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Drug Distribution Cost Optimization with Vogel, Russel, and Northwest Corner Approaches

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ABSTRACT

The increase in annual turnover in a drug distribution company reflects positive growth but is often accompanied by a significant increase in operating costs that can reduce profit margins if not managed efficiently. This study aims to optimize distribution costs using a transportation method approach by comparing three initial solution methods, namely Vogel's Approximation Method (VAM), Russell Approximation Method (RAM), and Northwest Corner Method (NWC). The study was conducted at a drug distribution company with three central warehouses serving four distribution branches, based on distribution data for December 2024, which was arranged in the form of a transportation table. From the calculation results, the VAM method produced the lowest total distribution cost of IDR23,426,407. Evaluation of this solution was carried out using the Steppingstone method and the Modified Distribution Method (MODI) to determine whether the solution was optimal. The evaluation results show that all opportunity cost values are positive, which means that no additional iterations or re-allocations are required so that the solution from the VAM method can be stated as an optimal solution. The novelty of this study lies in the integration of three initial solution methods with two optimal solution methods in one drug distribution case study, which has not been widely discussed in an integrated manner in previous studies. These findings provide strategic contributions to more precise and efficient logistics decision-making and support the sustainable operational growth of pharmaceutical distribution companies.

Keywords: VAM, RAM, NWC, Steppingstone, MODI

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Introduction

Drug distribution is a key logistics activity in company operations, particularly for those involved in the healthcare sector. This activity requires high efficiency because it addresses the community's needs and requires strict cost control (Goodarzian et al., 2021; Hidayat & Saleh, 2020; Lim & Rokhim, 2020). Along with the increase in annual turnover, companies often face significant increases in operational costs, particularly in the distribution process (Stopka et al., 2022; Swaroop et al., 2025; Yousefi Sarmad et al., 2023). If not handled efficiently, this can lead to reduced profit margins and decreased competitiveness in the market (Latunde et al., 2021; Liu, 2022; Szkutnik-Rogoż & Małachowski, 2023). Therefore, a measurable and efficient distribution strategy is needed to reduce logistics costs without sacrificing service effectiveness (Abdelati, 2024; Amaliah et al., 2022; Zabiba et al., 2023). One approach that can be used to optimize distribution planning is the transportation method,

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which is incorporated into the linear programming framework because it enables the formulation of problems in the form of objective functions and specific constraints (Hussein & Shiker, 2020; Pratihar et al., 2021).

Several previous studies have shown the effectiveness of transportation methods in solving distribution problems and saving costs. Sumathi and Sathiabama (2020) applied the VAM and MODI methods to the distribution of building materials, achieving a 25% reduction in the average cost. Roschyntawati et al. (2023) combined the NWC, Least Cost, and VAM methods for biodiesel distribution, achieving an efficiency of 31.05%. Ahmed et al. (2023) utilized RAM and Steppingstone in livestock distribution in Nigeria, demonstrating a significant reduction in distribution costs. Other studies conducted by Annisa & Mardiningsih (2021), Pratiwi and Siregar (2021) confirmed that combining initial solution methods, such as VAM, RAM, and NWC, with final solution methods, including MODI and Steppingstone, yields efficient and cost-effective distribution results. However, most of these studies have not examined the three initial solution methods in an integrated manner, with the notable exception of one case that focuses on drug distribution. Therefore, the gap in this research lies in the absence of an integrated comparative approach between VAM, RAM, and NWC in the context of drug distribution with further evaluation through MODI and Steppingstone.

The novelty of this study lies in the application of a comparative approach of three initial solution methods in the transportation method, namely Vogel's Approximation Method (VAM), Russell Approximation Method (RAM), and Northwest Corner Method (NWC), which are then tested for optimality using two optimal solution methods, namely Steppingstone and Modified Distribution Method (MODI). This approach provides a comprehensive picture of which method is the most efficient in the context of drug distribution and has not been widely used in previous studies. The combination of initial solutions and evaluation of optimal solutions provides a practical contribution to supporting distribution efficiency and more appropriate logistics decision-making in the health sector.

