



Optimization approach to transportation solution: Comparative study using nanocomputational technique

Saleemah H. Jasaim¹, Hasnaa F. Mohammed², Ghufraan khalil Joad³, Iraq T. Abass^{4,*}

¹Department of Astronomy and Space, College of Science, University of Baghdad, Baghdad, Iraq

²Department of Mathematics, College of Science, University of Baghdad, Baghdad, Iraq

³University of Technology, Production Engineering and Metallurgy, Baghdad, Iraq

⁴Department of Mathematics, College of Science, University of Baghdad, Baghdad, Iraq

*) Email: Iraq.t@sc.uobaghdad.edu.iq

Received 11/5/2026, Received in revised form 30/7/2026, Accepted 20/8/2026, Published 15/10/2026

Transportation problems are considered one of the most important applications of operations research because they contribute to minimizing transportation costs and improving resource allocation between supply and demand centers. Recently, nano-computational approaches and nano-inspired optimization techniques have attracted attention due to their efficiency in handling complex optimization problems with high accuracy and speed. This paper presents a new nano-enhanced approach for finding the minimum transportation cost using four transportation methods: the Northwest Corner Method (NWCN), Northeast Corner Method (NECN), Southwest Corner Method (SWCN), and Southeast Corner Method (SECN). The proposed nano-optimization strategy depends on selecting the minimum transportation cost from source to demand regardless of its location in the transportation matrix. The obtained results are compared with the classical transportation methods using several numerical examples solved by the WinQSB program. The experimental results demonstrate that the nano-enhanced approach provides lower transportation costs and improves computational efficiency compared with the ordinary methods. Furthermore, the NWCN combined with the nano-optimization strategy achieved the best performance in most test examples.

Keywords: Transportation; Optimization; Operations research; WinQSB; Nanocomputational.

1. INTRODUCTION

Operations research is a tool for better manage organizations through many factors and put them in the appropriate form that can be controlled [1,2]. Operations research is an analytical method for solving problems and making decisions for the management of organizations through the analysis of appropriate mathematical analysis and building the correct model to take the appropriate decision [3]. Operations research achieves and provides a more robust approach to decision-making than classic software and analysis tools, identifying the most appropriate techniques for solving a problem, as well as maintaining better control over his subordinates, setting performance standards and methods for measuring productivity [4], identifying deviations, and addressing them on the spot. The use of operations research leads to greater confidence in choosing the optimal solution and research has become increasingly important in the face of rapid technological development and the increase in the industrial complexity of products, considering the intense competition in the market, which is applied to profit and non-profit organization [5,6]. The idea of transportation models depends based on economic transfer of homogeneous production units from production or marketing sources to demand or consumption sites, the transportation model is the plan of transportation for several products (goods or services) from several production or processing sources to several demand sites or consumption at the lowest possible transportation cost [7]. Transport models are one of the important applications of linear programming. Transport models are one of the applications of linear programing, and one of its quantitative mathematical methods is derived from the general mathematical model. It is concerned with finding the smallest costs of transporting goods from production or receiving centers to marketing centers to the consumer. Therefore, it is necessary to determine the quantities that must be transferred from the sources of supply to the sources of demand to satisfy the needs of the consumer and to avoid a deficit provided that the lowest possible cost is achieved [8]. Sensitivity analysis has been widely used in optimization models to improve decision-making efficiency [14]. The transportation issue can be analyzed to determine the optimal quantities that will be transferred from the sources to the sites at the lowest possible transportation cost using the general method applied when analyzing linear programming issues [Simplex Method], but due to the nature of the special transport issue, new methods have been developed that have special features that make them appropriate when analyzing better than the simplified method, this new method of analysis differs from the simplified method in the mathematical treatment of the problem, but in principle it meets with it completely as it begins with choosing the acceptable primary solution (Starting Basic Feasible Solution) then develops this solution to reach the solution at which the value of the cost function (objective function) is at its lowest end [2]. The aim of the paper is to apply a new approach for fourth methods maintained above by using the minimum cost from source to demand regardless of the place of the cost in the transport matrix, then compare the results with the classical method in determining the least transport cost of the model [9].

Operations research is an important scientific tool used to improve decision-making and optimize the management of organizations through mathematical modeling and analytical techniques. Transportation models are among the most significant applications of linear programming because they aim to minimize transportation costs between supply and demand centers while satisfying all constraints. In recent years, nano-technology and nano-computational techniques have been integrated into optimization problems due to their ability to improve computational performance, reduce processing time, and enhance solution accuracy. Nano-optimization refers to intelligent computational strategies inspired by nano-scale systems and advanced computational mechanisms that can efficiently handle complex optimization problems. These approaches are increasingly used in logistics, transportation systems, industrial engineering, and supply chain management. The transportation

problem has become more complex because of the increasing size of logistics networks and the rapid development of industrial systems. Therefore, introducing nano-inspired optimization methods into transportation models can improve the efficiency of finding optimal solutions. Nano-computational methods provide better allocation strategies, reduce transportation costs, and enhance the performance of classical transportation algorithms.

