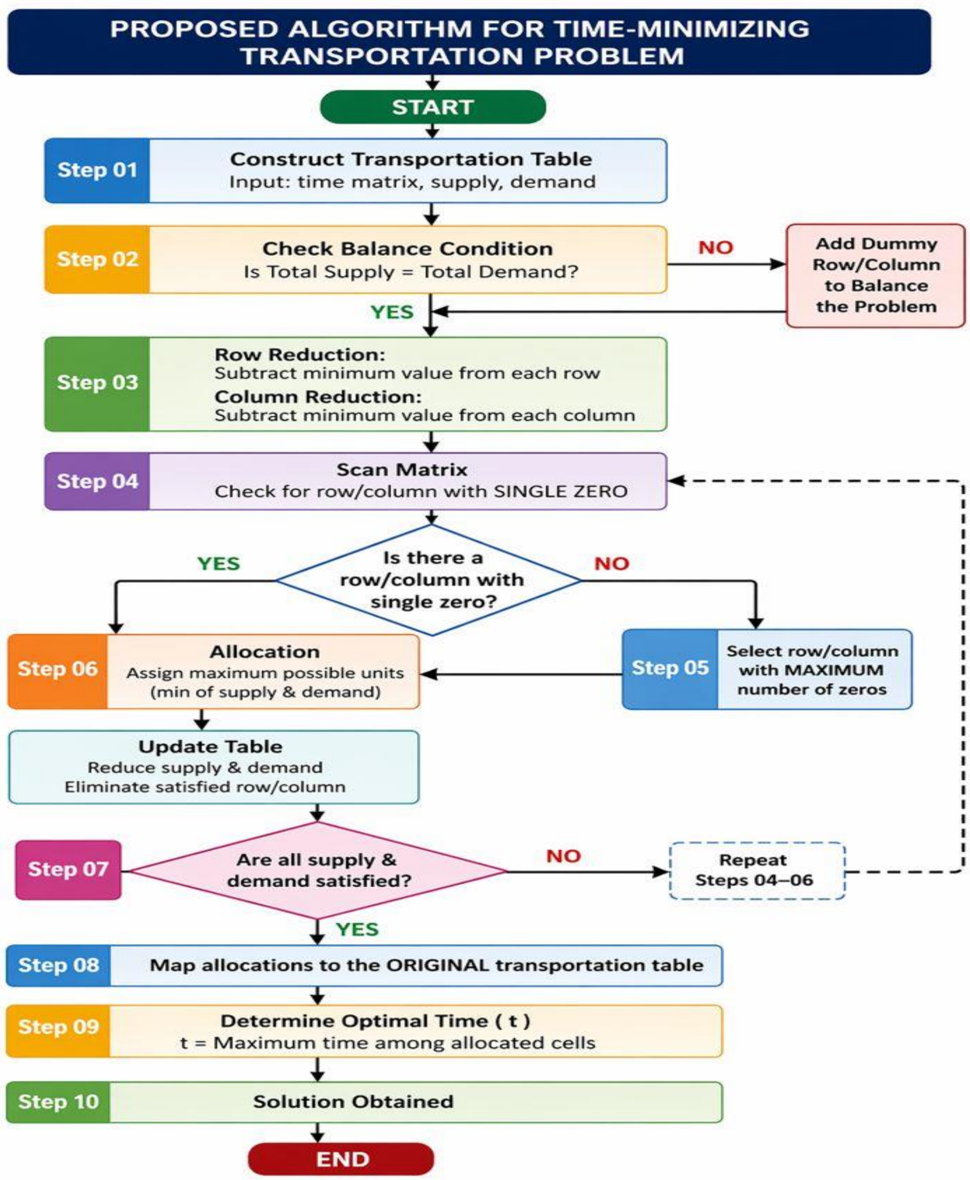
4.1.2 Proposition 2: Time Reduction Mechanism

The row and column reduction steps guide the solution toward minimizing the maximum transportation time.

Proof: Subtracting minimum values: reduces dominance of large time values and highlights smaller (better) routes. Creation of multiple zeros represents candidate optimal routes selecting rows/columns with more zeros. Preference for minimal time allocations. Which gives high-time cells are avoided so, maximum time (objective) is indirectly minimized.

Since the objective in the bottleneck (time-minimizing) transportation problem is to minimize the maximum transportation time, this strategy helps in controlling and reducing the upper bound of transportation time. Therefore, although global optimality is not guaranteed, the method is designed to produce high-quality and near-optimal solutions in a computationally efficient manner.

