Minimize the Distribution Cost of Tortillas at Corner Kebab Using the Stepping Stone Method

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Abstract

This research explores optimizing transportation costs for Corner Kebab, a kebab business, by employing the stepping stone method. It addresses operational expenses, encompassing factory and transportation costs, to enhance the delivery of kebab skin (tortilla). The study evaluates the distribution process from MiniFroz and Defroz factories in East Jakarta and Serpong to three Corner Kebab outlets in Pondok Benda, Cidodol South Jakarta, and Bukit Dago. By minimizing tortilla distribution costs, the stepping stone method identifies an optimal daily expense of Rp. 212,000,- for Corner Kebab, surpassing the Rp. 222,000,- incurred through the North West Coast Method. This approach offers cost-saving benefits for the company. Despite the well-established nature of transportation problems and optimization techniques, this research contributes novelty by applying the stepping stone method to the kebab industry, specifically analyzing tortilla delivery costs. This focus on a niche business context enhances understanding and provides valuable insights for operational cost reduction in similar enterprises.

Keywords: Transportation, Operational Costs, Stepping Stone Method, Product Distribution, Cost Optimization

Abstrak

Penelitian ini mengeksplorasi optimasi biaya transportasi untuk Corner Kebab, sebuah bisnis kebab, dengan menggunakan metode stepping stone. Ini mengatasi biaya operasional, meliputi biaya pabrik dan transportasi, untuk meningkatkan pengiriman kulit kebab (tortilla). Studi ini mengevaluasi proses distribusi dari pabrik MiniFroz dan Defroz di Jakarta Timur dan Serpong ke tiga outlet Corner Kebab di Pondok Benda, Cidodol Selatan Jakarta, dan Bukit Dago. Dengan meminimalkan biaya distribusi tortilla, metode stepping stone mengidentifikasi pengeluaran harian optimal sebesar Rp. 212.000,- untuk Corner Kebab, melampaui Rp. 222.000,- yang dikeluarkan melalui Metode North West Coast. Pendekatan ini menawarkan manfaat penghematan biaya bagi perusahaan. Meskipun sifat masalah transportasi dan teknik optimasi sudah mapan, penelitian ini memberikan kontribusi baru dengan menerapkan metode stepping stone pada industri kebab, khususnya menganalisis biaya pengiriman tortilla. Fokus ini pada konteks bisnis niche meningkatkan pemahaman dan memberikan wawasan berharga untuk pengurangan biaya operasional dalam perusahaan serupa.

Kata Kunci: Transportasi, Biaya operasi, Metode batu loncatan (stepping stone), Distribusi produk, Optimalisasi biaya

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1. Introduction

The term Operations Research was first introduced in 1940 by Mc Closky and Trefthen in a small town in England called Bowdsey. Literally, the definition of Operations Research consists of two words, "research," referring to an organized process to discover truths related to a problem, and "operations," defined as actions applied to the problem or hypothesis. According to Morse and Kimball (Damayanti et al., 2021), Operations Research is a scientific method that allows managers to make decisions regarding their activities based on quantitative grounds. However, there is lack of discussion about the evolution or current state of Operations Research beyond its initial introduction. Additionally, there is no indication of specific areas within Operation Research where further research or development is needed. This gap could be addressed by exploring recent trends, or practical applications of Operation Research in various industries, including food industry. In the food industry, Operations Research plays a crucial role in optimizing various processes throughout the supply chain, from production and distribution to inventory management and logistics. However, despite its importance, there's often a lack of Research within this sector.

