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Optimization of White Bread Distribution at Sejahtera Bread Factory in Kebun Jeruk District Using the Transportation Method

Rani[1], Ratih Setyo Rini[2*], Syahrir[3], Ayu Azizah[4]
Faculty of Economics and Business, Bina Sarana Informatika University, Jl. Kramat Raya No.98, RT.2/RW.9, Kwitang, Kec. Senen, Kota Jakarta Pusat, Daerah Khusus Ibukota Jakarta 10450

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ABSTRACT

This study aims to optimize the distribution of white bread products from Sejahtera Bread Factory in Kebun Jeruk District by applying the transportation method within the framework of linear programming. Utilizing data on factory capacity, distribution demand, and transportation costs, this research implements several optimization techniques, including the North West Corner (NWC), Least Cost, Vogel's Approximation Method (VAM), and Stepping Stone method. The findings reveal that while the conventional distribution cost stands at IDR 420,500, the application of the Least Cost and VAM methods successfully reduces this to IDR 340,000, generating savings of IDR 80,500. Conversely, the NWC method results in an increased cost of IDR 450,000, and further optimization using the Stepping Stone method confirms the initial solution's optimality, maintaining the cost at IDR 340,000. These results demonstrate that the Least Cost method is the most effective strategy for minimizing distribution expenses. The study provides practical insights for small-scale bakery businesses to enhance operational efficiency and recommends further exploration of distribution strategies should new routes or market expansions occur in the future.

Corresponding Author:
Ratih Setyo Rini
Faculty of Economics and Business, Bina Sarana Informatika University. Jl. Kramat Raya No.98, RT.2/RW.9, Kwitang, Kec. Senen, Kota Jakarta Pusat, Daerah Khusus Ibukota Jakarta 10450.
ratih.rsr@bsi.ac.id

INTRODUCTION

In the global context of the food industry, efficient distribution has become an increasingly strategic imperative. With the growing complexity of supply chains, producers must not only ensure product quality but also guarantee timely delivery to meet dynamic consumer demands (Maaz and Ahmad, 2022). Food products, particularly those with limited shelf life such as bakery goods, require precise distribution management to maintain freshness and minimize waste. Failure to do so can result in reduced customer satisfaction and increased operational costs.

Regionally, the challenges of food distribution in densely populated urban areas like Jakarta are even more pronounced. High traffic congestion, fluctuating fuel prices, and limited logistical infrastructure compound the difficulties faced by food producers, especially those operating at small or medium scale. For bakery products like white bread, these factors are critical because the product must reach consumers promptly to preserve its quality, considering its vulnerability to spoilage due to humidity and temperature sensitivity (Zhang *et al*., 2021). Therefore, optimizing distribution routes and reducing transportation costs are essential strategies for sustaining business viability in this highly competitive sector (Kartika, Taufik and Lestari, 2020; Putra, Purba and Anggraeni, 2020; Leng and Li, 2021).

Sejahtera Bread Factory, located in the Kebon Jeruk District of Jakarta, embodies these distribution challenges. As a local producer dedicated to supplying high-quality white bread, the company must navigate complex logistical constraints to ensure its products reach consumers efficiently. Despite their commitment to quality, the factory has been experiencing significant distribution inefficiencies, characterized by escalating transportation expenses and delivery delays. These issues not only burden the company financially but also risk eroding customer trust and loyalty in a market where alternatives are readily available.

Unlike large-scale enterprises that often have the resources to invest in advanced logistics management systems, small and medium enterprises (SMEs) such as Sejahtera Bread Factory typically rely on conventional distribution practices. These traditional methods may lack the sophistication required to adapt to dynamic market conditions or to optimize delivery networks effectively. As a result, SMEs frequently incur higher operational costs relative to their scale of production, reducing their competitiveness and profit margins in the long run.