4.1: Flow Chart of the Proposed Algorithm:



5. Numerical Examples of Bottleneck Transport Problem:

To reveal the effectiveness of the proposed method, five illustrative Bottleneck Transport Problem (BTP) are considered:

Example 01: [Rashid, et al., 2021]

	Destinations					
		1	2	3	4	Supply
Factory	1	19	30	50	10	7
	2	70	30	40	60	9
	3	40	8	70	20	18
	Demand	5	8	7	14	

Example 02: [Agarwal and Sharma, 2020]

	Destinations					
		1	2	3	4	Supply
Factory	1	3	6	8	5	20
	2	6	1	2	5	28
	3	7	8	3	9	17
	Demand	15	19	13	18	

Example 03: [Taha, 2013]

	Destinations					
		1	2	3	4	Supply
Factory	1	20	36	10	28	10
	2	40	20	45	20	4
	3	75	35	45	50	6
	4	30	35	40	25	5
	Demand	13	10	6	6	

Example 04:[Agarwal and Sharma, 2018]

	Destination						
		1	2	3	4	5	Supply
Factory	1	8	6	8	6	10	80
	2	9	8	9	6	7	120
	3	11	10	8	13	9	140
	Demand	40	40	60	80	80	

Example 05: [Taha 2013]

	Destination						
Factory		1	2	3	4	5	Supply
	1	12	13	15	15	9	500
	2	13	12	9	10	12	1000
	3	14	15	10	13	9	1500
	Demand	700	600	500	700	500	

Example 06: [Taha 2013]

	Destination					
Factory		1	2	3	4	Supply
	1	9	9	2	2	15
	2	2	2	9	9	20
	3	4	4	4	4	20
	Demand	10	15	12	8	

5.1 To illustrate this procedure, we consider the numerical example 1 mentioned above:

Table 1: Bottleneck Transport Problem

	Destination					
Factory		1	2	3	4	Supply
	1	19	30	50	10	7
	2	70	30	40	60	9
	3	40	8	70	20	18
	Demand	5	8	7	14	

Table 2: Using step-2 to step-9

	Destination					
Factory		1	2	3	4	Supply
	1	0	0	10	0	7
	2	30	0	0	20	9
	3	0	0	30	0	18
	Demand	5	8	7	14	

Table 3: Result using all step of proposed method

	Destination					
Factory		1	2	3	4	Supply
	1	$\boxed{5}$ 19	$\boxed{2}$ 30	50	10	7
	2	70	$\boxed{6}$ 30	$\boxed{3}$ 40	60	9

	3	40	8	$\boxed{4}$ 70	$\boxed{14}$ 20	18
	Demand	5	8	7	14	

Now, using the proposed algorithm. We get the following allotment.

$$.x_{11} = 5 \text{ with time } t_{11} = 19$$
$$x_{12} = 2 \text{ with time } t_{12} = 30$$
$$x_{22} = 6 \text{ with time } t_{22} = 30$$
$$x_{23} = 3 \text{ with time } t_{23} = 40$$
$$x_{33} = 4 \text{ with time } t_{33} = 70$$
$$x_{34} = 14 \text{ with time } t_{34} = 20$$

Thus, the best obtained time is 70.

5.2 To illustrate this procedure, we consider the numerical example 02 mentioned above:

Table 4: Bottleneck Transportation Problem (example 02)

	Destination					
Factory		1	2	3	4	Supply
	1	3	6	8	5	20
	2	6	1	2	5	28
	3	7	8	3	9	17
	Demand	15	19	13	18	

Now, using the proposed algorithm. We get the following allotment,

$$x_{11} = 15 \text{ with time } t_{11} = 3$$
$$x_{14} = 5 \text{ with time } t_{14} = 5$$
$$x_{22} = 19 \text{ with time } t_{22} = 1$$
$$x_{23} = 9 \text{ with time } t_{23} = 2$$
$$x_{33} = 4 \text{ with time } t_{33} = 3$$
$$x_{34} = 13 \text{ with time } t_{34} = 9$$

Thus, the best obtained time is 9.