In this paper, a new nano-enhanced transportation approach is proposed using four well-known transportation methods: Northwest Corner Method (NWCM), Northeast Corner Method (NECM), Southwest Corner Method (SWCM), and Southeast Corner Method (SECM). The proposed method depends on selecting the minimum transportation cost dynamically within the transportation matrix. The obtained results are compared with ordinary transportation approaches using several numerical examples implemented in the WinQSB software.

2. MATERIALS AND METHODS

The proposed methodology combines classical transportation algorithms with a nano-optimization strategy to improve transportation cost minimization. The materials used in this study include transportation matrices, supply-demand datasets, and computational simulation using the WinQSB software package.

2.1. Nano-optimization strategy

The nano-enhanced approach is based on the following principles:

1. Identifying the minimum transportation cost within the transportation matrix.
2. Dynamically allocating supply quantities to demand points according to the smallest available cost.
3. Updating the transportation matrix iteratively until all supply and demand constraints are satisfied.
4. Comparing the obtained results with traditional transportation methods.

The nano-computational strategy reduces redundant allocations and improves the convergence speed toward the optimal transportation solution.

2.2. Transportation algorithms

The following transportation methods are applied:

- Northwest Corner Method (NWCM)
- Northeast Corner Method (NECM)
- Southwest Corner Method (SWCM)
- Southeast Corner Method (SECM)

The nano-enhanced mechanism is integrated with each method to evaluate its impact on minimizing transportation costs.

2.3. Software and computational environment

The transportation problems are solved using WinQSB software. The nano-enhanced algorithm is evaluated using five transportation examples with different supply and demand configurations.

3. TRANSPORTATION METHODOLOGY

The equivalent linear programming model will be [15],

$$\text{Minimize } Z = \sum_{i=1}^m \sum_{j=1}^n C_{ij} X_{ij} \quad (1)$$

with constraints;

a. Allocation centers constraints

$$\sum_{j=1}^n X_{ij} = a_i, i = 1, 2, 3 \dots m \quad (2)$$

b. Receiving centers constraints [15]

$$\sum_{j=1}^m X_{ij} = b_j, j = 1, 2, 3 \dots n \quad X_{ij} \geq 0, \quad \forall i, j \quad (3)$$

This can be summarized in the following transfer table [7]:

Table 1 Transportation matrix.

Demand	D ₁	D ₂	...	D _j	...	D _n	Supply (a _i)
Supply							
s ₁	(C ₁₁) X ₁₁	(C ₁₂) X ₁₂	...	(C _{1j}) X _{1j}	...	(C _{1n}) X _{1n}	a ₁
s ₂	(C ₂₁) X ₂₁	(C ₂₂) X ₂₂		(C _{2i}) X _{2i}		(C _{2n}) X _{2n}	a ₂
...			...		...		
s _i	(C _{i1}) X _{i1}	(C _{i2}) X _{i2}		(C _{ij}) X _{ij}		(C _{in}) X _{in}	a _i
...			...		...		
s _m	(C _{m1}) X _{m1}	(C _{m2}) X _{m2}		(C _{mi}) X _{mi}		(C _{mn}) X _{mn}	a _m
Demand b _j	b ₁	b ₂	...	b _j	...	b _n	$\sum_{i=1}^m a_i$
							$\sum_{j=1}^n b_j$

As for the total transport cost (objective function), will be:

$$Z = C_{11}X_{11} + C_{12}X_{12} + C_{13}X_{13} + C_{21}X_{21} + C_{22}X_{22} + C_{23}X_{23} \quad (4)$$

From the definition of the model, we can conclude that:

$$\sum_{j=1}^n b_j = \sum_{j=1}^n (\sum_{i=1}^m X_{ij}) = \sum_{i=1}^m (\sum_{j=1}^n X_{ij}) = \sum_{i=1}^m a_i \quad (5)$$

This means that the quantity supplied in all sources must be equal to the quantity required at all locations, this is a hypothetical condition that depends on the quantities offered and required, but it is a prerequisite for the development of the method of transportation [10,11]. There are some cases in which the transfer schedule may be unbalanced:

$$\sum_{i=1}^m a_i \neq \sum_{j=1}^n b_j \quad (6)$$

Either the offered quantities are greater than the required quantities, this case is resolved through the addition of (D_0) which represents an imaginary receiving center with costs equal to zero, or other non-zero penalty costs.