One method in Operations Research is the transportation method, which is a technique used to manage the distribution of the same product from sources to destinations optimally with the lowest cost. Product allocation needs to be carefully arranged due to differences in allocation costs from source to different destination points. The transportation method can also be applied to solve various problems in the business world, such as advertising, capital budgeting, investment fund allocation, location analysis, assembly line balancing, and production planning and scheduling. (Fiftriatien, 2016)

One transportation method used is the Stepping Stone method, which aims to find optimal solutions for transportation problems by considering operational costs, including factory and transportation costs. The stepping stone method is a technique to obtain the optimal solution for transportation problems (minimum TC). This method is trial and error in nature, meaning by trial and error, moving filled cells (stones) to empty cells (water). Of course, these movements must reduce costs, so empty cells with low transportation costs must be selected, allowing for the movement to take place (Sinaga, 2023).

The transportation method was used in the study titled "Implementation of Transportation Method in Optimizing Distribution Costs of Bread at PT. Granedia Makassar" (Ibnas, 2017). The researchers attempted to find ways to reduce overall transportation costs in delivering bread from the warehouse to various marketing regions. In this study, the initial solution method chosen to solve the transportation problem was the Northwest Corner method, where the initial transportation cost was recorded at Rp. 2,785,000. However, after optimization using the MODI method, transportation costs were reduced to Rp. 2,432,500.

In 2018 (Khanti & Kristanto, 2020), a study was conducted to implement transportation distribution costs for goods delivery at Galeri Bimasakti. The initial calculation phase used the Northwest Corner method, and the final solution phase used the Stepping Stone method. Data processing results through manual calculation using the Northwest Corner method yielded a total cost of Rp. 124,900,000, while using the Stepping Stone method yielded an optimal cost of Rp. 123,700,000. Additionally, the Stepping Stone method was used to solve distribution route problems and shipping costs for 8mm glass products at UKM Rajawali Kaca dan Aluminium as a glass distribution company in the Bekasi and Bogor regions (Dimosuharto et al., 2021). Optimizing distribution costs impacted the level of cost efficiency incurred by UKM Rajawali Kaca dan Aluminium.

Various findings from these studies indicate that the use of transportation methods to optimize costs has successfully reduced costs significantly. From this background, a case study is conducted on a kebab business named Corner Kebab, located at Ruko Ogie Plaza Pamulang, Jl. Siliwangi No.8, Tangerang Selatan, Banten 15417, by applying the Stepping Stone method.

2. Literature Review and Hypothesis

Transportation Method

The use of the transportation method in operations research was first introduced by F.L. Hitchcock (1941), T.C. Koopmas (1949), and G.B. Dantzig (1951) (Fitriatien, 2016). Transportation Model is one type of linear programming that has specific characteristics, namely: products are shipped from multiple suppliers to various recipients at the lowest possible cost, and each supplier can send a certain quantity of products, while each recipient (destination) also has certain demand (Arimurti, et al, 2022). The transportation problem is formulated based on the following scenario (Wahyu, et al, 2021):

1. There are source/origin locations with their maximum capacities (supply).
2. There are destination locations with their minimum demands.
3. There are transportation routes from each source to each destination along with transportation costs per unit. The costs are linearly proportional to the distance.
4. Only one type of commodity is being transported.
5. Minimize transportation costs.
6. There exists an assumed linear objective function.

Characteristics of transportation problems include:
1. There are a number of predetermined sources and destinations.
2. The quantity of goods distributed from each source and the quantity requested by each destination are specific.
3. The quantity of goods shipped or transported from a source to a destination matches the demand or capacity of the source.
4. The demand and supply quantities must be balanced, and if not balanced, dummy variables should be added.
5. The transportation costs from each source to each destination have been determined. The number of basic variables is equal to the number of rows and columns. If the number of basic variables is less than desired, known as degeneracy, basic variables with zero values should be added.

Transportation Model Table

The image below illustrates the transportation model interpreted into a table, distinguishing between sources and destinations. Sources are placed in rows, while destinations are placed in columns. The quantity of supply from each source is placed at the end of the column, while the quantity of demand from each destination is placed at the end of the row.