The application of mathematical optimization techniques, such as the transportation method within the framework of linear programming, offers a promising solution to these distribution challenges. This method enables businesses to model distribution problems systematically, considering multiple sources and destinations while minimizing total transportation costs (Vimal, Rajak and Kandasamy, 2019). Moreover, the approach facilitates data-driven decision-making by identifying the most efficient allocation of resources and optimal routing strategies (Zhang et al., 2021).

Several prior studies have demonstrated the effectiveness of the transportation method in various industrial contexts. For instance (Aisyah, Purnamasari and Nasution 2019) applied Vogel's Approximation Method (VAM) and the Modified Distribution Method (MODI) at PT Nestle Balikpapan, achieving a notable cost reduction of 44.14% in distributing Carnation Coffee Mate. This finding underscores the potential of optimization models to significantly decrease operational expenses while enhancing logistical efficiency. Similarly, (Sembiring, Angin and Tanjung 2022) investigated the use of the North West Corner (NWC) method and VAM in optimizing delivery operations at J&T, a prominent logistics company. Although both methods yielded comparable results, they proved more effective than the company's previously applied strategies. These findings highlight the adaptability of transportation methods across diverse distribution scenarios and industries.

Further supporting this perspective (Lestari, Mustari and Muttaqien, 2023) implemented a combination of NWC, Least Cost, VAM, Stepping Stone, and MODI methods at PT IRC Inoac Indonesia. Their research demonstrated how integrating initial and advanced optimization techniques could enhance cost efficiency by as much as 23%, saving approximately IDR 3,650,850. This holistic approach illustrates the value of employing multiple optimization models to refine distribution strategies comprehensively. Recent developments in transportation optimization extend beyond large corporations to specialized food sectors. (Rini *et al*., 2024), for example, applied the Stepping Stone method to optimize the distribution of kebab skins (tortillas) at Corner Kebab. The study successfully reduced transportation costs, thereby offering valuable insights for companies in the culinary sector seeking to manage distribution expenses effectively.

Despite these encouraging findings, there remains a conspicuous gap in the literature concerning the application of transportation methods within SMEs, particularly those operating in the bakery industry at the local level. Previous research has predominantly focused on larger manufacturing contexts, where economies of scale and extensive logistical networks facilitate optimization. Small-scale enterprises, constrained by limited distribution points and resources, have not been adequately represented in such studies, leaving room for further exploration.

Moreover, while prior studies have effectively showcased the utility of transportation models, they have seldom compared these methods with alternative approaches such as route simulation or heuristic algorithms. These alternative models may offer advantages in flexibility, particularly in volatile market environments. However, they often require more complex computational resources and specialized expertise, which may be less accessible to SMEs. In contrast, the transportation method remains an approachable yet robust solution for SMEs looking to enhance their distribution systems without significant technological investment.

Given these research gaps, the present study seeks to systematically evaluate the application of the transportation method to optimize the distribution of white bread from Sejahtera Bread Factory. By employing multiple optimization techniques-including NWC, Least Cost, VAM, and the Stepping Stone method-this research aims to identify the most cost-efficient distribution strategy suited to the specific operational context of a small-scale bakery enterprise. The study aspires to offer actionable insights for SME practitioners, contributing to both academic discourse and practical applications in the field of supply chain optimization. Ultimately, this research endeavors to bridge the knowledge gap by providing empirical evidence on the applicability and effectiveness of transportation models for SMEs in the bakery sector. The findings are expected to inform better decision-making processes for business owners, enabling them to reduce distribution costs, improve delivery efficiency, and enhance customer satisfaction. Additionally, this study proposes future avenues for exploration, including the integration of digital logistics solutions and the evaluation of alternative optimization models as potential complements to the transportation method.

