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OPTIMIZATION OF DELIVERY COSTS USING VOGEL'S APPROXIMATION METHOD (VAM) AND STEPPING STONE METHODE

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ABSTRACT

Distribution is the delivery of goods from source to destination. Transporting goods from source to destination requires transportation and distribution costs. Distributing goods requires cost optimization. This research optimizes costs using a transportation model. Optimization is an activity to get the best result under a given situation. The ultimate goal of these activities is to minimize effort or maximize results. The transportation model is a model used to regulate the distribution of sources that provide the same product to destinations that need it optimally. The transportation model can be completed in two stages, namely the initial solution using the Vogel's Aproximation Method (VAM) and the optimum solution using the Stepping Stone method. This study aims to optimize the cost of distribution of goods from source to destination at UD Yosarita. The results of the study using the Vogel's Aproximation Method (VAM) as the initial solution and the Stepping Stone method as the optimum solution in April 2019 were Rp.4,615,000, in May 2019 Rp.4,810,000, in June 2019 Rp. 4,910,000.

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1. INTRODUCTION :

Along with the current state of the business world, companies are faced with increasingly fierce competition. One of the important things that must be considered so that a company can survive is cost optimization (Wijaya, 2010).

Cost optimization needs to be applied to various company activities, and one of the things the company does is to optimize transportation costs. To solve these problems, a method is designed, namely the method of transportation. (Pranati, 2018).

The transportation method is a method used to regulate the distribution of sources that provide the same product to places that need it optimally. (Subagyo, 2000).

Transportation methods can help solve the problem of distributing products from sources to several destinations and reduce total distribution costs. Therefore, transportation methods are useful to help optimal distribution. To optimize distribution costs, the right method is needed so that products can be distributed to destinations with minimum costs. Solving transportation problems for the initial transportation solution can use

the North West Corner (NWC), Least Cost, Vogel's Approximation Method (VAM) method, while for the optimum solution you can use the Stepping Stone and Modified Distribution (MODI) methods. (Subagyo, 2000).

Research conducted by Ardhyani (2017). The problem discussed in this research is optimizing the transportation costs incurred, by selecting the optimum distribution channel using the transportation method. The methods used to optimize transportation costs are North West Corner Method, Least Cost Method, Vogel's Approximation Method, optimal test using Stepping Stone and Modified Diatribution methods. Other research was conducted by Pranati, Jaya, and Sahari, (2018). This study discusses the distribution for the allocation of ceramics at PT. Indah Building is still a problem in terms of minimizing costs. PT Indah Bangunan requires the right method to distribute products from agents to consumers, the author uses the Vogel's Approximation Method and the Stepping Stone method.

2. LITERATURE REVIEW :

Optimization

Optimization is an activity to get the best results under given conditions. The ultimate goal of these activities is to minimize effort or maximize results, because the effort required or the desired result can be expressed from the function as a decision variable (Karo, 2016).

Shipping cost optimization is based on the distance traveled by the vehicle from a source to a destination. Vehicles must travel from a source to a destination to meet demand. The distance traveled by the vehicle at each destination is different, therefore the most effective distance is needed to be taken by the vehicle from the source to each destination (Ardhyani, 2017).

The procedure for solving optimization problems is to model the problem into a mathematical model and then solve it using optimization methods. In this study will use a transportation model consisting of the VAM method (Vogel's Approximations Method) for the initial solution, the Stepping Stone method for the optimal solution (Yahya, 2014).

Transportation Issues

The transportation problem is a special form of linear programming problem that deals with allocating a single commodity from a number of sources to a number of destinations. Transportation problems can be found in industry, communication networks, scheduling, delivery services, and others. Based on the fact that different shipping routes will result in different shipping costs, the purpose of solving the transportation problem is to determine how many types of commodities must be sent from each source to a number of destinations so that the demand from each destination is met with a minimum total shipping cost (Taufiq, 2017).

Transport Model

Definition of Transportation Model

The transportation model is an image that is poured into the form of a mathematical model of a transportation case that can help us to think quickly and systematically about the case (Nirwansah, 2016).

The purpose of this model is to determine the amount that must be sent from each source to each destination in such a way that the total transportation cost is minimum. (Ali, 2013).

