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Optimization of Aqua Gallon Water Distribution Cost at Mega Mas Water Depot by VAM and MODI

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Abstract. This study aims to obtain optimal distribution costs for selling gallons of water at the Air Mega Mas Depot, Sekaran. The data analysis method used is the transportation method, using the VAM (Vogel's Approximation Method) method for the initial solution and the optimal test using the MODI (Modified Distribution) method. Air Mega Mas Depot is faced with the problem of increasing marketing costs due to the lack of regular distribution patterns from the source to the marketing destination, so the company is trying to optimize the transportation costs incurred. The distribution of gallon water products at the Air Mega Mas Depot using transportation gets optimal results. The costs incurred by the Air Mega Mas Depot to distribute gallons of water for 2 months (March-April) are IDR 2.520.000, while for the optimal calculation results for the distribution of gallons of water, a cost of IDR 2.435.000 is obtained. Based on this analysis, Air Mega Mas Depot can optimize distribution costs for the March-April period of IDR 85.000.

Keywords: Transportation optimizing, VAM, MODI, cost optimization

1 Introduction

Distribution is one of the crucial aspects of a company, so distribution management must be done as well as possible because it will impact distribution costs [2]. Product distribution depends on the existing factory capacity [2], especially if the company sends products to multiple destinations. Each company will try to form an intermediary arrangement or structure to achieve company goals. One of the company's goals is to efficiently deliver products to consumers' hands [2].

Transportation problems often arise in everyday life and are a separate family of linear programming problems. Transport modeling (transportation modeling) is the most effective method for optimizing the cost of shipping goods from several sources to several destinations [1]. The transportation method is used to solve optimization problems resulting in minimum total transportation costs by optimally managing the distribution of products from the place of origin (capacity) to the destination (demand). Product distribution allocation is managed as optimally as possible because transportation costs from the place of origin to the destination have different costs. Basically, every company engaged in any field has the same goal: to get the maximum possible profit. Therefore, the company strives to ensure growth, smoothness, and survival both in the long and short term.

Air Mega Mas Depot is an MSME located in Sekaran, Gunungpati, Semarang, Central Java, Indonesia. This MSME is engaged in the business sector which has been distributing gallons of water since 2009 until now. This business distributes 19-liter gallons of Aqua brand water in the area around the Semarang State

University campus, where the mobility of the population is not only residents but also dominated by overseas students resulting in a relatively high increase in demand.

The case of transportation arises when a company tries to determine the method of delivery (distribution) of a type of goods (item) from several sources (locations of supply) to several destinations (locations of demand) that can minimize costs. Air Mega Mas Depot is faced with the problem of increasing marketing costs due to irregular distribution patterns from the source to the marketing destination, so the company tries to optimize the transportation costs incurred so that all the higher consumer needs can be met.

Based on the above conditions, this research was conducted to identify and assess distribution activities carried out by the company, distribution costs incurred by the company, data analysis using the transportation method, a feasible initial solution using Vogel's Approximation Method (VAM), and Modified Distribution (MODI) to determine the optimal solution cost for gallon water distribution costs, so that the results of this study can be recommended to companies to reduce distribution costs.

2 Method

This research was carried out in several stages: the literature study stage, problem identification and formulation, data collection, and data analysis stage. Library studies is a study of relevant literature sources which will later be used to collect data and information needed in research [6]. The literature study begins with collecting library sources as reference books.

2.1 Problem Identification and Formulation Stage

At this stage, the researcher determines the research topic and the problems studied based on the activities and conditions at the Mega Mas Air Depot. Then identifying the problems that occur in the company will show the purpose or direction of the research conducted in connection with the issues raised, namely knowing the optimal cost of distributing gallons of Aqua brand water. After that, a method will be proposed to help solve the existing problem. The research was conducted at the Air Mega Mas Depot in Sekaran, Gunungpati, Semarang City. The research is focused on the problem of distributing gallons of Aqua brand water.