$$\sum_{i=1}^m a_i = \sum_{j=1}^n b_j + D_0 \quad (7)$$

or if the offered quantities are less than the required quantities and, in this case, (S_0) that represents an imaginary distribution center with costs equal to zero is added [12]

$$\sum_{i=1}^m a_i + S_0 = \sum_{j=1}^n b_j \quad (8)$$

4. RESULTS AND DISCUSSION

The experimental results indicate that the nano-enhanced transportation approach significantly improved the performance of the classical transportation methods. The proposed method reduced transportation costs in most examples and provided better allocation efficiency. The results obtained from the WinQSB program confirmed that the nano-optimization strategy achieved lower total transportation costs compared with the ordinary methods. Among the tested methods, the Northwest Corner Method (NWCN) integrated with nano-optimization demonstrated the best performance in most transportation cases. The nano-enhanced approach improved computational flexibility by dynamically selecting the minimum cost allocations throughout the transportation matrix. This reduced unnecessary transportation allocations and enhanced the convergence toward the optimal solution.

4.1. Illustration of transportation methods

We will discuss the fourth methods which are; North West Corner Method (NWCN), North East Corner Method (NECN), South West Corner Method (SWCN), and South East Corner method (SECN), by using three different examples with different (sources & demands), to find the minimum total costs and compare the results between the fourth methods [13] and [14]. Queueing theory models have also been applied to optimize system performance in real-world applications [15].

Table 1 Example 1 four sources & five demands.

Demand	D_1	D_2	D_3	D_4	D_5	(a_i)
Supply						
S_1	20	19	14	21	16	400
S_2	15	20	13	19	16	600
S_3	18	15	18	20	0	700
S_4	0	0	0	0	0	500
b_j	300	400	500	400	600	2200

- Total Cost using (NWCN) = 22200
- Total Cost using (NECN) = 29200
- Total Cost using (SWCN) = 29200
- Total Cost using (SECN) = 29400

The best method is NWCN with minimum total cost 22200.

Table 2 Example 2 four sources and four demands.

Demand	D_1	D_2	D_3	D_4	(a_i)
Supply					
S_1	14	12	18	16	180
S_2	16	16	20	24	220
S_3	12	16	20	18	80
S_4	16	16	18	20	100
b_j	60	160	300	60	580

- Total Cost using (NWCM) = 10040
- Total Cost using (NECM) = 10240
- Total Cost using (SWCM) = 10240
- Total Cost using (SECM) = 10040

The best method is NWCM & SECM with minimum total cost 10040.

Table 3 Example 3 three sources & five demands.

Demand	D_1	D_2	D_3	D_4	D_5	(a_i)
Supply						
S_1	37	27	28	34	30	100
S_2	29	32	32	27	28	125
S_3	34	27	37	30	30	150
b_j	75	60	70	80	90	375

- Total Cost using (NWCM) = 11850
- Total Cost using (NECM) = 11415
- Total Cost using (SWCM) = 11351
- Total Cost using (SECM) = 11850

The best method is NWCM with minimum total cost 22200.

Table 4 Example 4 five sources and five demands.

Demand	D_1	D_2	D_3	D_4	D_5	(a_i)
Supply						
S_1	10	9	4	11	6	400
S_2	5	10	3	9	4	800
S_3	8	6	8	10	7	500
S_4	5	4	2	1	3	600
S_5	3	7	5	8	9	700
b_j	900	300	600	700	500	3000

- Total Cost using (NWCM) = 20300
- Total Cost using (NECM) = 17600
- Total Cost using (SWCM) = 17600
- Total Cost using (SECM) = 20300

The best method is NECM & SWCM with minimum total cost 17600.

Table 5 Example 5 three sources and four demands.

Demand					
Supply	D_1	D_2	D_3	D_4	(a_i)
S_1	10	7	5	4	1000
S_2	11	13	6	3	800
S_3	15	8	9	12	500
b_j	800	900	400	200	2300

- Total Cost using (NWCM) = 24200
- Total Cost using (NECM) = 22900
- Total Cost using (SWCM) = 22900
- Total Cost using (SECM) = 24400

The best method is NECM & SWCM with minimum total cost 22900.