METHODS

Research Framework

This research falls into the category of quantitative research because it uses an approach that focuses on the collection and analysis of numerical data to measure the efficiency of product distribution (Mohajan, 2020). The applied method, namely the transportation method in linear programming, allows researchers to calculate distribution costs and optimize routes mathematically (Gan, 2022). The data collected, such as transportation costs, number of products, and distribution points, will be analyzed statistically to obtain objective and measurable results. Thus, this research aims to provide a clear and concrete picture of the factors that influence the efficiency of white bread distribution at Sejahtera Bread Factory. The quantitative method is referred to as a scientific method because it fulfills scientific principles, namely being concrete, empirical, objective, measurable, rational, and systematic (Ardiawan *et al*., 2022). This research method is known as a quantitative method because it uses data in the form of numbers and analyzes that data with statistical techniques.

The research was conducted at Sejahtera Bread Factory located in Kebun Jeruk District, along with the white bread product distribution area around the district. The research will focus on the distribution process of products from the factory to distribution points in Kebun Jeruk District to evaluate and optimize the cost and effectiveness of white bread distribution using the transportation method in linear programming.

Research variables are the characteristics and properties of an object observed in research. In quantitative research, the relationship between variables and research objects is causal, which is related to independent and dependent variables (Ardiawan *et al*., 2022). The research variables used in this study are as follows:

1. Independent Variables
   a. Distribution Cost: The total cost required to deliver white bread products from the factory to various distribution points in Kebun Jeruk District.
   b. Demand Quantity at Each Distribution Point: The amount of white bread requested by each agent or store at the distribution location.
   c. Production and Delivery Capacity: The maximum number of white bread that can be produced and delivered by the factory in one distribution period.
2. Dependent Variable
   Minimum Distribution Cost: The lowest cost resulting from the optimization of white bread distribution, which is the goal of this research.
3. Intervening Variable
   Transportation Method in Linear Programming: An optimization technique used to find the most efficient distribution route. This includes:
   a. North-West Corner (NWC), Least Cost (LC), and Vogel's Approximation Method (VAM) to find initial solutions.
   b. Stepping Stone method to obtain the optimal solution from the initial solution.

Data Collection Techniques

The research "Optimization of White Bread Product Distribution at Sejahtera Bread Factory in Kebun Jeruk District Using the Transportation Method in Linear Programming," carries out relevant data collection techniques as follows:

Observation

The observational method is an approach based on scientific observation using the senses to produce conclusions regarding relationships, causes and effects, and the meaning of a situation (Ardiawan *et al.*, 2022). Observations were made by directly observing the distribution process of white bread products at Sejahtera Bread Factory. This observation was conducted to obtain data on the distribution flow of products, including delivery time, volume of products distributed, and challenges in the field. The observation process was carried out by visiting distribution locations in Kebun Jeruk District, observing distribution vehicles, and recording related data.

1. Interviews with Factory Representatives
   Interviews were conducted with informants from management, logistics, and delivery drivers at Sejahtera Bread Factory. The purpose of the interview was to obtain information about production capacity, stock quantity, delivery time, and main distribution points.
2. Literature Study
   According to Danial and Warsiah (Rahman and Selviyanti, 2018), a literature study is research conducted by researchers by collecting various books and journals relevant to the research problem and objectives. The literature reviewed is literature related to transportation methods and optimization in linear programming. The purpose is to obtain a theoretical foundation for the application of the transportation method as well as understanding appropriate optimization approaches. Literature studies are carried out by searching for relevant journals, books, and articles on transportation methods and linear programming optimization techniques.

Data Analysis Techniques

The data analysis technique used in this research is the transportation method in linear programming, which is a technique used to determine the optimal route and shipping quantity in distribution problems, with the aim of minimizing transportation costs. According to Hillier and Liberman, the transportation method is one of the applications of linear programming that can create an optimal transportation process (Tarigan, Tastrawati and Utari, 2023). This method is useful when there are several sources (e.g., factories) and several destinations (e.g., warehouses or customers), as well as different transportation costs for each route.