5.3 To illustrate this procedure, we consider the numerical example 03 mentioned above:

Table 5: Bottleneck Transportation Problem (example 03)

	Destination					
Factory		1	2	3	4	Supply
	1	20	36	10	28	10
	2	40	20	45	20	4
	3	75	35	45	50	6
	4	30	35	40	25	5
	Demand	3	10	6	6	

Now, using the proposed algorithm. We get the following allotment,

$$x_{11} = 3 \text{ with time } t_{11} = 20$$
$$x_{13} = 6 \text{ with time } t_{13} = 10$$
$$x_{14} = 1 \text{ with time } t_{14} = 28$$
$$x_{22} = 4 \text{ with time } t_{22} = 20$$
$$x_{32} = 6 \text{ with time } t_{32} = 35$$
$$x_{44} = 5 \text{ with time } t_{44} = 25$$

Thus, the best obtained time is 35.

5.4 To illustrate this procedure, we consider the numerical example 04 mentioned above:

Table 6: Bottleneck Transportation Problem (example 04)

	Destination						
		1	2	3	4	5	Supply
Factory	1	8	6	8	6	10	80
	2	9	8	9	6	7	120
	3	11	10	8	13	9	140
	Demand	40	40	60	80	80	

Now, using the proposed algorithm. We get the following allotment,

$$x_{11} = 40 \text{ with time } t_{11} = 8$$
$$x_{12} = 40 \text{ with time } t_{12} = 6$$
$$x_{24} = 80 \text{ with time } t_{24} = 6$$
$$x_{25} = 40 \text{ with time } t_{25} = 7$$
$$x_{35} = 40 \text{ with time } t_{35} = 9$$

Thus, the best obtained time is 9.

5.5 To illustrate this procedure, we consider the numerical example 05 mentioned above:

Table 7: Bottleneck Transportation Problem (example 05)

	Destination						
		1	2	3	4	5	Supply
Factory	1	12	13	15	15	9	500
	2	13	12	9	10	12	1000
	3	14	15	10	13	9	1500
	Demand	700	600	500	700	500	

Now, using the proposed algorithm. We get the following allotment,

$$x_{11} = 500 \text{ with time } t_{11} = 12$$
$$x_{22} = 600 \text{ with time } t_{22} = 12$$
$$x_{23} = 400 \text{ with time } t_{23} = 9$$
$$x_{31} = 200 \text{ with time } t_{31} = 14$$
$$x_{33} = 100 \text{ with time } t_{33} = 10$$
$$x_{34} = 700 \text{ with time } t_{34} = 13$$
$$x_{35} = 500 \text{ with time } t_{35} = 9$$

Thus, the best obtained time is 14.

5.6 To illustrate this procedure, we consider the numerical example 06 mentioned above:

Table 8: Bottleneck Transportation Problem (example 06)

	Destination					
		1	2	3	4	Supply
Factory	1	9	9	2	2	15
	2	2	2	9	9	20
	3	4	4	4	4	20
	Demand	10	15	12	8	

Now, using the proposed algorithm. We get the following allotment,

$$x_{13} = 10 \text{ with time } t_{13} = 2$$
$$x_{14} = 5 \text{ with time } t_{14} = 2$$
$$x_{22} = 15 \text{ with time } t_{22} = 2$$
$$x_{21} = 5 \text{ with time } t_{21} = 2$$
$$x_{31} = 5 \text{ with time } t_{31} = 4$$
$$x_{34} = 5 \text{ with time } t_{34} = 4$$
$$x_{35} = 10 \text{ with time } t_{35} = 0$$

Thus, the best obtained time is 4.

5.7 Comparison of various methods:

In the present work, five numerical problems were analyzed, which included three balanced and two unbalanced transportation problems shows in Table 8. The problems were solved by four existing methods, namely Vogel's Approximation Method (VAM), Zero Point Method, the Minimax Method, and North-West Corner Method, and the proposed algorithm. The performance of the methods was analyzed based on best obtained time. From the results, it is clear that the proposed algorithm outperforms or performs equally well compared to the existing methods for all five problems.