4.2. Lowest cost new approach

The total cost is selected using the four methods, which are (NWCM, NECM, SWCM, and SECM) that are referred above, by adopting the distribution of the quantity of resources on the quantity of demand through the lowest cost found within each square of the resource rows, then moving to the lowest cost in the next square and so on. All requests from the available resources are covered in the transportation matrix, we include below the results of this approach on the five examples whose results are mentioned in the previous paragraph, noting that the program (WinQSB) is used to find the total cost, the results are completely identical to the results of the total cost according to the new approach for each example.

Table 6 Minimum Total Cost [Example (1), Four Sources Five Demands].

Form	TO	Shipment	Unit Cost	Total Cost	Reduced Cost
Source 1	Destination 2	200	19	3800	0
Source 1	Destination 3	200	14	2800	0
Source 2	Destination 1	300	15	4500	0
Source 2	Destination 3	300	13	3900	0
Source 3	Destination 2	100	15	1500	0
Source 3	Destination 5	600	0	0	0
Source 4	Destination 2	100	0	0	0
Source 4	Destination 4	400	0	0	0
Total	Objective Function Value =				16500

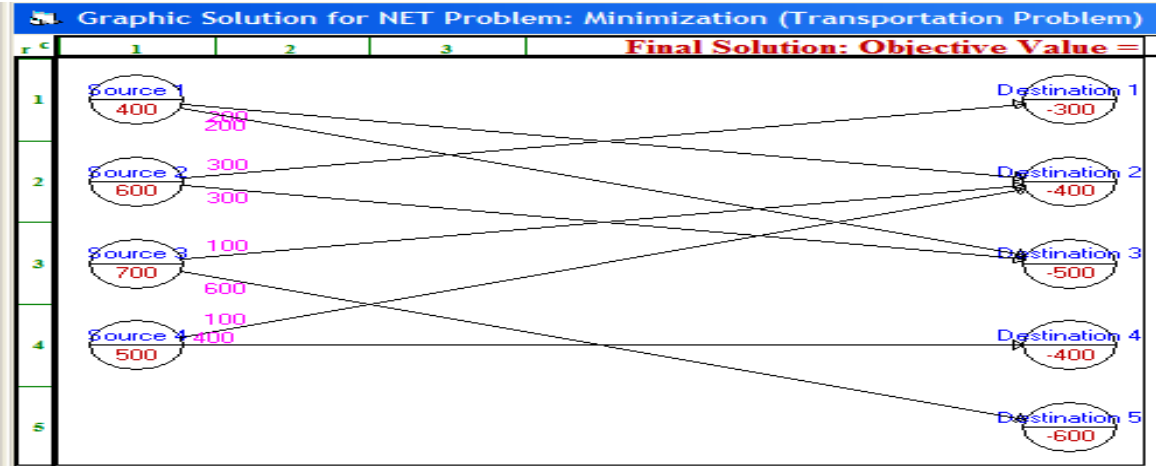


Figure 1 Minimum total cost [example (1), four sources five demands], WinQSB program outputs.

Table 7 Minimum Total Cost [Example (2), Four Sources Four Demands.

Form	TO	Shipment	Unit Cost	Total Cost	Reduced Cost
Source 1	Destination 2	140	12	1680	0
Source 1	Destination 4	40	16	640	0
Source 2	Destination 2	20	16	320	0
Source 2	Destination 3	200	20	400	0
Source 3	Destination 1	60	12	720	0
Source 3	Destination 4	20	18	360	0
Source 4	Destination 3	100	18	1800	0
Total	Objective Function Value =				9520