The transportation method consists of two types of solutions, namely direct and indirect methods. In the direct method, the optimal solution can be obtained through only one stage of the process. Conversely, the indirect method requires two process stages to achieve an optimal solution, namely the process of finding the initial solution and the process of determining the optimal value (Tarigan, Tastrawati and Utari, 2023).

To obtain the initial solution, several methods can be used, namely North-West Corner (NWC), Least Cost (LC), and Vogel's Approximation Method (VAM) (Harahap *et al.*, 2023). After obtaining the initial solution, the next step is optimization to check whether the initial solution can be improved. The process of determining the optimal value has two methods, namely the stepping stone method and the modified distribution method.
In the NWC method, sources and destinations are arranged from left to right and from top to bottom in the data matrix (Rini et al., 2024). The calculation of transportation costs in this method starts from the top left corner, then moves right or down, adjusted to the supply

capacity or demand at the destination. The Least-Cost method allocates deliberately in cells based on the lowest transportation cost. Meanwhile, the initial solution calculation using the Vogel method is more complex than the other two methods. However, this method usually produces a solution closer to optimal (Aisyah et al., 2018).

Stepping Stone and MODI (Modified Distribution Method) are two methods commonly used in transportation problems to find the optimal solution in distribution or resource allocation problems. Both methods share the same goal, namely to optimize transportation costs or resource allocation by finding the most efficient shipping pattern. Results from studies comparing Stepping Stone and MODI through literature reviews (Harahap et al., 2023). The Stepping Stone method is useful for small transportation problems or when the emphasis is placed on understanding the shipping route visually. Meanwhile, MODI is more recommended for large transportation problems, due to its time efficiency and calculation speed. Based on the explanation above, this research will compare the minimum distribution costs using the NWC, LC, and VAM methods to find the initial solution, then determine the optimal solution using the stepping stone method.

RESULTS AND DISCUSSION

Result

Sejahtera Bread Manufacturing Company, located on Flamboyan Street, Kebon Jeruk, is facing major challenges due to high transportation costs. This has led to a decline in the effectiveness and efficiency of work processes and has resulted in cost overruns. To address this issue, the application of the transportation method can be an effective solution to minimize transportation costs. Based on conventional calculations, the transportation costs from Sejahtera Bread Factory, Supplier 1, and Supplier 2 to ABC Bakery, Ampera Bakery, and Mirasa Bakery reach IDR 420,500. This bread distribution problem can be represented in standard form with 3 rows and 3 columns.

Creating a Transportation Table

The following are the data used in this research:

Factory Capacity Data

Capacity data refers to the maximum production amount that a company can produce within a certain period. The factory capacity data for the bread factory can be seen below:

Table 1. Factory Capacity

Factory	Capacity/Day
Sejahtera Bread Factory	80
Supplier 1	105
Supplier 2	55
Total	240

Based on Table 1, the total daily production capacity from all sources is 240 units, with Supplier 1 contributing the largest share at 105 units, while Sejahtera Bread Factory provides only 80 units, or about 33.3% of the total. This indicates a high dependency on external suppliers, highlighting the importance of an optimized distribution strategy. Without proper planning, imbalances in supply capacity could lead to inefficiencies in cost and delivery. Therefore, a method that ensures effective utilization of all available sources is essential for operational efficiency.

Product Delivery Data

Below is the data on bread deliveries from the factory to the store:

Table 2. Product Delivery Data

Source	Request Location			Total
	ABC Bakery	Ampera Bakery	Mirasa Bakery	
Sejahtera Bread Factory	30	15	35	80
Supplier 1	40	30	35	105
Supplier 2	25	10	20	55
Total	95	55	90	240

Table 2 presents the distribution of bread from three sources to three destination points. ABC Bakery receives the largest total allocation with 95 units, followed by Mirasa Bakery with 90 units, and Ampera Bakery with 55 units. Supplier 1 plays a central role in the supply chain, contributing significantly to all three destinations, especially Ampera and Mirasa. Sejahtera Bread Factory primarily supports ABC and Mirasa, while Supplier 2 delivers the least overall. The balanced demand across destinations reflects the need for a well-structured transportation plan to ensure timely and cost-efficient delivery. This data highlights the importance of strategic allocation to match source capacity with destination needs, minimizing both surplus and shortage.

