Comparative Analysis of Transportation Methods in The Distribution of Frozen Chicken Products (Case Study: CV. XYZ Batam)

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Abstract

Distribution is a critical component of logistics systems, especially in the food industry where perishable products such as frozen chicken require strict temperature control and timely delivery. CV. XYZ, a frozen chicken distributor in Batam, encounters several operational challenges, including high transportation costs, limited cold chain infrastructure, and inefficient allocation of distribution routes. These issues not only increase operational expenses but also pose risks to product quality and delivery reliability. Therefore, an effective distribution strategy is required to ensure cost efficiency and service performance. This study aims to identify the most efficient transportation method to minimize distribution costs by applying three initial solution approaches: North West Corner Rule (NWCR), Least Cost (LC), and Vogel's Approximation Method (VAM). The solutions obtained from each method were further evaluated using the Stepping Stone method to test their optimality. This research adopts a quantitative approach using a mathematical transportation model, with data collected through interviews and direct field observations. The results show that the VAM method produces the lowest initial distribution cost of Rp 57,062,000, compared to Rp 60,022,000 for the LC method and Rp 63,916,000 for the NWCR method. After optimality testing, only the VAM solution remained unchanged, indicating that it had already reached optimality. Thus, VAM is recommended as the most effective method for optimizing frozen chicken distribution costs at CV. XYZ Batam.

***Keywords*:** *Distribution, North West Corner Rule, Least Cost, Vogel's Approximation Method, Stepping Stone*

1. INTRODUCTION

Distribution is an important part of the logistics system that plays a direct role in ensuring the smooth delivery of goods from producers to consumers (Siregar and Rivai, 2019).In the food industry, especially for perishable frozen chicken products, special handling at low temperatures is required. Therefore, proper shipping route planning and transportation allocation are essential to maintain product quality. Where distribution allocation can be done using the Northwest Corner Rule (NWCR), Least Cost, Vogel's Approximation Method (VAM), and Stepping Stone methods to obtain the lowest distribution cost solution, and to formulate a strategy for improving the distribution of frozen chicken products at CV. XYZ in Batam based on mathematical and quantitative approaches.

Batam City is one of Indonesia's economic growth centers, experiencing rapid development, particularly in the industrial and trade sectors. As a region bordering

Singapore and Malaysia, and being one of the strategic areas in the Malacca Strait, Batam has great logistical potential to support the distribution of various types of commodities, including food products. However, as market demand for food commodities such as frozen chicken increases, various challenges arise in distribution management. The main problems faced are the high cost of inter-regional transportation caused by the distance of distribution from production centers to Batam, the limited supporting logistics infrastructure such as cold storage facilities, ports, and refrigerated vehicles, and the suboptimal selection of distribution routes that considers cost and time optimization.

Various methods for solving distribution problems have been developed in the field of transportation problems using a quantitative approach. The Northwest Corner Rule (NWCR), Least Cost Method, and Vogel's Approximation Method (VAM) are widely used techniques for obtaining initial solutions in the allocation of goods distribution (Akter et al., n.d.). After the initial solution is obtained, the evaluation process continues with the Stepping Stone Method because the three methods only produce a feasible initial solution, not necessarily an optimal one. Stepping Stone serves to test whether there is still a possibility of reducing distribution costs by diverting allocation thru specific routes on the distribution table (Handayani et al., 2020). Research by Shaikh et al. (2021) highlights the superiority of VAM over the NWCR method in terms of initial allocation effectiveness. Meanwhile, a study by Olaosebikan (2022) compared the three methods and showed that the Least Cost method was able to provide results quite close to optimal compared to other classical approaches.

However, the majority of studies testing these methods have focused more on the distribution of non-food products or those that do not require strict temperature and time management. Meanwhile, in the case of frozen chicken product distribution, which requires speed and route certainty, the combination of these research methods has not been extensively studied systematically. Although numerous studies have applied transportation methods such as NWCR, LC, and VAM in various distribution contexts, most of them focus on non-perishable goods or general logistics systems without strict temperature and time constraints. In contrast, frozen food distribution requires more precise route planning due to its sensitivity to delays and environmental conditions. Previous studies have also rarely compared these methods simultaneously within a real case study of a medium-scale frozen food distributor.