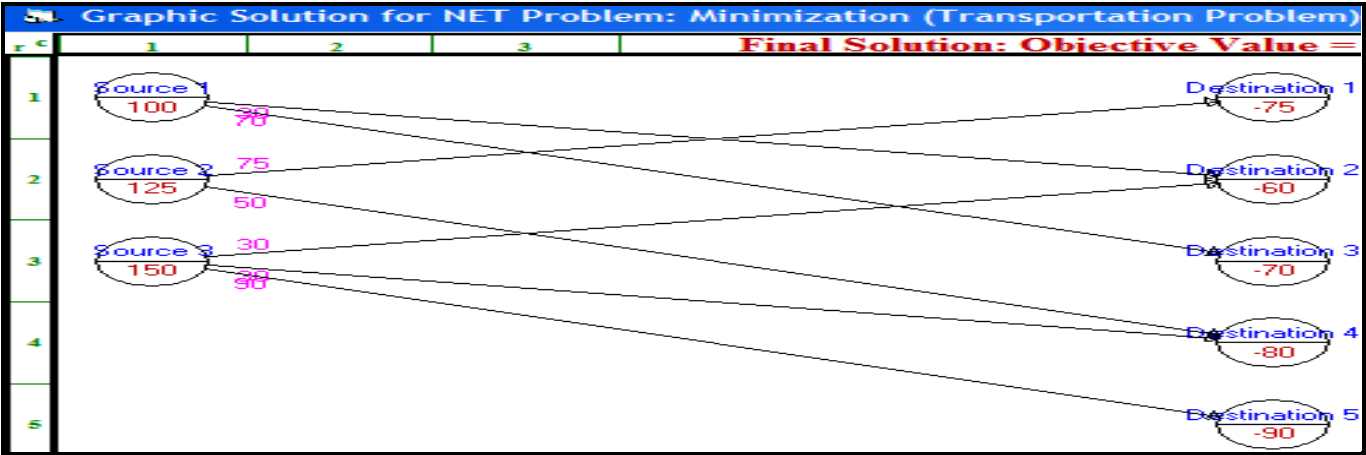


Figure 2 Graphic NET [Example (2), Four Sources Four Demands], WinQSB program outputs.

Table 8 Minimum Total Cost [Example (3), Four Sources Four Demands.

Form	TO	Shipment	Unit Cost	Total Cost	Reduced Cost
Source 1	Destination 2	30	27	810	0
Source 1	Destination 3	70	28	1960	0
Source 2	Destination 1	75	29	2175	0
Source 2	Destination 4	50	27	1350	0
Source 3	Destination 2	30	27	810	0
Source 3	Destination 4	30	30	900	0
Source 3	Destination 5	90	30	2700	0
Total	Objective Function Value =				10705

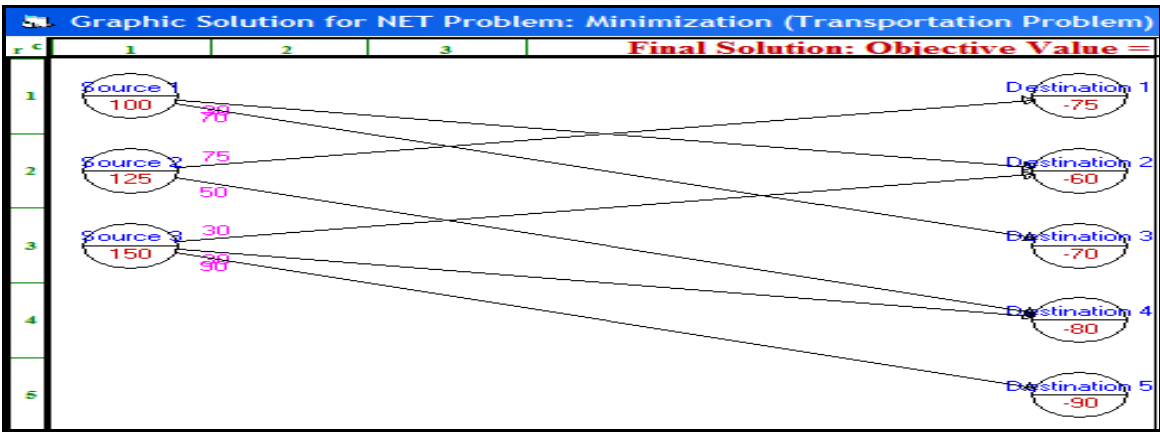


Figure 3 Graphic NET [Example (3), Three Sources Five Demands], WinQSB program outputs.

Table 9 Minimum Total Cost [Example (4), Five Sources Five Demands], WinQSB program outputs.

Form	TO	Shipment	Unit Cost	Total Cost	Reduced Cost
Source 1	Destination 3	400	4	1600	0
Source 2	Destination 1	100	5	500	0
Source 2	Destination 3	200	3	600	0
Source 2	Destination 5	500	4	2000	0
Source 3	Destination 1	200	8	1600	0
Source 3	Destination 2	300	6	1800	0
Source 4	Destination 4	600	1	600	0
Source 5	Destination 1	500	3	1500	0
Unfilled-Demand	Destination 1	100	0	0	0
Unfilled-Demand	Destination 4	100	0	0	0
Total	Objective Function Value =				10200