Transportation Costs

The cost of delivering bread from each factory to each store is calculated per dozen loaves of bread. Table 3 shows the delivery cost per dozen loaves:

Table 3. Delivery Cost Per Dozen Loaves

Source	Shipping costs		
	ABC Bakery	Ampera Bakery	Mirasa Bakery
Sejahtera Bread Factory	700	2,500	3,500
Supplier 1	800	2,300	1,800
Supplier 2	1,000	2,000	3,500

Table 3 outlines the shipping costs from each source to each bakery per dozen loaves of bread. The data reveals significant variations in transportation expenses depending on the route. The lowest cost is recorded from Sejahtera Bread Factory to ABC Bakery at 700 IDR per dozen, while the highest is 3,500 IDR from both Sejahtera and Supplier 2 to Mirasa Bakery. Supplier 1 offers the most balanced cost structure, particularly advantageous for Mirasa Bakery with a cost of only 1,800 IDR. These disparities underscore the critical importance of route optimization in minimizing distribution expenses. Strategic selection of delivery paths, based on cost differentials, is essential for achieving cost-efficiency and operational sustainability.

Determining the Initial Solution

The initial solution can be obtained by using one or trying all of the following methods: North West Corner, Least Cost, or Vogel's Approximation Method (VAM) to get a feasible initial solution. The calculation of this first stage optimization method is carried out by calculating the total transportation cost using NWC, Least Cost, and VAM methods as follows:

Table 4. NWC (North West Corner) Calculation

Source	Request Location			Total
	ABC Bakery	Ampera Bakery	Mirasa Bakery	
Sejahtera Bread Factory	80 700	2,500	3,500	80
Supplier 1	15 800	55 2,300	35 1,800	105
Supplier 2	1,000	2,000	55 3,500	55
Total	95	55	90	240

Initial Solution for Bread Distribution Transportation Costs Using the NWC Model is:
= (Source from Pabrik Roti Sejahtera to Toko Roti ABC x Transportation Cost)
= (Source from Supplier 1 to Toko Roti ABC x Transportation Cost)
= (Source from Supplier 1 to Toko Roti Ampera x Transportation Cost)
= (Source from Supplier 1 to Toko Roti Mirasa x Transportation Cost)
= (Source from Supplier 2 to Toko Roti Mirasa x Transportation Cost)
= (80 x 700) + (15 x 800) + (55 x 2300) + (35 x 1800) + (55 x 3500)
= 56,000 + 12,000 + 126,500 + 63,000 + 192,500
= Rp 450,000

The total transportation cost resulting from the North West Corner (NWC) method is IDR 450,000, which is the highest among all initial solution methods tested. This outcome is primarily due to the NWC method's rigid allocation process, which simply fills transportation routes from the top-left corner of the matrix without considering cost efficiency. As a result, several high-cost routes—such as the delivery from Supplier 2 to Mirasa Bakery at IDR 3,500 per dozen—are heavily utilized. This lack of cost consideration leads to inefficient route selection and ultimately higher overall expenses. For small-scale businesses like Sejahtera Bread Factory, such inefficiencies can significantly impact profit margins, emphasizing the need for more strategic approaches like the Least Cost or Vogel's Approximation Method, which better align with cost minimization objectives.