Table 9: Comparison of various methods

	Example 01	**Example 02**	**Example 03**	**Example 04**	**Example 05**	**Example 06**
Various Method	Best obtained time	Best obtained time	Best obtained time	Best obtained time	Best obtained time	Best obtained time
Vogel's Approximation Method	70	9	35	10	14	9
Zero Point Method	72	10	40	9	16	9
Minimax Method	71	9	35	11	15	4
North West Corner Method	70	10	40	13	14	9
Proposed Algorithm	**70**	**9**	**35**	**9**	**14**	**4**

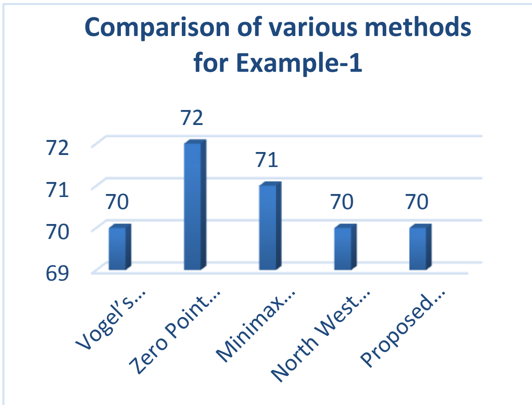


Figure 2. Comparison for Example 1

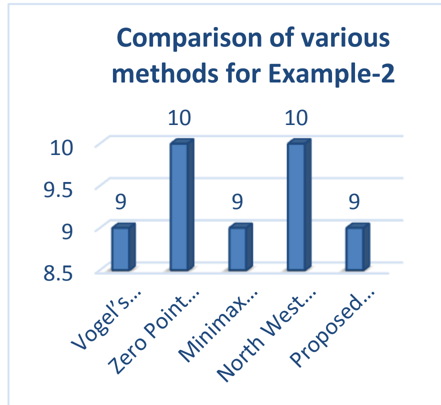


Figure 3. Comparison for Example 2

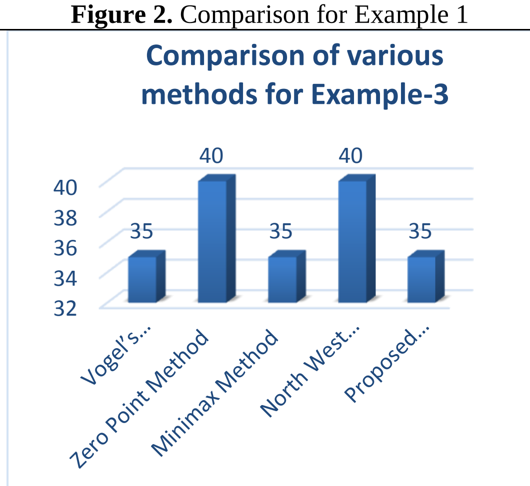


Figure 4. Comparison for Example 3

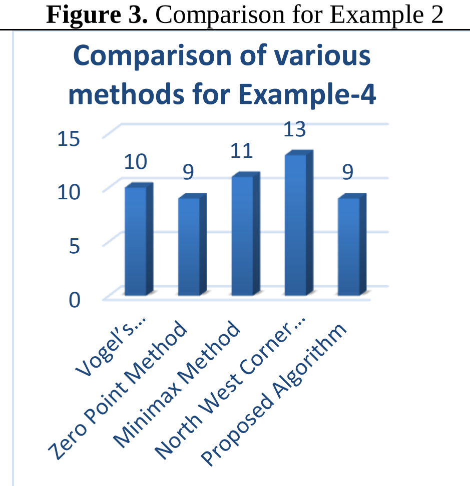


Figure 5. Comparison for Example 4

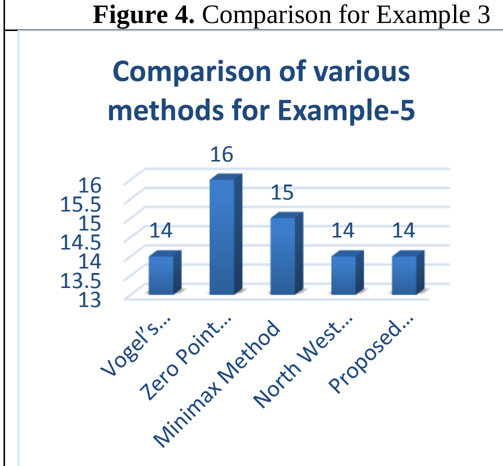


Figure 6. Comparison for Example 5

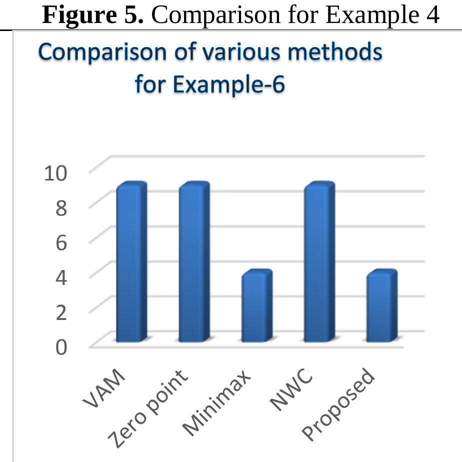


Figure 7. Comparison for Example 6

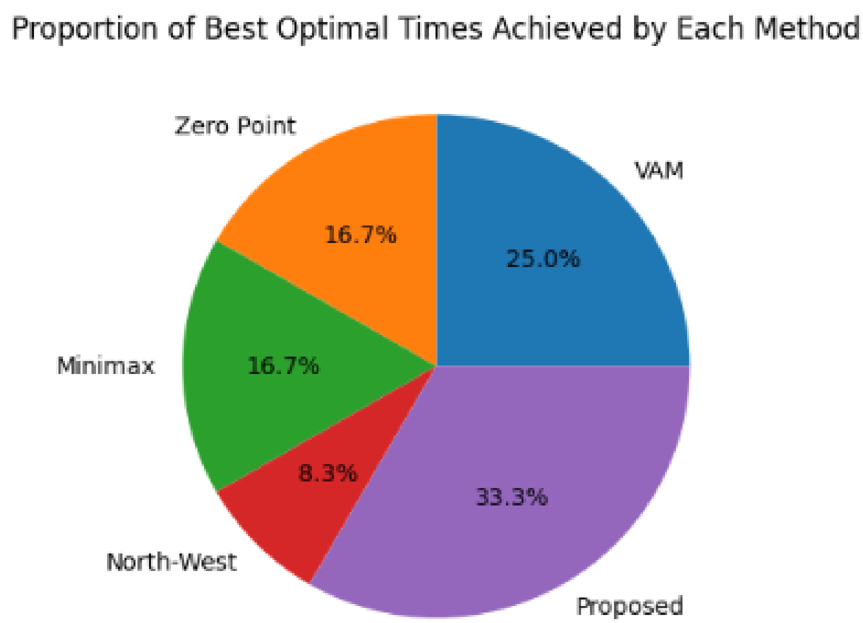


Figure 8. The proportion of all method

Figure 2 state that the best obtained time of 70 obtained by the proposed algorithm is optimal, just like Vogel's Approximation Method and North-West Corner Method, and is close to the best value (69) obtained by the Zero Point Method. It also outperforms the Minimax Method (71) for Example1. Similarly Figure 3 for Example 02 represents the proposed method provides an best obtained time of 9, which is the minimum value obtained in this example (shared with VAM and Minimax), and outperforms the Zero Point and North-West Corner methods. That is six separate bar charts (Figure 01–06), one for each example (Example 01–06), clearly showing method-wise best obtained time comparison. Where example-(1-5) are balanced and example 6 is unbalanced problem. One grouped bar chart in Figure 9 comparing all six examples simultaneously across the five methods. The experimental results show that the proposed algorithm always performs either the best or the best of the best best obtained time in all examples. In contrast, the existing algorithms have varying levels of performance and, in some examples, have higher best obtained times. The proposed algorithm is also robust in both balanced and unbalanced transportation problems, which shows its effectiveness and reliability. Therefore, the comparative analysis confirms that the proposed algorithm is competitive and, in most cases, better than the existing algorithms. Pie -chart in Figure 8 showing the proportion of cases in which each method achieved the best (minimum) best obtained time.