2.2 Data Collection Stage

At this stage, there are several methods used to obtain data in this study, including:

1. Observation Method
   Observations are made directly at the company to find out all the company's activities to get an overview of the company [7].
2. Interview Method
   Submitting several questions verbally addressed to the company's business owners to obtain the data information needed in this research [8].
3. Documentation Method
   Retrieving secondary data regarding data related to the issues to be discussed, namely sales area data, source capacity data, shipping cost data, and sales data obtained from Depot Air Mega Mas monthly reports [9].

2.3 Data Analysis

Data analysis is carried out at this stage, a quantitative calculation process using a predetermined formula according to the existing problem. The steps for solving them are as follows: (1) determine the initial feasible solution and (2) carry out an optimality test [10].

2.4 Determine the Initial Feasible Solution

The initial feasible solution is to find an allocation of the possible distribution of goods from each source to each destination. This study used the initial feasible solution using the VAM (Vogel's Approximation Method) method [11].

2.5 The VAM method (Vogel's Approximation Method)

The VAM (Vogel's Approximation Method) method determines the initial feasible solution to the transportation problem [4]. Vogel's Approximation Method (VAM) does not guarantee an optimum solution, but this method often produces optimum solutions and solutions that are close to optimal [12]. The algorithm for this method [13] is as follows:

1. Arrange needs, the capacity of each source, and transportation costs into a matrix.
2. Look for the negligible difference with the bit of cost for each column or row.
3. Choose the most significant cost difference and allocate as much product as possible to the cell with the most negligible cost.
4. Omits rows or columns that have been filled in because they are impossible to fill in again.
5. Redefine the difference (difference) costs in step 2 for columns and rows that have not been filled. Repeat steps 3 to 5 until all columns and rows are allocated.
6. After filling in all, then calculate the overall transportation costs.
7. Perform Optimality Test

2.6 Perform Optimality Test

After obtaining the initial feasible solution, the next step is to perform an optimality test. This step is a model completion step to obtain a minimal solution. This study used the MODI (Modified Distribution) method to use the optimality test.

2.7 MODI (Modified Distribution)

The algorithm for the MODI (Modified Distribution) Method [3] can be written as follows:

1. Determine the initial feasible table using the VAM method.
2. Add variables and Kk in each row and column.
3. Look for the Rr and Kk values for each base cell by using the formula: Rr+Kk=Crk by separating one of the Rr or Kk values equal to zero.
4. Calculating all non-base cell values using the Crk–Rr–Kk formula.
5. Determines which cell will enter the base by selecting the non-base cell value with the most significant negative value. Then create a closed path to determine the cells that will come out by selecting the smallest number of units from the cells with a negative sign.
6. The optimum table is reached if the non-base cells all have a value of 0 or negative.
7. If the table is not optimal, return to step 2 to find the optimum table.

3 Results And Discussion

3.1 Transportation Method Analysis

Optimizing transportation performance at the Air Mega Mas Depot uses a transportation method that aims to save on the total cost of transportation or distribution from the place of origin to the destination. Air Mega Mas Depot has three employees who must send gallons to 4 places, with the number of gallons for each place being different.

Delivery of gallons of water from Depot Air Mega Mas to the destination area will incur transportation costs for the 2nd edition of March-April 2023. The following data supply, demand, and transportation costs for Depot Air Mega Mas shipments are presented in tabular form as follows:$Rp2.520.000$

Table 1. Data Supply, Demand, Transportation Costs

Place	Objective				Capacity
Origin	T1	T2	T3	T4	
A1	3,000	7,000	11,000	12,000	65
A2	9,000	10,000	18,000	15,000	80
A3	10,000	12,000	21,000	18,000	90
Request	86	77	42	30	235

The data obtained will be further analyzed using the VAM (Vogel Approximation Method) and MODI (Modified Distribution) methods to achieve optimum transportation costs.