Therefore, this study fills the research gap by systematically comparing NWCR, LC, and VAM methods combined with Stepping Stone optimization in the specific context of frozen chicken distribution. This research positions itself as an applied optimization study that integrates classical transportation methods with real operational constraints in cold-chain logistics, particularly within CV XYZ Batam.

Based on this context, the main issues examined in this journal are: how to apply and compare the results of transportation cost calculations using Vogel's Approximation Method (VAM), Least Cost Method (LC), and North West Corner Rule (NWCR), and what the results of each method are after optimization testing using the Stepping Stone method to determine the most optimal distribution. Assuming the transportation cost of 1kg of chicken from Jakarta to BFC, Pasar Jodoh, and Pasar Tiban Center is Rp. 1,800, plus employe wages of Rp. 20,000/day, and plus gasoline costs to BFC of Rp. 2,400, to Pasar Jodoh of Rp. 6,300, and to Pasar Tiban of Rp. 12,600 per delivery. All these assumptions are based on 3 factors: monthly employe wages, calculated to determine daily employe wages per delivery, gasoline costs based

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on the delivery route distance from CV. XYZ to each destination, and distribution costs from each source to CV. XYZ for 1 kilo of frozen chicken.

Therefore, the purpose of this article is to determine the most efficient distribution method for minimizing the transportation costs of frozen chicken from CV. XYZ, considering several methods used in transportation problems, namely Vogel's Approximation Method (VAM), Least Cost Method (LC), and North West Corner Rule (NWCR), and then testing them using the Stepping Stone method.

2. METHODOLOGY

2.1 Research Design

This study applies a quantitative approach using a mathematical transportation model to solve the distribution cost problem of frozen chicken products at CV Gading Gemilang Sukses. The research focuses on determining the most efficient distribution method by comparing three initial solution methods, namely North West Corner Rule (NWCR), Least Cost (LC), and Vogel's Approximation Method (VAM), followed by optimality testing using the Stepping Stone method. The research process was conducted systematically, starting from problem identification, data collection, data processing using transportation methods, and ending with result evaluation and comparison of distribution costs obtained from each method.

2.2 Data Collection

Data collection in this study was carried out using two methods, namely:

2.2.1 Interviews

Interviews were conducted face-to-face, asking questions directly to employes of CV. XYZ related to the necessary data for the research, including transportation costs for purchasing and delivering frozen chicken and labor costs.

2.2.2 Observation

Observation is a data collection method that involves direct observation and gathering necessary field data related to frozen chicken distribution research, such as tracking the weight of frozen chicken distribution and calculating the cost of frozen chicken distribution.

2.3 Data Processing

Data processing is a stage of research conducted to obtain a solution to problems occurring in the field. The initial stage of data processing is determining an initial solution based on supply data from CV. XYZ and demand from CV. XYZ by comparing the solutions provided using the Vogel's Approximation Method (VAM), North West Corner Rule (NWCR), and Least Cost methods. After obtaining a feasible initial solution, the next step is to test the optimization of the initial solution obtained using the Stepping Stone method.

2.3.1 North-West Corner Rule (NWCR)

The NWCR method is a method for determining delivery routes that starts with allocation, beginning from the top-left corner (initial cell) (Kanthi and Kristanto, 2020). The initial cell allocation depends on the needs and constraints that arise. NWCR has an iterative procedure commonly used to find a feasible basic solution to a problem by considering costs (Hasil et al., 2020).

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2.3.2 Least Cost (LC)

The Least Cost (LC) method is an optimization of transportation by prioritizing the route with the lowest cost (Rinaldi et al., 2021). LC finds the cell with the lowest cost across the entire matrix and makes the maximum possible assignment, which is the minimum demand and supply value for a specific selected cell (Prasad and Singh, 2020).

2.3.3 Vogel's Approximation Method (VAM)

The VAM method is a method related to finding the optimal solution by considering the relationship between price indices. This method always compares the two lowest price indices in both columns and rows (Hlatká et al., 2017). The procedure for using VAM is to calculate the difference between two cells with the smallest cost in each row and each column; determine the row or column resulting from the first step with the largest difference. If there is more than one, choose one; place as many items as possible into the cell at the lowest cost in the selected row or column; and repeat the initial step until all requests or supplies are exhausted (Handayani et al., 2020; Sahito, 2021).