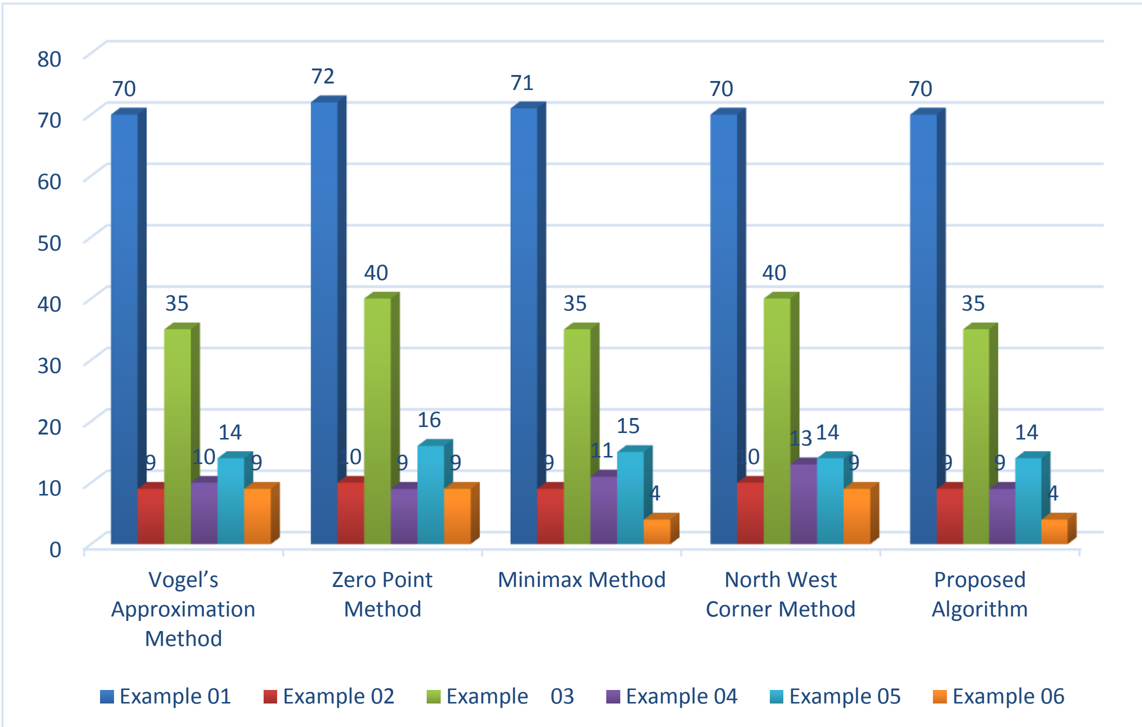


Figure 9. Overall Comparison

6. Conclusions and Future Research:

6.1 Conclusions:

The transportation problem encompasses planning, transportation facilities, and the overall transportation policy of an organization. Efficient management of this problem has become increasingly important, particularly with respect to time minimization. Minimizing transportation time is essential because it enhances customer satisfaction, prevents product spoilage, strengthens competitiveness, indirectly reduces costs, and improves the overall responsiveness and efficiency of supply chains. A new model and method have been developed to investigate both balanced and unbalanced transportation problems with the objective of minimizing transportation time. The comparative study presented in Figure 2 shows that the proposed method consistently provides better results than other existing approaches in terms of accuracy, efficiency, and computational simplicity. The method is flexible and adaptable, making it applicable to a wide range of real-world transportation and logistics problems. This approach establishes a stronger quantitative basis for decision-making, thereby helping organizations to optimize operations and gain a competitive advantage. In addition, the model opens new avenues for further research in quantitative analysis, particularly in transportation and supply chain optimization.

In this study, we propose novel and efficient algorithms to obtain initial basic feasible solutions for transportation problems, with the primary objective of minimizing total transportation time. The developed technique demonstrates strong potential to assist companies in significantly reducing transportation time and improving operational performance.

6.2 Future Research:

The proposed algorithm demonstrates strong performance in minimizing transportation time; however, several avenues remain for future research. One significant extension is the incorporation of uncertainty through grey, fuzzy, or probabilistic transportation times, which would enhance the model's applicability in real-world environments. Furthermore, the development of a multi-objective framework integrating both time and cost minimization would provide a more comprehensive decision-making tool. Finally, theoretical analysis along with software implementation, would significantly strengthen the practical and academic contributions of this research.

Availability of information and resources: The authors have attested that the corresponding author can provide the data substantiating the findings upon request.

Ethical issues: Not applicable.

Interests that are in conflict: The authors of this research declare no conflicts of interest pertaining to this work.

References

[1] Shimshak, D., Alan Kaslik, J., & Barclay, T. 1981. A modification of Vogel's approximation method through the use of heuristics. *INFOR: Information Systems and Operational Research*, *19*(3), 259-263.

[2] Ramakrishnan, C. S. 1988. An Improvement to Goyal's Modified VAM for the Unbalanced Transportation Problem. *Journal of the Operational Research Society*, *39*(6), 609–610.

[3] Arora, S., & Puri, M. C. 1998. A variant of time minimizing assignment problem. *European Journal of Operational Research*, *110*(2), 314-325.