Source: Sri Rahmawati Fitriatien

Figure 1. Transportation Model Table

Steps for Solving Transportation Model Problems
In the context of transportation methods, there are two approaches to solving transportation problems: using initial solution methods and final solution methods (Ibnas, 2017).
Initial Solution Methods In determining an initial solution, several methods can be utilized (Dimosuharto et al., 2021):

1. Least Cost Method, The Least Cost (LC) method is an optimization technique in transportation that prioritizes routes with the lowest costs. LC searches for the cell with the lowest cost in the overall matrix and assigns the maximum possible for the demand and supply values associated with the selected cell. If there are multiple cells with the same lowest cost, selection is made randomly. Although simple, this approach is time-consuming as searching for the lowest-cost cell across the entire matrix each time is impractical.

2. North West Corner (NWC) Method, The Northwest Corner Method is one of the initial approaches in solving transportation problems. It was first developed in the early 1940s and has become one of the simplest and most intuitive techniques for solving transportation problems (Khanti & Kristanto, 2020). The basic concept of the Northwest Corner method is to start the allocation from the northwest corner of the transportation table. This means that the first location considered for allocation is the top-left corner of the transportation table, and allocation proceeds sequentially to the right and downward. The main advantage of this method lies in its simplicity in concept and implementation, making it easily understood and applicable even without computer assistance. However, its weakness lies in the fact that it does not always produce optimal solutions and may require additional iterations with other methods to improve solutions.

3. Vogel's Approximation Method (VAM), This method is an approach where allocation begins by evaluating the difference in values between each cell in the row and column (referred to as differences or S), then the row or column with the largest difference value is selected, and allocation is made to the cell with the lowest cost in the selected row or column (Ibnas, 2017).

Final Solution Methods After performing initial solution methods for transportation problem resolution, the next step is to achieve the final or optimal solution. There are two common techniques used in final solution methods: the Stepping Stone method and the MODI method. The Stepping Stone method is a technique used to generate feasible solutions in transportation problem-solving by considering operational costs, including factory and transportation costs, making shipping costs relative (Khanti & Kristanto, 2020). The process involves forming allocation cycles that connect unallocated cells (non-basic variables). Prior to this, an examination is conducted on the number of filled cells in the initial solution to ensure that it meets the requirements (m + n + 1). If it does not meet, filled cells are added by allocating zero to empty cells. The goal of this step is to maintain balance between supply and demand while reallocating products to empty cells. All empty cells are evaluated in the same way to determine if they can reduce costs, thus becoming entering variables. Entering variables are empty cells that have negative values in cost addition and cost reduction.

The MODI (Modified Distribution) Method is a technique used to arrange the distribution of the same products from various sources to various destinations optimally with minimal costs (Liefofid et al., 2023). The allocation of these products must be carefully arranged as allocation costs may vary from one source to another destination. Solutions produced using the Modified Distribution Method (MODI) are the result of the development of the stepping stone method in solving transportation cases.

The Stepping Stone method is an advanced stage from the initial method in achieving an optimal solution. In the Stepping Stone method, product allocation is carefully adjusted to achieve optimal production allocation using a trial and error approach. Essentially, this method is used to identify and evaluate empty cells in the transportation cost matrix. This matrix includes transportation costs from one location to another. Each cell in the matrix represents the shipping cost between a source-destination pair. If a cell is empty, it means there is no transportation allocation there. The Stepping Stone method assists in finding optimal solutions by testing and evaluating various possible paths for transportation allocation. This approach allows dynamic changes in allocation to achieve minimal total costs.

Steps of the Stepping Stone Method (Kiftiah, 2019):
1. Fill the initial table with the initial solution method.
2. Choose any empty cell to fill, with the condition that it forms a closed cycle starting and ending at an empty cell, and only the cells to be filled are included in the cycle.
3. Mark empty cells alternatively with a plus sign (+) and a minus sign (-) on each box in the newly passed closed path.
4. Calculate improvement indices by adding unit costs in each box with a plus sign (+), then subtracting unit costs in each box with a minus sign (-).
5. Repeat steps 3 to 4 until all improvement indices for all unused cells have been calculated. If all calculated indices are greater than or equal to zero, then the optimal solution has been achieved. If not, these steps can be further improved to reduce total shipping costs.