Table 5. Least Cost Calculation

Source	Request Location			Total
	ABC Bakery	Ampera Bakery	Mirasa Bakery	
Sejahtera Bread Factory	80 700	2,500	3,500	80
Supplier 1	15 800	2,300	90 1,800	105
Supplier 2	1,000	55 2,000	3,500	55
Total	95	55	90	240

Initial Solution for Bread Distribution Transportation Costs Using the Least Cost Model is :

= (Source from Pabrik Roti Sejahtera to Toko Roti ABC x Transportation Cost)
= (Source from Supplier 1 to Toko Roti ABC x Transportation Cost)
= (Source from Supplier 2 to Toko Roti Ampera x Transportation Cost)
= (Source from Supplier 1 to Toko Roti Mirasa x Transportation Cost)
= (80 x 700) + (15 x 800) + (55 x 2000) + (90 x 1800)
= 56,000 + 12,000 + 110,000 + 162,000
= Rp 340,000

The application of the Least Cost method resulted in a total transportation cost of IDR 340,000, which is IDR 110,000 lower than the cost obtained using the North West Corner method. This significant reduction highlights the efficiency of the Least Cost approach in allocating resources based on the lowest available shipping rates. For instance, the majority of deliveries to Mirasa Bakery—one of the largest demand points—are routed through Supplier 1, which offers the most economical cost at IDR 1,800 per dozen. Likewise, Ampera Bakery's demand is partially met by Supplier 2, which also offers a more cost-effective route compared to the main factory. This method effectively minimizes high-cost allocations and strategically utilizes lower-cost options across the distribution network. For small-scale enterprises with limited budgets, such optimization can provide immediate and tangible financial benefits, improving profit margins and operational sustainability.

Table 6. Vogel's Approximation Method Calculation

Source	Request Location			Total
	ABC Bakery	Ampera Bakery	Mirasa Bakery	
Sejahtera Bread Factory	80 700	2,500	3,500	80
Supplier 1	15 800	2,300	90 1,800	105
Supplier 2	1,000	55 2,000	3,500	55
Total	95	55	90	240

Initial Solution for Bread Distribution Transportation Costs Using the VAM (Vogel's Approximation Method) Model is

= (Source from Pabrik Roti Sejahtera to Toko Roti ABC x Transportation Cost)
= (Source from Supplier 1 to Toko Roti ABC x Transportation Cost)
= (Source from Supplier 2 to Toko Roti Ampera x Transportation Cost)
= (Source from Supplier 1 to Toko Roti Mirasa x Transportation Cost)
= (80 x 700) + (15 x 800) + (55 x 2000) + (90 x 1800)
= 56,000 + 12,000 + 110,000 + 162,000
= Rp 340,000

The Vogel's Approximation Method (VAM) also produced a total transportation cost of IDR 340,000, identical to the result generated by the Least Cost method. However, the underlying strength of VAM lies in its systematic approach to penalizing inefficient allocations by considering the opportunity cost between the two lowest costs in each row and column. This feature often leads to a solution that is closer to optimal from the start, especially in more complex distribution matrices. In this case, VAM successfully avoided high-cost routes and concentrated allocations on the most cost-effective paths, such as from Supplier 1 to Mirasa Bakery and from Supplier 2 to Ampera Bakery. The result validates the effectiveness of VAM in optimizing distribution costs in a structured and mathematically grounded manner. For SMEs with limited computational tools, VAM offers a practical balance between optimization accuracy and ease of implementation, making it an attractive option for improving logistical efficiency without relying on advanced software systems.

From Tables 4, 5, and 6, it can be seen that among the three initial solutions used, the Least Cost method provides the lowest total cost, which is Rp 340,000. This cost is Rp 80,500 lower than the previous cost of Rp 420,500. Thus, the result obtained from the Least Cost method represents the minimum cost.

Calculating the Optimal Solution

After achieving the minimum cost in the initial solution, the next step is to determine a further solution using the Stepping Stone Method. Table 7 below presents the transportation costs calculated using the Stepping Stone Method in the first iteration.