2.3.4 Transportation Method Testing with Stepping Stone

Optimalization testing of the transportation method using the Stepping Stone method. This method produces a feasible solution regarding operational costs in transportation (Kanthi and Kristanto, 2020). The rule in the stepping stone method is that the number of shipping routes occupying a cell is equal to the number of rows plus the number of columns minus one (Anwar Septiana et al., 2020).To determine whether the allocation of each cell is optimal or not, an optimality evaluation is needed by evaluating the empty cells and sending units into them to see if the cost will increase or decrease (Dimasuharto et al., 2021).

3. RESULTS AND DISCUSSION

3.1 Data Collection

The results of the transportation cost calculation performed conventionally from the starting point of waste collection to the waste collection point based on the route with transportation costs. Assuming the transportation cost of 1kg of chicken from Jakarta to BFC, Pasar Jodoh, and Pasar Tiban Center is Rp.1,800, plus employe wages of Rp.20,000/day, and plus gasoline costs to BFC of Rp.2,400, to Pasar Jodoh of Rp.6,300, and to Pasar Tiban of Rp.12,600 per delivery. All these assumptions are based on 3 factors: monthly employe wages, calculated to determine daily employe wages per delivery; gasoline costs based on the delivery route distance from CV. XYZ to each destination; and distribution costs from each source to CV. XYZ for 1kg of frozen chicken. Table 1 is frozen chiscken distribution costs, Table 2 is frozen chicken transportation capacity, and Table 3 is frozen chicken demand.

Table 1 Frozen Chicken Distribution Costs

Source	Destination		
	BFC	Pasar Jodoh	Pasar Tiban Center
Jakarta	112.4k	170.4k	112.6k
Medan	50.4k	152.4k	116.6k
Bandung	70.4k	138.4kk	96.6k

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Table 2 Frozen Chicken Transportation Capacity

Jakarta	Medan	Jawa
180	170	140

Table 3 Frozen Chicken Demand

BFC	Pasar Jodoh	Pasar Tiban Center
100	240	150

3.2 Data Processing

3.2.1 North-West Corner Rule (NWCR)

Table 4 shows the calculation of the initial cost for the distribution of frozen chicken products at CV. XYZ using the NWCR method.

Table 4 Transportation Table Using the NWCR Method

Source	Destination			*Supply*
	BFC	Pasar Jodoh	Pasar tiban Center	
Jakarta	112.4k 100	170.3k 80	112.6k	180
Medan	50.4k	152.3k 160	116.6k 10	170
Jawa	70.4k	138.3k	96.6k 140	140
Demand	100	240	150	

The initial solution for transportation costs using the NWCR method is as follows: Z = (100 × 112,400) + (80 × 170,300) + (160 × 152,300) + (10 × 116,600) + (140 × 96,600) = Rp 63,916,000.

3.2.2 Least Cost (LC)

Table 5 is the cost calculation for the initial frozen chicken product distribution solution at CV. XYZ using the Least Cost method.

Table 5 Transportation Table Using the Least Cost

Source	Destination			*Supply*
	BFC	Pasar Jodoh	Pasar tiban Center	
Jakarta	112.4k	170.3k 180	112.6k	180
Medan	50.4k 100	152.3k 60	116.6k 10	170
Jawa	70.4k	138.3k	96.6k 140	140
Demand	100	240	150	

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The initial solution for transportation costs using the Least Cost (LC) method is as follows: Z = (100 × 50,400) + (180 × 170,300) + (60 × 152,300) + (10 × 116,600) + (140 × 96,600) = Rp 60,022,000.

3.2.3 Vogel's Approximation Method (VAM)

Table 6 is the cost calculation for the initial frozen chicken product distribution solution at CV. XYZ using the VAM method.

Table 6 Transportation Table Using the VAM

Source	Destination			*Supply*
	BFC	Pasar Jodoh	Pasar tiban Center	
Jakarta	112.4k	170.3k 30	112.6k 150	180
Medan	50.4k 100	152.3k 70	116.6k	170
Jawa	70.4k	138.3k 140	96.6k	140
Demand	100	240	150	

The initial solution for transportation costs using the VAM method is as follows: Z = (100 × 50,400) + (30 × 170,300) + (70 × 152,300) + (140 × 138,300) + (150 × 112,600) = Rp 57,062,000.