3. Data and Method
Type of Research
This research utilizes a quantitative method with an Experimental design that manipulates specific variables in the application of the Stepping Stone method. This research design was chosen because it enables the control of particular variables and explicitly tests the effects of using the Stepping Stone method in the context of optimizing kebab skin delivery costs. This experiment can provide deep insights into the effectiveness of this method in enhancing efficiency in the kebab skin distribution chain.
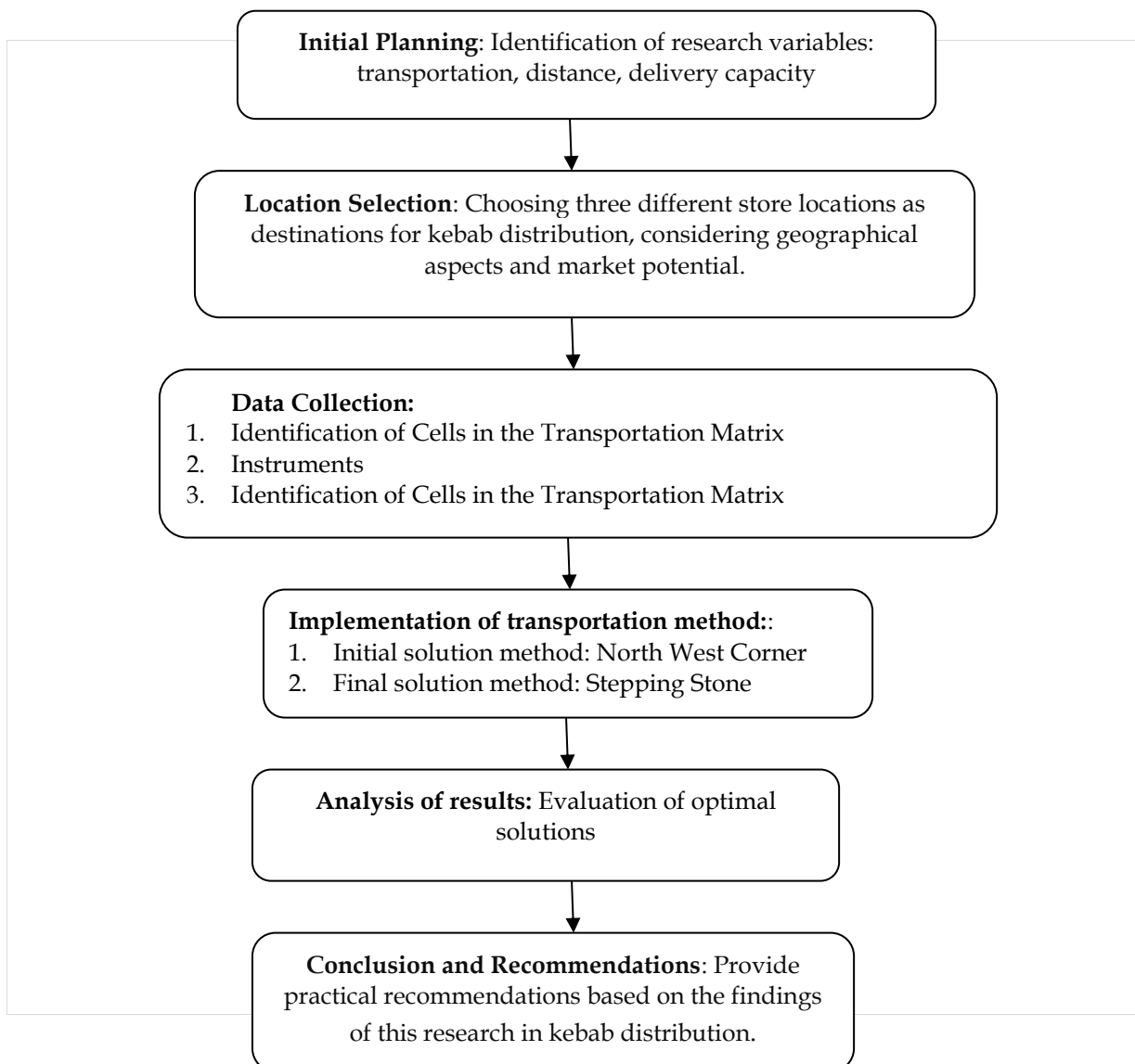
Methods of Data Collection
Data were collected through simulating kebab skin delivery using the Stepping Stone method and direct observations related to delivery costs and distances.