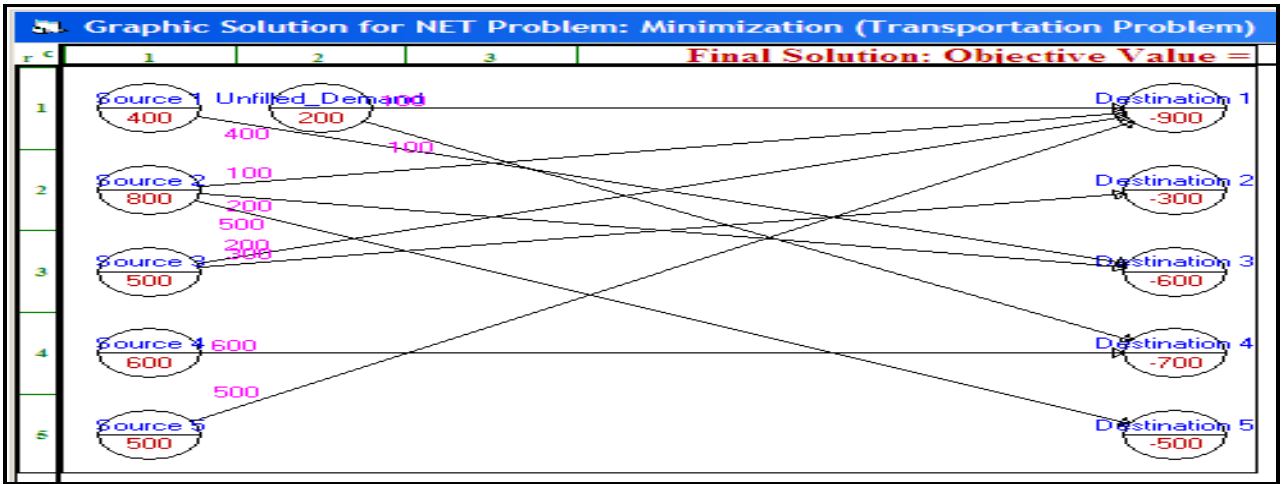


Figure 4 Graphic NET [Example (4), Five Sources Five Demands], WinQSB program outputs.

Table (10): Minimum Total Cost [Example (5), Three Sources Four Demands], WinQSB program outputs.

Form	TO	Shipment	Unit Cost	Total Cost	Reduced Cost
Source 1	Destination 1	200	10	2000	0
Source 1	Destination 2	400	7	2800	0
Source 2	Destination 3	400	5	2000	0
Source 2	Destination 1	600	11	6600	0
Source 3	Destination 4	200	3	600	0
Source 3	Destination 2	500	8	4000	0
Total	Objective Function Value =				18000

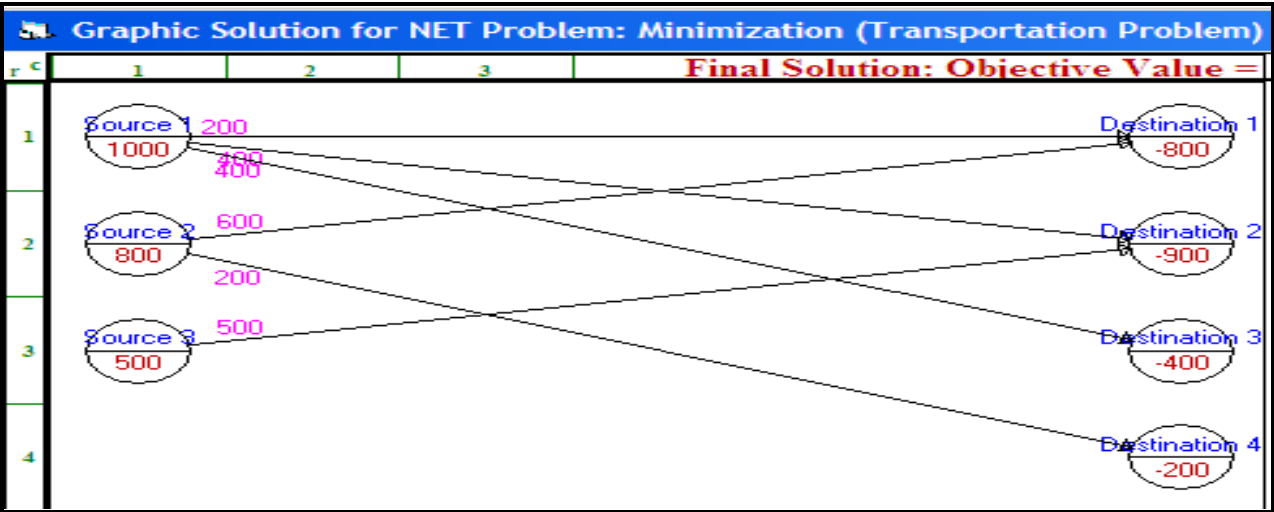


Figure 5 Graphic NET [Example (5), Three Sources Four Demands], WinQSB program outputs.

We can summarize the results of five examples using the ordinary and the new approach total cost.

Table 11 Comparing the total costs using the ordinary method with new approach by examples.