3.2.4 Transportation Method Testing with Stepping Stone

3.2.4.1 Optimal Testing of NWCR Results with Stepping Stone

The initial solution obtained from the NWCR method was then optimized using the Stepping Stone method. In the initial testing and the first iteration, there were still negative values, indicating that the solution obtained was not yet optimal. Therefore, a second iteration was performed, and the second iteration yielded an optimal solution. Table 7 shows the Stepping Stone and NWCR Methods after finished the testing for the 2nd iteration.

Table 7 Result of 2nd Iteration using Stepping Stone for NWCR

Source	Destination			*Supply*
	BFC (X)	Pasar Jodoh (Y)	Pasar Tiban Center (Z)	
Jakarta (A)	112.4k 20	170.3k 150	112.6k 10	180
Medan (B)	50.4k 80	152.3k 90	116.6k	170
Jawa (C)	70.4k	138.3k	96.6k 140	140
Demand	100	240	150	

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In Table 7, there are symbols A, B, C and X, Y, Z, which are auxiliary symbols in the calculation process. A, B, and C are symbols for distribution sources, while X, Y, and Z are symbols for distribution destinations. From the table, there are 3 coordinates that need to be tested: coordinate BZ (Medan-Pasar Tiban Center), coordinate CX (Jawa-BFC), and coordinate CY (Jawa-Pasar Jodoh).

BZ = 116.600−112.600+112.400−50.400+152.300 =218.300

CX = 70.400−96.600 +112.600−112.400+50.400 = 24.400

CY = 138.300−96.600 +112.600−170.300 +152.300 = 136.300

In the calculation above, it can be seen that all values are already positive, so the solution is optimal. Transportation Costs (in thousands) using the stepping stone and NWCR methods at CV XYZ, applying the transportation model, are as follows: Z = (20 × 112,400) + (150 × 170,300) + (10 × 112,600) + (80 × 50,400) + (90 × 152,300) + (140 × 96,600) = Rp 60,182,000.

3.2.4.2 Optimal Testing of Least Cost Results with Stepping Stone

The initial solution obtained from the Least Cost method was then optimized using the Stepping Stone method. In the initial testing and the first iteration, there were still negatives, so the solution obtained was not yet optimal. Therefore, a second iteration was performed, and in the second iteration, an optimal solution was obtained. Table 8 shows the Stepping Stone and Least Cost Methods after finished the testing for the 2nd iteration.

Table 8 Result of 2nd Iteration using Stepping Stone for Least Cost

Source	Destination			*Supply*
	BFC (X)	Pasar Jodoh (Y)	Pasar Tiban Center (Z)	
Jakarta (A)	112.4k	170.3k 160	112.6k 20	180
Medan (B)	50.4k 100	152.3k 70	116.6k	170
Jawa (C)	70.4k	138.3k 10	96.6k 130	140
Demand	100	240	150	

In Table 8, there are symbols A, B, C and X, Y, Z, which are auxiliary symbols in the calculation process. A, B, and C are symbols for distribution sources, while X, Y, and Z are symbols for distribution destinations. From the table, there are 3 coordinates that need to be tested: coordinate AX (Jakarta-BFC), coordinate AZ (Medan-Pasar Tiban Center), and coordinate CX (Java-BFC).

AX = 112,400 - 50,400 + 152,300 - 170,300 = 44,000

BZ = 116,600 - 112,600 + 170,300 - 152,300 = 22,000

CX = 70,400 - 138,300 + 152,300 - 50,400 = 34,000

Since all values are positive, the solution is already optimal. Transportation Costs (in thousands) using the stepping stone and Least Cost methods at CV. XYZ, applying the transportation model, are as follows: Z = (100 × 50,400) + (160 ×

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170,300) + (70 × 152,300) + (10 × 138,300) + (20 × 112,600) + (130 × 96,600) = Rp 59,646,000.

3.2.4.3 Optimal Testing of Vogel's Approximation Method Results with Stepping Stone

The initial solution obtained from the VAM method was then optimized using the Stepping Stone method. The VAM method only performed one test and obtained an optimal solution. The following is the VAM test using the Stepping Stone method. Table 9 shows the Stepping Stone and VAM Methods after finished the testing for the 2nd iteration.