Data Analysis Methods
Data analysis will involve implementing the steps of the Stepping Stone method to find optimal delivery cost solutions. The following are the research steps for optimizing kebab distribution from East Jakarta and Serpong to three different store locations using transportation methods, particularly the Stepping Stone method:

Figure 2. Research Methodology Flowchart

Initial Planning: Identification of research variables: transportation, distance, delivery capacity

Location Selection: Choosing three different store locations as destinations for kebab distribution, considering geographical aspects and market potential.

Data Collection:
1. Identification of Cells in the Transportation Matrix
2. Instruments
3. Identification of Cells in the Transportation Matrix

Implementation of transportation method::
1. Initial solution method: North West Corner
2. Final solution method: Stepping Stone

Analysis of results: Evaluation of optimal solutions

Conclusion and Recommendations: Provide practical recommendations based on the findings of this research in kebab distribution.

4. Results

The production of tortillas at MiniFroz located in East Jakarta and Serpong is sent to 3 kebab store locations in Pondok Benda, Cidodol South Jakarta, and Bukit Dago. The maximum tortilla production capacity is 450 pcs from the East Jakarta Factory and 400 pcs from the Serpong Factory for each delivery. The Tortilla Company has 2 central and branch factories in different locations, MiniFroz located in East Jakarta and Defroz (Branch Factory) in

Serpong, with capacities of 450 pcs and 400 pcs respectively for each delivery.
1. MiniFroz, East Jakarta: 450 pcs
2. Defroz (branch), Serpong: 400 pcs

The produced tortillas are sent to three store locations: Pondok Benda, Cidodol, and Bukit Dago, with store demands of 200 pcs, 350 pcs, and 300 pcs respectively.
1. Pondok Benda, South Tangerang: 200 pcs
2. Cidodol, South Jakarta: 350 pcs
3. Bukit Dago, South Tangerang: 300 pcs

The Shipping Costs from each factory to the store location are as follows:

From the Tortilla Factory / to the Kebab Store	Kebab Store			Supply
	Pondok Benda	Cidodol	Bukit Dago	
Minifroz	350	300	450	450
Defroz	270	320	150	400
Demmand	200	350	300	850

Implementation of Transportation Method
 1. Initial Solution Step Using the NWC Method

From the Tortilla Factory / to the Kebab Store	Kebab Store			Supply
	Pondok Benda	Cidodol	Bukit Dago	
Minifroz	350 200	300 250	450	450
Defroz	270	320 100	150 300	400
Demmand	200	350	300	850

Explanation:
The MiniFroz Tortilla Factory (East Jakarta) supplies:
Kebab Store Pondok Benda   : 200 units
Kebab Store Cidodol   : 250 units
Kebab Store Bukit Dago   : 0 units

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Remaining Supply: 0

The Defroz Tortilla Branch Factory (Serpong) supplies:
Kebab Store Pondok Benda   : 0 units
Kebab Store Cidodol   : 100 units
Kebab Store Bukit Dago   : 300 units

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Remaining Supply: 0

The total shipping cost of Tortillas from the Factory to the Kebab Store with the initial solution of the North West Corner (NWC) Method is:
Z   = 200(350) + 250(300) + 100(320) + 300 (150)
Z   = 70.000 + 75.000 + 32.000 + 45.000
Z   = Rp. 222.000,-

 2. Final Solution Steps Using the Stepping Stone Method:
   1. Identify Empty Cells: Find empty cells in the transportation matrix indicating undetermined transportation allocations.