The transportation model can be formulated into the following:

Minimize : $Z = \sum_{i=1}^{n}\sum_{j=1}^{m} C_{ij} X_{ij}$

That meets the constraints,

$$\sum_{j=1}^{m} X_{ij} = K_i, \text{ for } i = 1,2,\ldots m$$

$$\sum_{i=1}^{n} X_{ij} = P_j, \text{ for } i = 1,2,\ldots n \text{ (Aminudin, 2005).}$$

Therefore :

X_{ij} = number of units of product or goods sent from source - i to destination - j

C_{ij} = price of goods transport per unit from source to - i destination - j

K_i = capacity from source to- i

P_j = the number of requests for goods from the th destination - j .

Transportation Troubleshooting Method :

The transportation problem solving for the initial transportation solution is the North West Corner (NWC), Least Cost, Vogel's Approximation Method (VAM), while for the optimum solution there are the Stepping Stone and Modified Distribution (MODI) methods.

1. Initial Solution

The initial solution is a solution to find a possible allocation of goods/products from the source to each destination. The method used to determine the initial solution is the Vogel's Approximation Method (VAM).
The steps of the Vogel's Approximation Method (VAM) method:

a. In each row and column calculate the difference of the two smallest cells.
b. Determine the row/column of the first step with the largest difference. If there is more than one, choose any.
c. In the selected row/column, enter the maximum number of items in the cell with the smallest cost. Delete rows/columns that are spent because of filling in the next calculation.
d. Repeat the steps above until all requests/supply are exhausted (Erwansyah, 2017).

2. Optimum Solution

The optimum solution is a step taken to test the initial solution that has been done previously. This is done because the initial solution does not guarantee that the total shipping costs have been minimum. A test case with the optimum solution is said to have been optimum if there is no longer a negative sign in the process of using the optimum solution method (Yahya, 2014). The method used in the optimum solution is the Stepping Stone method.
The Stepping Stone method is a method used to produce a feasible solution for transportation problems with operating costs (factory costs and transportation costs) so that they get relative shipping costs (Fahmi, 2017).
Stepping Stone method steps:

a. Select non base variable (box that has no capacity)
b. Determine the path of the Stepping Stone with a box that has the capacity to return to the non-basic variable.
c. Allocate as much as possible to the non-basic variables that produce the greatest cost reduction (the biggest negative), if there is no negative value then the solution is optimal.
d. Repeat the above steps until all non-basic variables have positive cost changes that indicate the optimal solution has been achieved (Subagyo, 2000).

3. A GENERAL DESCRIPTION OF THE COMPANY :

UD Yosarita is a company engaged in the manufacture of household furniture such as cabinets, beds, doors, windows, and so on. UD Yosarita was founded in 2013 by Mr. Khairudin. UD Yosarita is located in Pasar Baru Village, Porsea District, Toba Samosir Regency. Trading business is the activity of buying and reselling goods or services with the aim of making a profit. For this matter, UD Yosarita buys wood from several areas in Toba Samosir Regency and then processes it into household furniture in order to get selling value and profit.

The distribution of the production is sent to several places in Toba Samosir Regency, namely Balige, Lagu Boti, Porsea, Lumban Lobu, Indorayon, Sihiong, and Jangga. UD Yosarita has three vehicles to distribute the produce to every place, the types of vehicles owned by UD Yosarita are two pick ups and one medium pickup truck, the distribution is carried out 3-4 times a week.

UD Yosarita's household furniture manufacturing activities started from sawing, drying wood, basic material, construction, sanding, assembling, and finishing. In making household furniture, UD Yosarita uses meranti, teak, and jihor wood. There are 13 employees who work at UD Yosarita.

4. RESEARCH METHODS

This research was conducted at UD Yosarita, Pasar Baru Village, Porsea District, Toba Samosir Regency. The data collection technique used in this study was direct interviews with the head of UD Yosarita's handyman to Mr. Usman (interview guidelines). And collect data on delivery of goods, capacity from each warehouse, and product requests from each destination at UD Yosarita. The type of research used is quantitative research,

The variables studied in the preparation of this thesis are the cost of shipping goods from the source to the destination, the capacity of each warehouse, and the demand for products from each destination at UD Yosarita, Pasar Baru Village, Porsea District, Toba Samosir Regency.