Table 9 Result of 2nd Iteration using Stepping Stone for VAM

Source	Destination			*Supply*
	BFC (X)	Pasar Jodoh (Y)	Pasar Tiban Center (Z)	
Jakarta (A)	112.4k	170.3k 30	112.6k 150	180
Medan (B)	50.4k 100	152.3k 70	116.6k	170
Jawa (C)	70.4k	138.3k 140	96.6k	140
Demand	100	240	150	

In the Table 9, there are symbols A, B, C and X, Y, Z, which are auxiliary symbols in the calculation process. A, B, and C are symbols for distribution sources, while X, Y, and Z are symbols for distribution destinations. From the table, there are 4 coordinates that need to be tested: AX (Jakarta-BFC), BZ (Medan-Pasar Tiban Center), CX (Java-BFC), and CY (Java-Pasar Jodoh).

AX = 112.400−50.400 +152.300−170.300 = 44.000

BZ = 116.600 −112.600 +170.300−152.300 = 22.000

CX = 70.400−138.300 +152.300 −50.400 = 34.000

CY = 96.600 −112.600+170.300−138.300 = 16.000

Since all values are positive, the solution is already optimal. Transportation Costs (in thousands) using the stepping stone and VAM methods at CV. XYZ, applying the transportation model, are as follows: Z = (30 × 170,300) + (150 × 112,600) + (100 × 50,400) + (70 × 152,300) + (140 × 138,300) = Rp57,062,000.

3.3 Discussion

Based on the results of calculating the distribution of frozen chicken products from three main sources, namely Jakarta, Malang, and Java, to three destinations, namely BFC, Pasar Jodoh, and Pasar Tiban Center, an analysis was conducted using three initial solution construction methods: Vogel's Approximation Method (VAM), Least Cost Method (LC), and North West Corner Rule (NWCR). From the initial calculations, it was found that the total distribution cost using the VAM method was Rp57,062,000, LC was Rp60,022,000, and NWCR was Rp63,916,000. This result shows that the VAM method provides the most cost-effective initial solution compared to the other two methods.

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Next, an optimization test was conducted using the Stepping Stone method to evaluate whether each initial solution could be optimized. The results of the stepping stone test showed that the solution from the NWCR method experienced a cost decrease to Rp 60,128,000, LC to Rp 59,646,000, while the VAM solution remained at Rp 57,062,000, meaning that the initial VAM solution was optimal from the start and could not be improved further. This reinforces the superiority of the VAM method, not only as an initial solution method but also as a method that yields the most optimal results even after being tested with an optimization method, namely the stepping stone method.

Thus, the distribution of frozen chicken by CV. XYZ, using the VAM method, proved to be the most optimal in reducing total distribution costs. The LC and NWCR methods can still be used as alternatives, but both require further optimization processes to achieve near-optimal results.

4. CONCLUSION

Based on the analysis conducted using three transportation methods, namely North West Corner Rule (NWCR), Least Cost (LC), and Vogel's Approximation Method (VAM), it can be concluded that VAM provides the most optimal solution for minimizing the distribution costs of frozen chicken at CV Gading Gemilang Sukses. The initial calculation results show that VAM produces the lowest total transportation cost of Rp 57,062,000, compared to Rp 60,022,000 using the LC method and Rp 63,916,000 using the NWCR method. Furthermore, the optimality test using the Stepping Stone method confirms that the VAM solution does not experience any change, indicating that it has already reached an optimal condition from the initial stage. In contrast, the NWCR and LC methods require further iterations to achieve near-optimal results. Therefore, VAM is considered the most efficient and reliable method for solving transportation problems in the distribution of frozen chicken products in this study.

However, this study has several limitations, particularly the use of static data for supply, demand, and transportation costs, which may not fully represent real-world conditions that are dynamic and uncertain. Additionally, factors such as delivery time, traffic conditions, and variability in fuel prices were not included in the analysis. Therefore, future research is recommended to incorporate dynamic or stochastic models, as well as multi-objective optimization approaches that consider not only cost but also delivery time and product quality. The integration of decision-support systems or optimization software is also suggested to enhance the practical implementation of distribution planning in cold-chain logistics.

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