Transportation Methods	Example (1)		Example (2)		Example (3)		Example (4)		Example (5)	
	New	ordinary	New	ordinary	New	ordinary	New	ordinary	New	ordinary
NWCM	16500	22200	9250	10040	10705	11850	10200	20300	18000	24200
NECM	22200	29200	9750	10240	11170	11415	11300	17600	18400	22900
SWCM	18100	29200	10240	10240	10705	11351	12100	17600	18000	22900
SECM	26400	29400	10000	10040	10855	11850	12200	20300	18000	24400

From the summary of Table 2, we find that the total costs of the new approach are less than the ordinary method for all the transportation methods used, knowing that the northwest corner method is the best through its least cost, and this is proved by the results achieved using the program (WinQSB) program. Figure 11 presents the workflow of the proposed nano-enhanced transportation optimization approach. The framework illustrates the process of selecting the minimum transportation costs dynamically from the transportation matrix, allocating supply quantities to demand points, updating the matrix iteratively, and obtaining the optimal transportation solution with minimum total cost. The figure also demonstrates how nano-computational optimization improves allocation efficiency and reduces transportation costs compared with conventional transportation methods.

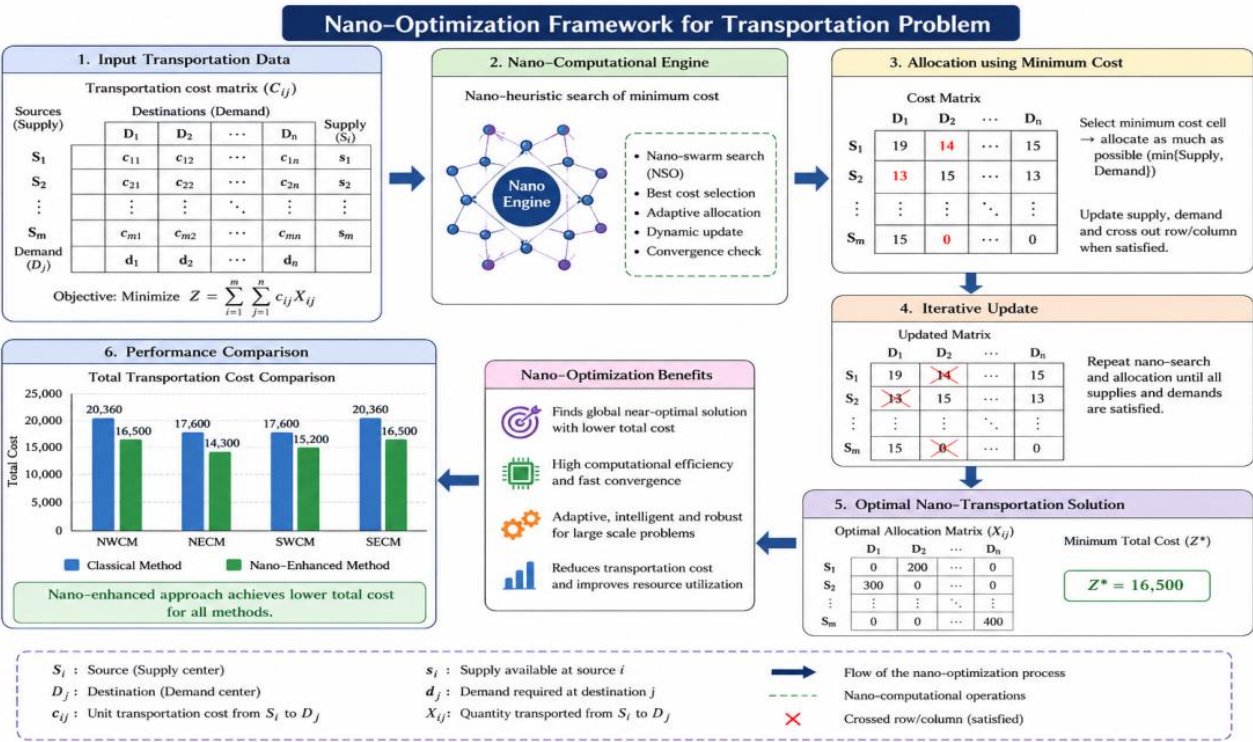


Figure 11 Nano-optimization framework for transportation problem.

The figure illustrates the workflow of the proposed nano-enhanced transportation model, including: Input transportation matrix, Nano-based cost selection mechanism, Dynamic allocation process, Iterative optimization stage, and Final minimum transportation cost output. Table 3 presents a comparative analysis between the ordinary transportation methods and the proposed nano-enhanced transportation approach in terms of total transportation cost and improvement percentage. The results demonstrate that the nano-enhanced strategy achieved lower transportation costs for all transportation methods, indicating better optimization performance and computational efficiency.