Methods

This study uses a quantitative approach with a linear programming method to optimize drug distribution costs from three warehouses to four branches in Java. The data includes branch demand, warehouse capacity, and distribution costs between locations. The data was obtained from drug distribution in December 2024, as this month reflects the highest volume of demand. The warehouses used were Jakarta 1 (located in East Jakarta), Jakarta 2 (South Jakarta), and Tangerang, with delivery destinations including Semarang, Solo, Surabaya, and Malang. The data was organized as a

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transportation table to show the allocation of costs, supply, and demand, as shown in Table 1. The research flow is depicted in Figure 1, from data collection, preparation of transportation tables, and calculation of initial solutions to optimality evaluation.

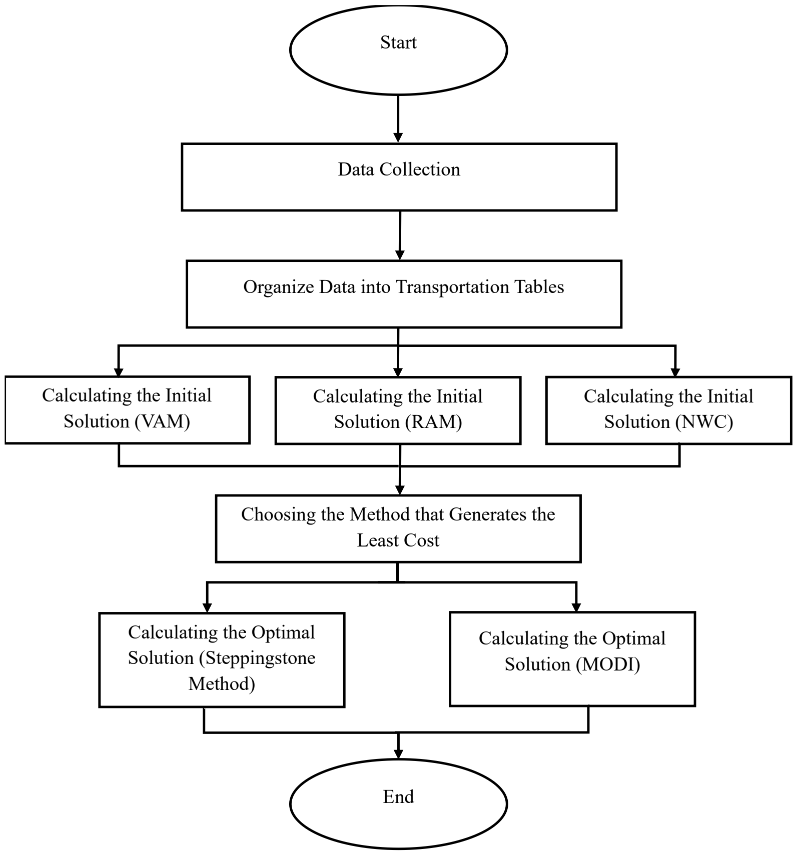

Figure 1. *Research Flow Diagram*

Table 1. *Initial Distribution Data Transformation Table*

Destination / From	Semarang	Solo	Surabaya	Malang	Supply
Jakarta 1	11081	6552	1335	10542	2500
Jakarta 2	11208	6614	1342	10604	2200
Tangerang	12346	7174	1420	11167	2300
Demand	356	723	5201	720	7000

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The initial solution is calculated by three methods: Vogel's Approximation Method (VAM), Russell Approximation Method (RAM), and Northwest Corner Method (NWC). The VAM method works by calculating the difference between the two smallest costs in each row and column and then allocating supply or demand to the cell with the highest difference as a priority to minimize the chance of loss (Handayani et al., 2020; Kankarofi et al., 2021; Niluminda et al., 2023). The NWC method starts from the top left corner of the table. It gradually allocates the minimum value between supply and demand towards the right and down without considering the cost (Agboola et al., 2025; Al Khauzar Victorio et al., 2023; Ramakrishna & Ashok, 2022). Meanwhile, RAM calculates the value, which is the difference between the transportation cost and the maximum value of the row or column, and selects the smallest value as the allocation reference option (M et al., 2021; Putcha et al., n.d.).

The objective of this transportation method is to minimize the total distribution cost, which is formulated as follows:

$$Z = \sum_{a=1}^{m} \sum_{b=1}^{n} x_{ab} \cdot y_{ab} \qquad (1)$$

Where x_{ab} is the number of products shipped from warehouse a to branch b, y_{ab} is the shipping cost per unit. This formula only applies when the total supply equals the total demand. If the demand exceeds the supply, a dummy row needs to be added on the supply side to balance the transportation model. Conversely, if the supply exceeds the demand, a dummy column needs to be added on the demand side. This dummy is used to accommodate excess supply or a lack of demand, ensuring the model is balanced and can be solved mathematically (Drs. Siswanto, 2007; Wireko et al., 2025).