Table 7. Stepping Stone Calculation – 1st Iteration

Source	Request Location			Total
	ABC Bakery	Ampera Bakery	Mirasa Bakery	
Sejahtera Bread Factory	80 [700]	[2500]	[3500]	80
Supplier 1	15 [800]	55 [2300]	35 [1800]	105
Supplier 2	[1000]	[2000]	55 [3500]	55
Total	95	55	90	240

1B = 2500-700 + 800-2300 = 300
1C = 3500-700 + 800-1800 = 1800
3A = 1000-3500 + 1800-800 = -1500
3B = 2000-3500 + 1800-2300 = -2000

The first iteration of the Stepping Stone method, as illustrated in Table 7, was conducted to evaluate whether the initial feasible solution obtained from the Least Cost and VAM methods could be further optimized. The results indicate that some of the alternative routes, particularly cells 3A and 3B, yield negative opportunity costs of -1500 and -2000 respectively. These negative values signal that there are more cost-efficient paths available than those currently allocated. Specifically, route 3B, which involves deliveries from Supplier 2 to Ampera Bakery, reflects the most significant inefficiency and thus has the greatest potential for cost reduction. Meanwhile, routes such as 1B and 1C exhibit positive opportunity costs, indicating that shifting allocations to these routes would not improve the overall cost. These findings highlight the potential for optimization beyond the initial solution and justify the need for a second iteration to refine the distribution plan. The negative opportunity costs detected in this stage suggest that the existing allocation, although close to optimal, can still be improved by reallocating units through more cost-effective cycles. The calculation result above is not yet optimal because there are negative values; therefore, we proceed with the second iteration calculation:

Table 8. Stepping Stone Calculation – 2nd Iteration

Source	Request Location			Total
	ABC Bakery	ABC Bakery	ABC Bakery	
Sejahtera Bread Factory	700 80	2500	3500	80
Supplier 1	800 15	2300	1800 90	105
Supplier 2	1000 0	2000 55	3500	55
Total	95	55	90	240

1B = 2500-2000 + 1000-700 = 800
1C = 3500-700 + 800-1800 = 1800
2B = 2300-2000 + 1000-800 = 500
3C = 3500-1000 + 800-1800 = 1500

In the second iteration of the Stepping Stone method, the evaluation revealed that all opportunity costs are now positive: 1B = 800, 1C = 1800, 2B = 500, and 3C = 1500. The absence of negative opportunity costs indicates that no further improvements in the total transportation cost can be achieved by shifting allocations. This confirms that the previous allocation—obtained through the Least Cost and Vogel's Approximation Method—has reached its optimal state. In other words, the solution achieved in the initial phase is already the most efficient in minimizing total distribution expenses. This outcome also validates the

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robustness of the initial allocation strategy, particularly in the context of a small-scale supply chain with limited routes and predictable demand. The convergence of the Stepping Stone iterations to a stable solution demonstrates the method's effectiveness in verifying optimality and underscores that simple heuristic methods, when appropriately applied, can yield highly efficient outcomes for SMEs without the need for advanced computational tools.

The results of the second iteration using the Stepping Stone method indicate that the distribution cost remains at IDR 340,000, confirming that the initial solution is already optimal. This final allocation minimizes transportation costs without the need for further adjustments. The comparative analysis of the three initial solution methods-North West Corner (NWC), Least Cost, and Vogel's Approximation Method (VAM)-reveals important insights. The NWC method produced the highest total cost (IDR 450,000), primarily due to its rigid allocation logic, which does not consider cost efficiencies. In contrast, both the Least Cost and VAM methods significantly reduced the cost to IDR 340,000, a reduction of IDR 80,500 or approximately 19% compared to the conventional cost. Interestingly, the identical results of Least Cost and VAM in this case suggest that the cost-minimizing opportunities were already captured effectively in the initial allocation.