The procedures for this research are as follows:

1. Start
   a. Study of literature
      This research begins with a literature study, namely collecting material as a reference from various sources such as articles, books, journals, papers, other literatures related to the Vogel's Approximation Method (VAM) method, and the Stepping Stone method.
   b. Field Observation
      This activity is carried out to synchronize the secondary data that has been obtained by conducting direct observations in the field to ensure the data that has been obtained is valid data.
2. Problem Identification
   The problem experienced in this research is how to optimize the cost of shipping goods using the Vogel's Approximation Method (VAM), and the Stepping Stone method.
3. Data Collection
   Data was collected by interviewing and documenting data to UD Yosarita.
4. Data Processing
   The steps in data processing are carried out, namely:
   a. Arrange the data into the form of a transportation table
   b. Calculating the cost of shipping goods using the Vogel's Approximation Method (VAM) method as the initial solution
   c. After knowing the initial solution using the Vogel's Approximation Method (VAM) method, then the optimum solution is sought using the Stepping Stone method.
5. Drawing Conclusion
   From data processing using the Vogel's Approximation Method (VAM), Stepping Stone method, shipping costs can be determined.

5. RESULTS AND DISCUSSION :

Research data

UD Yosarita is engaged in the manufacture of household furniture which is distributed to several places in Toba Samosir Regency, in distributing the results of its business UD Yosarita has a means of transportation in the form of pick ups. The data taken at UD Yosarita are the capacity of each warehouse, the demand for each destination from the warehouse, and the cost of distribution from the source to the destination. Trading business (UD) Yosarita has three warehouses in Toba Samosir Regency, namely in the Par-parean, Indorayon, and Balige areas. The following is a table of warehouse capacity at UD Yosarita for April, May and June 2019:

Table 4.1 Warehouse Capacity in April 2019

Warehouse	Capacity (unit)
A	43
B	30
C	34
Quantity	107

Source: UD Yosarita Pasar Baru Village, Porsea District, Toba Samosir Regency

Table 4.2 Warehouse Capacity in May 2019

Warehouse	capacity (unit)
A	44
B	35
C	32
Quantity	111

Source: UD Yosarita Pasar Baru Village, Porsea District, Toba Samosir Regency

Table 4.3 Warehouse Capacity in June 2019

warehouse	capacity (unit)
A	48
B	37
C	39
Quantity	124

Source: UD Yosarita Pasar Baru Village, Porsea District, Toba Samosir Regency

Information :
A = Par-parean
B = Indorayon
C = Balige

The distribution of UD Yosarita's products has destination areas, namely Lagu Boti, Narumonda, Porsea, Lumban Lobu, Sipitu-pitu, Dolok Nauli, Lumban Julu. The following table shows the distribution of UD Yosarita for April, May, and June 2019:

Table 4.4 Demand from Destinations in April 2019

Purpose,	Demand (unit),
D	19
E	7
F	11
G	23
H	14
I	28
J	5
Quantity	107

Source: UD Yosarita Pasar Baru Village, Porsea District, Toba Samosir Regency

Table 4.5 Demand from Destinations in June 2019

Purpose	Demand (Unit)
D	21
E	14
F	12
G	18
H	20
I	27
J	12
Quantity	124

Source: UD Yosarita Pasar Baru Village, Porsea District, Toba Samosir Regency

Information :
D = Lagu Boti
E = Narumonda
F = Porsea
G = Lumban Lobu
H = Sipitu-pitu
I = Dolok Nauli
J = Lumban Julu

Distribution costs can be seen in the following table:

Table 4.6 Distribution Costs from Source to Destination

To / From	D Rp/Unit	E Rp/Unit	F Rp/Unit	G Rp/Unit	H Rp/Unit	I Rp/Unit	J Rp/Unit
A	50	35	25	55	70	60	85
B	75	55	50	45	60	30	60
C	20	60	75	100	85	150	125

Source: UD Yosarita Pasar Baru Village, Porsea District, Toba Samosir Regency.
Description: distribution costs in thousands