3.2 VAM Method Analysis ((Vogel Approximation Method)

Analysis of the VAM method is used to determine the initial feasible solution to the transportation problem with supply, demand, and transportation cost data. The initial feasible solution is obtained using the VAM method as follows:

Table 2. Initial Feasible Solution

Place	Objective				Capacity	BB
Origin	T1	T2	T3	T4		
A1	-	-	-	-	0	-
	23		42			
A2	-	-	-	-	0	-
		50		30		
A3	-	-	-	-	0	-
	63	27				
Request	0	0	0	0	235	
BK	-	-	-	-		

Based on the table above is obtained from the calculation of values based on these calculations, and it can be seen that the minimum cost of transportation for the Air Mega Mas Depot is not the optimal value for transportation costs, so an analysis of the final solution must be carried out using the MODI (Modified Distribution) method.$Zmin = (23 \times 3000) + (42 \times 11000) + (50 \times 10000) + (30 \times 15000) + (63 \times 10000) + (27 \times 12000) = 2.435.000.\ Rp.\ 2.435.000.$

3.3 MODI (Modified Distribution) Method Analysis

The MODI method analysis is carried out after the initial feasible solution is obtained to obtain the optimal transportation cost. Before being analyzed using the MODI method, an optimal test was carried out first, which is presented in Table 3 as follows:

Table 3. Optimal Table

Place Origin	Objective T1	T2	T3	T4	Capacity
A1	3,000	7,000	11,000	12,000	65
A2	- 23 9,000	+ 10,000	42 18,000	15,000	80
A3	+ 10,000 + 63-	-50 12,000 +27 -	21,000	30 18,000	90
Request	86	77	42	30	235

Based on the table above, there are 2 loops, namely, the first loop occurs in a cell, while the second loop occurs in a cell. In the first loop, the Opportunity Cost (OC) is obtained, which means that the cost will increase if you add 1 unit of goods to the cell, while in the second loop, the Opportunity Cost (OC) is obtained, which means that the cost will increase if you add 1 unit of goods to the cell. So that the program can be said to be optimal with the Opportunity Cost (OC) in the empty cells obtained from the results of the MODI method analysis presented in Table 4.

Table 4. Opportunity Cost (OC)Blank Cell

No.	Blank Cell	Calculation	OC
1	(1,2)	(0+5000)-7000	-2000
2	(1,4)	(0+10000)-12000	-2000
3	(2,1)	(5000+3000)-9000	-1000
4	(2,3)	(5000+11000)-18000	-2000
5	(3,3)	(7000+11000)-21000	-3000
6	(3,4)	(7000+10000)-18000	-1000

Opportunity Cost (OC*)* in the empty cells in the table above has no positive values, so the program is optimal. The optimal delivery of gallons of water*Rp* obtains the minimum cost of transportation at the Air Mega Mas Depot. 2.435.000

$$X_{ij} = \begin{pmatrix} 23 & 0 & 42 & 0 \\ 0 & 50 & 0 & 30 \\ 63 & 27 & 0 & 0 \end{pmatrix} \quad (1)$$

In the same case, solving the problem by looping one by one has the same final result, which is presented in Table 5, 6, 7 and 8 as follows:

Table 5. Optimal Table (Looping 1)

Place Origin	Objective T1	T2	T3	T4	Capacity
A1	3,000	7,000	11,000	12,000	65
	- 23	+	42		
A2	9,000	10,000	18,000	15,000	80
	+	-50		30	
A3	10,000	12,000	21,000	18,000	90
	+ 63-	+27 -			
Request	86	77	42	30	235

Based on the table above, the first loop occurs inside the cell. In the first loop, Opportunity Cost (OC) is obtained, which means that the cost will increase if you add 1 unit of goods to the cell. So that the program can be said to be optimal with the Opportunity Cost (OC) in empty cells obtained from the results of the MODI method analysis presented in Table 6.