The Stepping Stone method, which aims to refine these initial solutions, confirmed the optimality of the result, showing no further cost reduction. This outcome reinforces the efficiency of the Least Cost method in smaller-scale distribution scenarios where routes are limited and cost structures are straightforward. In comparison with previous studies, such as (Aisyah et al. 2019) and (Lestari et al. 2023), where iterative methods like MODI provided substantial improvements, the current findings indicate that for SMEs with limited nodes, simpler methods may already yield optimal solutions.

From a managerial standpoint, saving IDR 80,500 per distribution cycle could result in significant monthly savings when aggregated-especially relevant for micro and small enterprises that operate on tight profit margins. This reinforces the strategic value of even basic linear programming applications for SMEs in the food sector. Ultimately, the results affirm that optimization models like Least Cost and VAM are not only theoretically sound but also practically viable for cost-conscious operations in local bakery distribution networks.

CONCLUSION

This study comprehensively examined the optimization of white bread distribution from Sejahtera Bread Factory, which supplies three destination points: ABC Bakery, Ampera Bakery, and Mirasa Bakery. Utilizing conventional distribution methods, the factory incurs transportation costs amounting to IDR 420,500. Through the application of the North West Corner (NWC) method, costs were recalculated at IDR 450,000, reflecting an increase of IDR 29,500 compared to the initial expenditure. Conversely, both the Least Cost method and Vogel's Approximation Method (VAM) demonstrated significant effectiveness, successfully reducing total distribution costs to IDR 340,000, thereby achieving savings of IDR 80,500. Further optimization was pursued through the application of the Stepping Stone method, which is designed to refine initial solutions. However, this method did not yield additional cost reductions beyond the outcomes achieved by the Least Cost and VAM methods. The persistence of the total cost at IDR 340,000 can be attributed to two principal factors. First, the initial solution derived from the Least Cost and VAM methods was already near-optimal, limiting the scope for further improvements. Second, constraints such as limited route availability, vehicle capacity, and logistical challenges in the field restrict alternative distribution paths, thus reducing the flexibility of the optimization process. Based on the findings of this research, it can be conclusively stated that the Least Cost method is the most efficient strategy for optimizing the bread distribution process at Sejahtera Bread Factory. This method not only surpasses the performance of the North West Corner approach but also equals the optimization level of the Stepping Stone method while requiring less complex computational steps. Consequently, the Least Cost method is strongly recommended for the factory's ongoing distribution planning, especially given its balance between simplicity of application and effectiveness in reducing costs. From a managerial perspective, the adoption of the Least Cost method provides clear operational advantages. It enables factory managers to make data-driven decisions that enhance cost efficiency without necessitating sophisticated technological investments. Moreover, by systematically analyzing distribution routes and costs, the factory can allocate resources more effectively and respond swiftly to fluctuating demand patterns, thereby improving customer satisfaction and maintaining competitive positioning in the local market. Beyond the immediate practical implications, this study also contributes to the broader discourse on distribution optimization for SMEs in the food production sector. It illustrates that even small-scale enterprises can significantly benefit from the application of linear programming models, which are often perceived as tools exclusive to larger corporations. The research demonstrates that with accurate data and structured analysis, SMEs can achieve meaningful cost reductions and operational improvements. For future research, several avenues warrant exploration. First, subsequent studies could expand the distribution network to include additional destination points or integrate inter-district deliveries to assess the scalability of the transportation method. Second, incorporating external variables such as traffic congestion, delivery time windows, and fuel price volatility could provide a more comprehensive understanding of the factors influencing distribution efficiency. Third, comparative analyses with alternative optimization methods, such as heuristic algorithms or route simulations, may uncover complementary strategies that further enhance distribution performance. Additionally, future research should consider the integration of digital technologies, such as geographic information systems (GIS) and real-time route optimization software, to enrich decision-making processes. These advancements could provide dynamic, real-time solutions that adapt to changing logistical environments, offering SMEs a competitive edge in an increasingly data-driven marketplace.

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