2. Form Stepping Stone Paths: Apply the Stepping Stone method to form paths or routes that create a stepping stone pattern within the matrix.
3. Evaluate Total Cost: Calculate the total cost by considering allocations at each stepping stone.
4. Determine the optimal solution by considering the analysis results using the Stepping Stone method.

From the Tortilla Factory / to the Kebab Store	Kebab Store			Supply
	Pondok Benda	Cidodol	Bukit Dago	
Minifroz	350 200	300 250	450	450
Defroz	270	320 100	150 300	400
Demmand	200	350	300	850

Testing empty cells with Stepping Stone
Distributing Empty Columns
MiniFroz -> Bukit Dago (green arrow) = 450 - 300 + 320 - 150 = 320 (positive)
Defroz -> Pondok Benda (red arrow)   = 270 - 350 + 300 - 320 = -100 (negative)

It appears that Defroz -> Pondok Benda still has a negative value, so a shift is performed as follows:

200 (-) 100	250 (+) 100	Becomes	100	350
X (+) 100	100 (-) 100		100	x

As a result, the table becomes:

From the Tortilla Factory / to the Kebab Store	Kebab Store			Supply
	Pondok Benda	Cidodol	Bukit Dago	
Minifroz	350 100	300 350	450	450
Defroz	270 100	320	150 300	400
Demmand	200	350	300	850

Minimizing Costs
Z   = 100(350) + 350(300) + 100(270) + 300(150)
Z   = 35.000 + 105.000 + 27.000 + 45.000
Z   = Rp. 212.000,-

Testing empty cells with Stepping Stone:

From the Tortilla Factory / to the Kebab Store	Kebab Store			Supply
	Pondok Benda	Cidodol	Bukit Dago	
Minifroz	350 100	300 350	450	450
Defroz	270 100	320	150 300	400
Demmand	200	350	300	850

Distributing Empty Columns
Minifroz -> Bukit Dago (orange arrow) = 450 - 300 + 350 - 270 + 150 = 380 (positive)
Defroz -> Cidodol (blue arrow)   = 320 - 300 + 350 - 270 = 100 (positive)

Evaluation
Since no negative values (cost savings) were found from the calculations, the execution process is complete. All values are now positive, indicating that the results are optimal. The allocation of products from the factory to store locations according to the North West Corner method tested with the stepping stone method, and the transportation costs are as follows.

From the Tortilla Factory	To the Kebab Store	Number of Tortillas	Shipping Cost per unit	Shipping Cost (Rp)
Minifroz	Pondok Benda	100	350	Rp. 3.500
Minifroz	Cidodol	350	300	Rp. 10.500
Defroz	Pondok Benda	100	270	Rp. 2.700
Defroz	Bukit Dago	300	150	Rp. 4.500
Total Cost				**Rp. 212.000**

5. Discussion
Research Analysis
The Stepping Stone Method starts with a feasible initial solution, often derived from other methods like the Northwest Corner method, and iteratively improves it until an optimal solution is reached. This process involves trial and error adjustments to the allocations. The objective here is to minimize the costs associated with distributing Tortillas for Corner Kebab. This involves finding the most cost-effective allocation of resources (in this case, transportation routes) to meet demand. The final result of the optimization process is an optimal cost, which represents the minimum total cost that Corner Kebab needs to incur for its Tortilla distribution on a daily basis.

The final result of solving the problem of minimizing Tortilla distribution costs at Corner Kebab using the Stepping Stone method obtains the fact that the optimal cost to be incurred by Corner Kebab is Rp. 212,000,- per day, which is more cost-effective than only using The North West Coast Methode, which was Rp. 222,000,- per day, providing benefits for the company management in reducing costs.