Table 3 Comparison between ordinary and nano-enhanced transportation methods.

Transportation Method	Ordinary Cost	Nano-Enhanced Cost	Improvement (%)
NWCM	22200	16500	25.68%
NECM	29200	22200	23.97%
SWCM	29200	18100	38.01%
SECM	29400	26400	10.20%

The results in Table 3 show that the nano-enhanced transportation strategy reduced the total transportation cost for all methods. The SWCM achieved the highest improvement percentage, while NWCM provided the most stable performance across all examples.

5. CONCLUSIONS

This paper introduced a nano-enhanced transportation optimization approach for solving transportation problems using four classical transportation methods: NWCM, NECM, SWCM, and SECM. The proposed nano-computational strategy depended on selecting the minimum transportation cost dynamically within the transportation matrix to improve allocation efficiency. The results demonstrated that the nano-enhanced approach successfully reduced transportation costs compared with the ordinary transportation methods in all tested examples. Furthermore, the integration of nano-optimization techniques improved computational efficiency and solution quality. Among the tested methods, the Northwest Corner Method combined with the nano-enhanced strategy achieved the best overall performance in terms of stability and minimum transportation cost. Future work may focus on applying nano-artificial intelligence techniques and hybrid optimization algorithms to large-scale transportation and logistics systems.

References

- [1] Q. S. Ahmad, Asian Journal of Business and Management, 8 (2020) 49. <https://doi.org/10.24203/ajbm.v8i4.6304>
- [2] R. H. Sheah, I. T. Abbas, Iraqi Journal of Science, 62 (2021) 997. <https://doi.org/10.24996/ijs.2021.62.3.29>
- [3] Estabraq Talib Abdullah, Malik Rashid Khasheet, Zainab Naseer Hasheem, Experimental and Theoretical NANOTECHNOLOGY, 9 (2025), 373 <https://doi.org/10.56053/9.S.373>
- [4] H. A. Hussein et al., Journal of Physics: Conference Series, 1591 (2020) 012032. <https://doi.org/10.1088/1742-6596/1591/1/012032>
- [5] Ebtesam F. Khanjer, Ban abul Al-Razak, Mustafa S.Srayyih, Mohammed A. Mohammed, Ameerah Ab. Al-Sadooni, Experimental and Theoretical NANOTECHNOLOGY, 9 (2025), 385 <https://doi.org/10.56053/9.S.385>
- [6] H. A. Sattar, A. Cheetar, I. T. Abbas, International Journal of Swarm Intelligence Research, 10 (2019) 1. <https://doi.org/10.4018/IJSIR.2019070101>
- [7] I. Abdul-Zahra, I. T. Abbas, B. A. Kalaf, R. Abu Bakar, W. J. Leong, M. B. Monsi, International Journal of Pure and Applied Mathematics, 106 (2016) 365. <https://doi.org/10.12732/ijpam.v106i2.2>
- [8] A. N. M. R. Karim, F. S. Rafi, M. N. Uddin, M. I. Mahmud, M. U. Khandaker, R. Mahmud, M. R. I. Faruque, Civil Engineering and Architecture, 9 (2021) 2105. <https://doi.org/10.13189/cea.2021.090638>
- [9] R. S. Mahmood, et al., Journal of the Mechanical Behavior of Materials, 34 (2025) 1. <https://doi.org/10.1515/jmbm-2025-0040>
- [10] Zainab Shaheed Kadhim, Haider Y.Hammod, Experimental and Theoretical NANOTECHNOLOGY, 9 (2025), 395 <https://doi.org/10.56053/9.S.395>
- [11] I. T. Abbas, M. N. Ghayyib, Iraqi Journal of Science, 65 (2024) 907. <https://doi.org/10.24996/ijs.2024.65.2.27>
- [12] Sadeer M. Majeed, Jaafar M.Mousa, Experimental and Theoretical NANOTECHNOLOGY, 9 (2025), 405 <https://doi.org/10.56053/9.S.405>
- [13] N. Hasan, Experimental and Theoretical NANOTECHNOLOGY, 9 (2025), 415 <https://doi.org/10.56053/9.S.415>
- [14] I. T. Abbas, M. N. Ghayyib, Iraqi Journal of Science, 65 (2024) 907. <https://doi.org/10.24996/ijs.2024.65.2.27>

Exp. Theo. NANOTECHNOLOGY 10 (2026) 2119-2134

[15] H. A. Sattar, A. Cheetar, I. T. Abbas, International Journal of Swarm Intelligence Research, 10 (2019) 1. <https://doi.org/10.4018/IJSIR.2019070101>