The compilation of data into the transportation table for April, May and June 2019 can be seen in the following table :

Table 4.7 Transportation Table in April 2019

To / From	D	E	F	G	H	I	J	Capacity
A	50	35	25	55	70	60	85	43
B	75	55	50	45	60	30	60	30
C	20	60	75	100	85	150	125	34
Demand	19	7	11	23	14	28	5	107

Table 4.8 Transportation Table in May 2019

To / From	D	E	F	G	H	I	J	Capacity
A	50	35	25	55	70	60	85	44
B	75	55	50	45	60	30	60	35
C	20	60	75	100	85	150	125	32
Demand	16	11	14	21	17	24	8	111

Table 4.9 Transportation Table in June 2019

To / From	D	E	F	G	H	I	J	Capacity
A	50	35	25	55	70	60	85	48
B	75	55	50	45	60	30	60	37
C	20	60	75	100	85	150	125	39
Demand	21	14	12	18	20	27	12	124

Calculation with Transportation Method:
1. Initial solution using Vogel's Approximation Method (VAM)
The steps of the Vogel's Approximation Method (VAM) method:

a. In each row and column calculate the difference of the two smallest cells.
b. Determine the row/column of the first step with the largest difference. If there is more than one, choose any.
c. In the selected row/column, enter the maximum number of items in the cell with the smallest cost. Delete rows/columns that are spent because of filling in the next calculation.
d. Repeat the steps above until all requests/supply are exhausted (Erwansyah, 2017).

Here are the initial solutions for April, May and June 2019:

Table 4.10 Results of Initial Solutions for April 2019

To / From	D	E	F	G	H	I	J	Capacity
A	50	35 7	25 11	55 22	70	60	85 3	43
B	75	55	50	45	60	30 28	60 2	30
C	20 19	60	75	100 1	85 14	150	125	34
Demand	19	7	11	23	14	28	5	107

Based on the results of the initial solution using the Vogel's Aproximation Method (VAM) method in June 2019 it can be described that the distribution of household furniture can be carried out by UD Yosarita, namely:

1. Par-parean distributed 14 units to Narumonda, 12 units to Porsea, 18 units of Lumban Lobu, 2 units of Sipitu-pitu, and 2 units of Lumban Julu.
2. Indorayon distributed 27 units to Dolok Nauli, and 10 units to Lumban Julu.
3. Balige distributed 21 units to Lagu Boti, and 18 units to Sipitu-pitu

Z = 14(35,000) + 12(25,000) + 18(55,000) + 2(70,000) + 2(85,000) + 27(30,000) + 10(60,000) + 21(20,000) + 18(85,000)
Z = 4.910,000

Table 4.11 Results of Initial Solutions for May 2019

To / From	D	E	F	G	H	I	J	Capacity
A	50	35 11	25 14	55 18	70 1	60	85	44
B	75	55	50	45 3	60	30 24	60 8	35
C	20 16	60	75	100	85 16	150	125	32
Demand	16	11	14	21	17	24	8	111

Based on the results of the initial solution using the Vogel's Aproximation Method (VAM) method in June 2019 it can be described that the distribution of household furniture can be carried out by UD Yosarita, namely

1. Par-parean distributed 14 units to Narumonda, 12 units to Porsea, 18 units of Lumban Lobu, 2 units of Sipitu-pitu, and 2 units of Lumban Julu.
2. Indorayon distributed 27 units to Dolok Nauli, and 10 units to Lumban Julu.
3. Balige distributed 21 units to Lagu Boti, and 18 units to Sipitu-pitu

Z = 14(35,000) + 12(25,000) + 18(55,000) + 2(70,000) + 2(85,000) + 27(30,000) + 10(60,000) + 21(20,000) + 18(85,000)
Z = 4.910,000

4.12 Results of Initial Solutions for June 2019

To / From	D	E	F	G	H	I	J	Capacity
A	50	35 14	25 12	55 18	70 2	60	85 2	48
B	75	55	50	45	60	30 27	60 10	37

C	20 21	60	75	100	85 18	150	125	39
Demand	21	14	12	18	20	27	12	124

Based on the results of the initial solution using the Vogel's Aproximation Method (VAM) method in June 2019 it can be described that the distribution of household furniture can be carried out by UD Yosarita, namely:

1. Par-parean distributed 14 units to Narumonda, 12 units to Porsea, 18 units of Lumban Lobu, 2 units of Sipitu-pitu, and 2 units of Lumban Julu.
2. Indorayon distributed 27 units to Dolok Nauli, and 10 units to Lumban Julu.
3. Balige distributed 21 units to Lagu Boti, and 18 units to Sipitu-pitu

Z = 14(35,000) + 12(25,000) + 18(55,000) + 2(70,000) + 2(85,000) + 27(30,000) + 10(60,000) + 21(20,000) + 18(85,000)
Z = 4.910,000

2. Optimum Solution with Stepping Stone method.
The method used in the optimum solution is the Stepping Stone method.
Stepping Stone method steps:
a. Select non base variable (box that has no capacity)
b. Determine the path of the Stepping Stone with a box that has the capacity to return to the non-basic variable.
c. Allocate as much as possible to the non-basic variables that produce the greatest cost reduction (the biggest negative), if there is no negative value then the solution is optimal.
d. Repeat the above steps until all non-basic variables have positive cost changes that indicate the optimal solution has been achieved (Subagyo, 2000).

- Following The Optimum Solution with the Stepping Stone method for April 2019.
  The following non-basic variables will determine the path according to table 4.11:

$$C_{11} - C_{14} + C_{34} - C_{31} = 50 - 55 + 100 - 20 = 75$$
$$C_{15} - C_{14} + C_{34} - C_{35} = 70 - 55 + 100 - 85 = 30$$
$$C_{16} - C_{17} + C_{27} - C_{26} = 60 - 85 + 60 - 30 = 5$$
$$C_{21} - C_{31} + C_{34} - C_{14} + C_{17} - C_{27} = 75 - 20 + 100 - 55 + 85 - 60 = 125$$
$$C_{22} - C_{12} + C_{17} - C_{27} = 55 - 35 + 85 - 60 = 45$$
$$C_{23} - C_{13} + C_{17} - C_{27} = 50 - 25 + 85 - 60 = 50$$
$$C_{24} - C_{14} + C_{17} - C_{27} = 45 - 55 + 85 - 60 = 15$$
$$C_{25} - C_{35} + C_{34} - C_{14} + C_{27} - C_{17} = 60 - 85 + 100 - 55 + 85 - 60 = 45$$
$$C_{32} - C_{12} + C_{17} - C_{27} + C_{25} - C_{35} = 60 - 35 + 85 - 60 + 60 - 85 = 25$$
$$C_{33} - C_{13} + C_{14} - C_{34} = 75 - 25 + 55 - 100 = 5$$
$$C_{36} - C_{34} + C_{14} - C_{17} + C_{27} - C_{26} = 150 - 100 + 55 - 85 + 60 - 30 = 50$$

The optimization test in April 2019 using the Stepping Stone method by determining the Stepping Stone trajectory and changes in costs for each non-basic variable turned out to have no negative value (the largest cost reduction), then the completion of the initial solution was optimal with distribution costs:

Z = 7(35.000) + 11(25.000) + 22(55.000) + 3(85.000) + 28(30.000) + 2(60.000) + 19(20.000) + 1(100.000) + 14(85.000)

Z = 4.615.000

So, the minimum distribution cost incurred by UD Yosarita in April 2019 is Rp.4,615,000

- Following are the Optimum Solutions with the Stepping Stone method for the month of May 2019. The following non-basic variables will determine the path according to table 4.12

$$C_{11} - C_{15} + C_{35} - C_{31} = 50 - 70 + 85 - 20 = 45$$
$$C_{16} - C_{14} + C_{24} - C_{26} = 60 - 55 + 45 - 30 = 20$$
$$C_{17} - C_{14} + C_{24} - C_{27} = 85 - 55 + 45 - 60 = 15$$
$$C_{21} - C_{24} + C_{14} - C_{15} + C_{35} - C_{31} = 75 - 45 + 55 - 70 + 85 - 20 = 80$$
$$C_{22} - C_{12} + C_{14} - C_{24} = 55 - 35 + 55 - 45 = 30$$
$$C_{23} - C_{13} + C_{14} - C_{24} = 50 - 25 + 55 - 45 = 35$$
$$C_{25} - C_{15} + C_{14} - C_{24} = 60 - 70 + 55 - 45 = 0$$
$$C_{32} - C_{12} + C_{15} - C_{35} = 60 - 35 + 70 - 85 = 10$$
$$C_{33} - C_{13} + C_{15} - C_{35} = 75 - 25 + 70 - 85 = 35$$
$$C_{34} - C_{14} + C_{15} - C_{35} = 100 - 55 + 70 - 85 = 30$$