The results of this research using application of the Stepping Stone Method to optimize distribution cost is similar to research papers that deal with optimizing distribution costs furniture industry in Galeri Bimasakti, in Cental Java and Eaast Java (Khanty, 2020). The initial calculation phase used the Northwest Corner method, and the final solution phase used the Stepping Stone method. Data processing results through manual calculation using the Northwest Corner method yielded a total cost of Rp. 124,900,000, while using the Stepping Stone method yielded an optimal cost of Rp. 123,700,000. The study involved two main phases: an initial calculation phase using the Northwest Corner method and a final solution phase using the Stepping Stone method. This is the key findings:
1. Northwest Corner Method: This method was initially employed for the calculation phase. It's one of the basic methods for finding an initial feasible solution to transportation problems. The manual calculation using this method yielded a total cost of Rp. 124,900,000.
2. Stepping Stone Method: After obtaining the initial solution with the Northwest Corner method, the study moved to the final solution phase using the Stepping

Stone Method. This method allows for iterative adjustments to the initial solution to improve cost efficiency. Using the Stepping Stone method, the optimal cost for transportation distribution at Galeri Bimasakti was determined to be Rp. 123,700,000.

Comparing the results obtained from both methods, it's evident that the Stepping Stone method yielded a lower optimal cost compared to the Northwest Corner method. This suggests that the iterative optimization process of the Stepping Stone method led to a more efficient allocation of resources, resulting in cost savings for both Galeri Bimasakti in their goods delivery operations in 2019, and also for Corner Kebab in 2024.

6. Conclusion

Transportation method is a technique used to manage the distribution from sources providing the same product to destinations optimally with the lowest cost in allocating products from one or multiple sources to different destinations. Therefore, transportation methods can also be used to solve other business problems for directed and optimal solutions, including advertising, capital financing, fund allocation for investments, location analysis, assembly line balancing, and production planning and scheduling. One transportation method, the Stepping Stone Method, is a repetitive technique that allocates production to move from a feasible initial solution to an optimal solution using trial and error or trial-and-error in transportation methods by distributing products based on cheaper financing by jumping from the boxes of the matrix used by the Northwest Corner method and clockwise or counterclockwise.The final result of solving the problem of minimizing Tortilla distribution costs at Corner Kebab is that the optimal cost that must be incurred by Corner Kebab is Rp. 212,000,- per day.

The final result, concerning the optimization of Tortilla distribution costs at Corner Kebab, demonstrates the practical application of transportation methods in real-world scenarios. By determining an optimal cost of Rp. 212,000 per day, Corner Kebab can streamline its distribution processes, potentially enhancing profitability and competitiveness in the market. This showcases the tangible benefits of applying mathematical modeling and optimization techniques to address operational challenges within businesses.

It suggests that these methods can be applied to various business problems, including advertising, capital financing, fund allocation, location analysis, assembly line balancing, and production planning. This implies that the principles underlying transportation methods offer a versatile framework for optimizing resource allocation and decision-making across different domains within a business.

Recommendation

1. In line with the finding that the use of the Stepping Stone method results in minimal distribution costs, Corner Kebab should consider integrating transportation methods into its distribution management system. This entails adopting techniques like the Stepping Stone Method to optimize resource allocation and minimize costs across its distribution network consistently. After implementation, conduct continuous monitoring and evaluation of distribution performance. Pay attention to whether the costs remain optimal or if there are changes in conditions that require adjustment.
2. It's crucial for Corner Kebab to conduct regular evaluations of its distribution processes and costs. By continuously monitoring performance metrics and identifying areas for improvement, the company can refine its strategies over time to maintain cost-effectiveness and operational efficiency.

Limitations and avenue for future research

The limitations of this study include the specific production capacities of tortilla factories, as well as the distribution to designated store locations. For future research, it is recommended to explore additional factors that may affect distribution costs, and to test more complex transportation methods to achieve a more optimal solution in product allocation.

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