Once an initial solution is obtained from the three methods, the least cost result is evaluated using two optimal solution methods: Steppingstone and MODI. The Steppingstone method evaluates empty cells by forming a closed looping path and calculates the change in cost that occurs if a new allocation is made. The evaluation value *ΔZ* is calculated, and if there is a negative value, the allocation is updated following that path until no negative value is found. Meanwhile, according to research (Castaneda et al., 2022). Whereas in the MODI method, the first step is to calculate the potential values of rows and columns using a formula:

$$C_{ab} = u_a + v_b \qquad (2)$$

The u_a and v_b values are calculated only on cells that have allocations. Once all potential values are obtained, evaluation is done on empty cells using:

$$d_{ab} = C_{ab} - u_a - v_b \qquad (3)$$

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If all values of $d_{ab} \geq 0$, then the solution is optimal. However, if $d_{ab} \leq 0$ is found, re-allocation is done through the improvement trajectory until the minimum total cost is obtained.

The calculation process is done manually and supported by the use of Microsoft Excel software. Manual calculations aim to ensure the accuracy of each stage in the transportation method, starting from initial allocation, identification of empty cells, formation of cycle paths, and evaluation of opportunity values. Meanwhile, Microsoft Excel is used to expedite the processing of numerical data and minimize the potential for calculation errors. This approach allows the results obtained to be verified transparently and replicated by other researchers using similar procedures.

Results and Discussion

This study begins by compiling a transportation table based on demand data from four branches, namely Semarang, Solo, Surabaya, and Malang, and the capacity of three warehouses, namely Jakarta 1, Jakarta 2, and Tangerang. Table 1 shows data on demand, capacity, and distribution cost per unit used to form the initial transportation table.

Table 2. *Final Result of Transportation Table Allocation with VAM*

Destination / From	Semarang	Solo	Surabaya	Malang	Supply	Line Reduction (7)
Jakarta 1	11081 356	6552 723	1335 701	10542 720	0	0
Jakarta 2	11208	6614	1342 2200	10604	0	0
Tangerang	12346	7174	1420 2300	11167	0	0
Demand	0	0	0	0	7000	
Column Reduction (7)	0	0	0	0		

The first step is done with the VAM. This method starts by calculating the difference between the two smallest costs in each row and column. The most significant difference is prioritized for allocation, and the cell with the lowest cost in that row or column is allocated. Once allocated, supply and demand are updated, and the step is repeated until all are satisfied. The final result is shown in Table 2 with a total distribution cost of Rp23,426,407, which is obtained based on the calculation results using the objective function in Equation 1.

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Table 3. *Final Result of Transportation Table Allocation with RAM*

From \ Destination	Semarang	Solo	Surabaya	Malang	Supply
Jakarta 1	11081 356	6552	1335 2144	10542	0
Jakarta 2	11208	6614 723	1342 757	10604 720	0
Tangerang	12346	7174	1420 2300	11167	0
Demand	0	0	0	0	7000

The following calculation uses RAM. The RAM procedure begins by finding the index value in each row and column based on the average minimum cost. The index values are then used to determine the initial allocation cells. Allocation is made to the cell with the lowest cost, then supply and demand are updated until all needs are met. The results of the RAM method allocation are presented in Table 3, with a total distribution cost of Rp23,505,772. The total cost is calculated based on the objective function previously described in Equation 1.

Table 4. *Final Result of Transportation Table Allocation with NWC Method*

From \ Destination	Semarang	Solo	Surabaya	Malang	Supply
Jakarta 1	11081 356	6552 723	1335 1421	10542	0
Jakarta 2	11208	6614	1342 2200	10604	0
Tangerang	12346	7174	1420 1580	11167 720	0
Demand	0	0	0	0	7000

Next, the NWC method uses a stepwise allocation approach from the transportation table's top leftmost cell (northwest corner). Allocation is done according to the minimum value between supply and demand in that cell. The value is updated, and the process continues to the next cell until all supply and demand are met. The final result is shown in Table 4, with a total distribution cost of Rp23,815,207. The cost is calculated based on the objective function listed in Equation 1.