The optimization test in May 2019 using the Stepping Stone method by determining the Stepping Stone trajectory and changes in costs for each non-basic variable turned out to have no negative value (the largest cost reduction), then the completion of the initial solution was optimal with distribution costs:

Z = 11(35.000) + 14(25.000) + 18(55.000) + 1(70.000) + 3(45.000) + 24(30.000) + 8(60.000) + 16(20.000) + 16(85.000)

Z = 4.810.00

So, the minimum distribution cost incurred by UD Yosarita in May 2019 is Rp.4,810,000

- Following are the Optimum Solutions with the Stepping Stone method for the month of June 2019. The following non-basic variables will determine the path according to table 4.13

$$C_{11} - C_{31} + C_{35} - C_{15} = 50 - 20 + 85 - 70 = 45$$
$$C_{16} - C_{26} + C_{27} - C_{17} = 60 - 30 + 60 - 85 = 5$$
$$C_{21} - C_{31} + C_{35} - C_{15} + C_{17} - C_{27} = 75 - 20 + 85 - 70 + 85 - 60 = 95$$
$$C_{22} - C_{12} + C_{17} - C_{27} = 55 - 35 + 85 - 60 = 45$$
$$C_{23} - C_{13} + C_{17} - C_{27} = 50 - 25 + 85 - 60 = 50$$
$$C_{25} - C_{15} + C_{17} - C_{27} = 60 - 70 + 85 - 60 = 15$$
$$C_{32} - C_{12} + C_{15} - C_{35} = 60 - 35 + 70 - 85 = 10$$
$$C_{33} - C_{13} + C_{15} - C_{35} = 75 - 25 + 70 - 85 = 35$$
$$C_{34} - C_{14} + C_{15} - C_{35} = 100 - 55 + 70 - 85 = 30$$
$$C_{36} - C_{35} + C_{15} - C_{17} + C_{27} - C_{26} = 150 - 85 + 70 - 85 + 60 - 30 = 80$$
$$C_{37} - C_{35} + C_{15} - C_{27} = 120 - 85 + 70 - 85 = 25$$

The optimization test in June 2019 using the Stepping Stone method by determining the Stepping Stone trajectory and changing costs for each non-basic variable turned out to have no negative value (the largest cost reduction), then the completion of the initial solution was optimal with distribution costs:

Z = 14(35,000) + 12(25,000) + 18(55,000) + 2(70,000) + 2(85,000) + 27(30,000) + 10(60,000) + 21(20,000) + 18(85,000)
Z = 4.910,000

So, the minimum distribution cost issued by UD Yosarita in June 2019 is Rp.4.910.000

6. CONCLUSION:

From the results of the study, the problem was that the costs incurred for distributing products from the warehouse to their destination in April 2019 before using the Vogel's Aproximation Method (VAM) and the Stepping Stone method were Rp.5,190,000, while after using the Vogel's Aproximation Method. (VAM) and the Stepping Stone method of Rp.4,615,000, in May 2019 before using the Vogel's Aproximation Method (VAM) and the Stepping Stone method of Rp.5.425,000, while after using the Vogel's Aproximation Method (VAM) and Stepping Stone was Rp.4.810.000, in June 2019 before using the Vogel's Aproximation Method (VAM) and Stepping Stone method was Rp.5.510.000, while after using the Vogel's Aproximation Method (VAM) and the Stepping Stone method it was Rp. 4,910,000.

Distribution costs at UD Yosarita are more optimal using the Vogel's Aproximation Method (VAM) and the Stepping Stone method when compared to distribution costs before using the Vogel's Aproximation Method (VAM) and the Stepping Stone method.

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