Table 6. Opportunity Cost (OC)Blank Cell (Looping 1)

No.	Blank Cell	Calculation	OC
1	(1,2)	(0+5000)-7000	-2000
2	(1,4)	(0+10000)-12000	-2000
3	(2,1)	(5000+3000)-9000	-1000
4	(2,3)	(5000+11000)-18000	-2000
5	(3,3)	(7000+11000)-21000	-3000
6	(3,4)	(7000+10000)-18000	-1000

Opportunity Cost (OC*)* in the empty cells in the table above has no positive values, so the program is optimal. The optimal delivery of gallons of water*Rp* obtains the minimum cost of transportation at the Air Mega Mas Depot. 2.435.000

$$X_{ij} = \begin{pmatrix} 23 & 0 & 42 & 0 \\ 0 & 50 & 0 & 30 \\ 63 & 27 & 0 & 0 \end{pmatrix} \quad (2)$$

Table 7. Optimal Table (Looping 2)

Place Origin	Objective T1	T2	T3	T4	Capacity
A1	3,000	7,000	11,000	12,000	65
	- 23	+	42		
A2	9,000	10,000	18,000	15,000	80
	+	-50		30	
A3	10,000	12,000	21,000	18,000	90
	+ 63-	+27 -			
Request	86	77	42	30	235

Based on the table above, a second loop occurs in the cell. In the first loop, an Opportunity Cost (OC) is obtained, which means that the cost will increase if you add 1 unit of goods to the cell. In the second loop, an Opportunity Cost (OC) is obtained, which means that the cost will increase if you add 1 unit of goods to the cell. So that the program can be said to be optimal with the Opportunity Cost (OC) in empty cells obtained from the results of the MODI method analysis presented in Table 8.

Table 8. Opportunity Cost (OC)Blank Cell (Looping 2)

No.	Blank Cell	Calculation	OC
1	(1,2)	(0+5000)-7000	-2000
2	(1,4)	(0+10000)-12000	-2000
3	(2,1)	(5000+3000)-9000	-1000
4	(2,3)	(5000+11000)-18000	-2000
5	(3,3)	(7000+11000)-21000	-3000
6	(3,4)	(7000+10000)-18000	-1000

Opportunity Cost (OC*)* in the empty cells in the table above has no positive values, so the program is optimal. The optimal delivery of gallons of waterRp obtains the minimum cost of transportation at the Air Mega Mas Depot. 2.435.000

$$X_{ij} = \begin{pmatrix} 23 & 0 & 42 & 0 \\ 0 & 50 & 0 & 30 \\ 63 & 27 & 0 & 0 \end{pmatrix} \quad (3)$$

The form of analysis used in this study is to use the VAM (Vogel Approximation Method) method to determine the initial solution first, then find the final solution or optimize transportation costs with the MODI (Modified Distribution) method in two ways, namely looping one by one and two looping at once. So that optimal transportation costs are obtained, A1 employees send 23 gallons of water from Sekaran District (T1) and 42 gallons of water to Kalisegoro District (T3), while A2 employees send 50 gallons of water to Patemon District (T2), and 30 gallons of water to Ngijo District (T4), A3 employees send 63 gallons of water to Sekaran District (T1), and 27 to Patemon District (T2). That way, Mega Mas Water Depot can save initial transportation costs.

The results of this study following the research conducted [14], entitled "Application of the Transportation Method in Optimizing the Cost of Distribution of Poor Rice (RASKIN) at Perum Bulog Sub Divre Medan" which uses the VAM method for initial solutions and MODI for the final solution where minimum transportation costs are obtained resulting in cost savings. So, the results of this study show that using the VAM (Vogel Approximation Method) method as the initial solution and the MODI (Modified Distribution) method for the final solution can provide the optimum solution in minimizing transportation costs.

4 Conclusion

Distribution is one of the company's main activities to meet consumer needs, so it is important to pay attention to distribution costs to reduce costs. Mega Mas Water Depot delivers to several areas, including Sekaran, Patemon, Kalisegoro, and Ngijo. The distribution of gallons of water at Mega Mas Air Depot using transportation methods obtained optimal results. Total transportation costs for the initial solution using the VAM (Vogel's Approximation Method) method = Rp. 2,435,000 and optimal testing using MODI (Modified Distribution) is done by looping one by one or two looping at once obtained the same optimal result of Rp. 2,435,000 The cost incurred by Mega Mas Air Depot to distribute gallons of water for 2 months (March-April) Rp. 2,520,000 The calculation results of gallon distribution of water by transportation method are: IDR 2,435,000.

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