The optimal solution is evaluated using the Steppingstone method based on the final results of the VAM, which was chosen because it produces the minimum total distribution cost compared to the RAM and NWC methods. The initial evaluation stage is done by determining empty cells and forming a closed

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path (cycle) that starts from an empty cell, moves horizontally or vertically through filled cells, and returns to the starting point. The total cost change is calculated from the cycle to assess potential improvements. The calculation results show the following cost (ΔZ) change values: Jakarta 2-Semarang by 120, Jakarta 2-Solo by 55, Jakarta 2-Surabaya by 55, Tangerang-Semarang by 1,180, Tangerang-Solo by 537, and Tangerang-Malang by 540.

From these results, all cost change values (ΔZ) are positive, which means that the total distribution cost will increase if allocations are made to these cells. Since no negative ΔZ values were found, no further improvements can be made. Thus, it can be concluded that the initial solution obtained using VAM has achieved the most optimal result, namely with a total distribution cost of Rp23,426,407.

After evaluating the solution using the Steppingstone method, its optimality is rechecked by applying the MODI method. The first stage in the MODI method involves determining the values of the dual variables *u* for each row (from) and *v* for each column (destination) based on the allocation cost of the initial VAM solution. The values of *u* and *v* are calculated based on cells that have been allocated using Equation 2.

By setting the initial value $u_{jkt1} = 0$, then the value is obtained:

- $C_{jkt1-smrg} = u_{jkt1} + v_{smrg} \rightarrow 0 + v_{smrg} \rightarrow v_{smrg} = 11081$
- $C_{jkt1-solo} = u_{jkt1} + v_{solo} \rightarrow 0 + v_{solo} \rightarrow v_{solo} = 6552$
- $C_{jkt1-sby} = u_{jkt1} + v_{sby} \rightarrow 0 + v_{sby} \rightarrow v_{smrg} = 1335$
- $C_{jkt1-mlg} = u_{jkt1} + v_{mlg} \rightarrow 0 + v_{mlg} \rightarrow v_{mlg} = 10542$

Next, the *u* values for the remaining rows were obtained:

- $1342 = u_{jkt2} + v_{sby} \rightarrow u_{jkt2} + 1335 \rightarrow 1342 - 1335 \rightarrow u_{jkt2} = 7$
- $1420 = u_{tgrg} + v_{sby} \rightarrow u_{tgrg} + 1335 \rightarrow 1420 - 1335 \rightarrow u_{tgrg} = 85$

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Table 5. *Final Result of Transportation Table VAM Allocation with MODI*

	v	$v_{smrg} = 11081$	$v_{solo} = 6552$	$v_{sby} = 1335$	$v_{mlg} = 10542$	
u	Destination / From	**Semarang**	**Solo**	**Surabaya**	**Malang**	**Supply**
$u_{jkt1} = 0$	**Jakarta 1**	**11081** **356**	**6552** **723**	**1335** **701**	**10542** **720**	**2500**
$u_{jkt2} = 7$	**Jakarta 2**	**11208**	**6614**	**1342** **2200**	**10604**	**2200**
$u_{tgrg} = 85$	**Tangerang**	**12346**	**7174**	**1420** **2300**	**11167**	**2300**
	Demand	**356**	**723**	**5201**	**720**	**7000**

The optimal solution was evaluated by calculating the opportunity cost values (d_{ab}) in each empty cell based on the closed loop path derived from the initial allocation obtained using Vogel's Approximation Method (VAM). The calculation results showed that all d_{ab} values were positive, namely: Jakarta 2–Semarang at 120, Jakarta 2–Solo at 55, Jakarta 2–Malang at 55, Tangerang–Semarang at 1,180, Tangerang–Solo at 537, and Tangerang–Malang at 540. These positive values indicate that there is no alternative route that could reduce the total distribution cost. Therefore, the initial solution obtained from the VAM method is considered optimal and does not require further iterations using the Steppingstone or MODI methods. The total transportation cost resulting from this calculation was Rp23,426,407. The final allocation, along with the values of u, v, and the results of the MODI optimization, are presented in Table 5.

Conclusion

This study shows that of the three initial solution methods used, the VAM approach produces the most efficient distribution allocation. Evaluation using the Steppingstone and MODI methods did not find negative opportunity cost values, indicating that the VAM solution has reached optimal conditions without requiring re-allocation. This finding reinforces that the application of transportation optimization methods can significantly reduce logistics costs. In addition to improving operational efficiency, this approach also has the potential to contribute to more sustainable company growth through strategic and data-based distribution planning.

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