[4] Arora, S., & Puri, M. C. 1999. On a standard time transportation problem. *ASOR BULLETIN*, *18*, 9-24.

[5] Taha, H. A. 2013. *Operations research: an introduction*. Pearson Education India.

[6] Samuel, A. E., & Venkatachalapathy, M. 2011. Modified Vogel's approximation method for fuzzy transportation problems. *Applied Mathematical Sciences*, 5(28), 1367-1372.

[7] Pandian, P., & Anuradha, D. 2010. A new approach for solving solid transportation problems. Applied mathematical sciences, 4(72), 3603-3610.

[8] Samuel, A. E. 2012. Improved zero point method (IZPM) for the transportation problems. *Applied mathematical sciences*, *6* (109), 5421-5426.

[9] Sharma, S., Shanker, R., & Shanker, R. 2013. A modified zero suffix method for finding an optimal solution for transportation problems. *European journal of scientific research*, *104*(4), 673-676.

[10] Juman, Z. A. M. S., Hoque, M. A., & Buhari, M. I. 2013. A sensitivity analysis and an implementation of the well-known Vogel's approximation method for solving unbalanced transportation problem. *Malaysian Journal of Science*, *32*(1), 66-72.

[11] Girmay, N., & Sharma, T. 2013. Balance an unbalanced transportation problem by a heuristic approach. *International Journal of Mathematics and its applications*, *1*(1), 12-18.

[12] Sharma, A., Verma, V., Kaur, P., & Dahiya, K. 2015. An iterative algorithm for two level hierarchical time minimization transportation problem. *European Journal of Operational Research*, *246*(3), 700-707.

[13] Alkubaisi, M. 2015. Modified Vogel method to find Initial Basic Feasible Solution (IBFS) introducing a new methodology to find best IBFS. *Business and Management Research*, *4*(2), 22-36.

[14] Juman, Z. A. M. S., & Hoque, M. A. 2015. An efficient heuristic to obtain a better initial feasible solution to the transportation

problem. *Applied Soft Computing*, *34*, 813-826.

[15] Ahmed, N. U., Khan, A. R., & Uddin, M. S. 2015. Solution of mixed type transportation problem: a fuzzy approach. *Buletinul Institutului Politehnic Din Iaşi*, *61*(2), 19-31.

[16] Akpan, S., Usen, J., & Ajah, O. 2015. A modified Vogel approximation method for solving balanced transportation problems. *American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)*, *14*(3), 289-302.

[17] Sonia, & Chidambaran, S. 2022. Time paradox in transportation problems. *International Journal of Operational Research*, *45*(4), 540-552.

[18] Niluminda, K. P. O., & Ekanayake, E. M. U. S. B. 2023. The Novel Efficient Method to Solve Balanced and Unbalanced Profit Maximization in Transportation Problems. *American Journal of Mathematical and Computer Modelling*, *8*(2), 17-24.

[19] Babu, K. M. 2023. Mixed Constraints Cost Minimization Transportation Problem: An Effective Algorithmic Approach. *Anvesha*, *15*, 47-55.

[20] Memon, M. 2024. Time Optimization Transportation Problem with Minimum Cost Penalty. *Educational Administration: Theory and Practice*, *30*(3), 3164-3169.

[21] Agarwal, S., & Sharma, S. 2018. A minimax method for time minimizing transportation problem with mixed constraints. *International Journal of Computer & Mathematical Sciences*, *7*(3), 1-6.

[22] Agarwal, S., & Sharma, S. 2020. A Shootout Method for Time Minimizing Transportation Problem with Mixed Constraints. *American Journal of Mathematical and Management Sciences*, *39*(4), 299–314. https://doi.org/10.1080/01966324.2020.1730274.

[23] Rashid, F., Khan, A., & Uddin, M. 2021. An innovative approach to minimizing time of a transportation problem with mixed constraints. *Int. J. Sci. Engin. Res*, *12*, 1118-1121.

[24] Monge, G. 1781. Mémoire sur la théorie des déblais et des remblais. *Mem. Math. Phys. Acad. Royale Sci.*, 666-704.

[25] Kantorovich, L. V. 1942. On the translocation of masses. *Dokl. Akad. Nauk. USSR (NS)*, 37, 199-201.

[26] Hitchcock, F. L. 1941. The distribution of a product from several sources to numerous localities. *Journal of mathematics and physics*, *20*(1-4), 224-23