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Optimization of Delivery Costs of PT. Citra Van Titipan Kilat Makassar by Using the Danzing Method and Total Opportunity Cost Matrix-Sum Approach

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Abstract:- Transportation is a very common problem for entrepreneurs, especially logistics entrepreneurs, PT Citra Van Titipan Kilat (TIKI) Makassar also faces the same problem. By using the danzing method (MODI), the minimum shipping cost of Rp 1,174,300 is obtained. By using the total opportunity cost matrix-sum approach (TOCM-SUM Approach) method, the minimum shipping cost is obtained at Rp 1,188,000. And the results of the comparison of the two methods, the danzing / modified distribution (MODI) method has the most optimal total delivery cost with a difference of Rp 13,700.

Keywords:- *Transportation Model.*

I. INTRODUCTION

Transportation problem is a problem that is very common in the general public, especially for those who are entrepreneurs, even one of the oldest linear applications of programming problems. Of course in a company always trying to find the right way or method to get the optimal point of this transportation problem, so that the costs incurred are not excessive or even result in losses for the company. [1]

PT Citra Van Titipan Kitat (TIKI) Makassar, is one of the companies that provides leading logistics services in Indonesia that has been serving the needs of package delivery since 1970. With decades of experience, TIKI has become a trusted partner for customers who need fast delivery services at affordable prices. Of course, to send goods quickly and at an affordable price, it is necessary to determine the distance between the station and the nearest recipient and the least cost (lower cost). [2]

Linear program is a branch of Mathematics which is one of the methods in finding the optimal solution, namely the maximum or minimum solution of a problem according to certain constraints. Transportation problem is one type of linear programming problem that deals with allocating from a number of sources to a number of destinations. The main problem is the difference in transportation costs per unit of goods from each source to several different destinations, so a transportation method is needed that can determine the distribution that will minimize the total cost of distribution and not exceed the source capacity and meet the demand of the destination. [3]

Therefore, in this thesis, we will apply the danzing method (modified distribution method (MODI)) with the total opportunity cost matrix-sum approach. Danzing method, also known as MODI method, is a method developed based on duality theory. This method can provide an optimal solution. [4] While the total opportunity cost matrix-sum approach method is a method created by Kirca and Satir in 1990. This method can produce feasible solutions to transportation problems. [5]

After applying the two methods, they will then be compared to find the most optimal solution to the cost of delivering goods to PT Citra Van Titipan Kilat (TIKI) Makassar.

II. LITERATURE REVIEW

- *Transportation Model*

- *General formula :*

Minimize

$$Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}$$

- *Constraints :*

$$\sum_{j=1}^{n} x_{ij} = a_i \, , i = 1, 2, \ldots, m$$

$$\sum_{i=1}^{m} x_{ij} = b_j \, , j = 1, 2, \ldots, n$$

$$x_{ij} \geq 0 \text{ , for all } i \text{ and } j$$

➢ *Danzing Method / Modified Distribution (MODI)*

The Modified Distribution (MODI) method is a method developed based on duality theory. The initial solution of this method is the other west corner (NWC) method, namely each row i of the table is known as a multiplier U_i and for column j is called a multiplier V_j, for each base fisible sollution X_{ij} is in the base fisible solution, then U_i and V_j can be found, so that for each base variable X_{ij} the equation $U_i + V_j = C_{ij}$ is obtained.

- *The Steps of the Modified Distribution Method (MODI) are as follows :*

✓ For each table with an initial feasible solution

$$c_{ij} = U_i + V_j \text{ where } U_i = 0$$

$$\bar{c}_{ij} = U_i + V_j \text{ for all } (i,j)$$

✓ Calculate the improvement index

$$I_{ij} = U_i + V_j - c_{ij}$$

This step is calculated for all non-base squares. If $I_{ij} \leq 0$ then the solution is optimal, if $I_{ij} \geq 0$ proceed to the next step.

✓ Table the closed path of the box with the largest positive improvement index, which becomes the base.
✓ Put a (+) then (-) sign alternately on the costs of the boxes that form the trajectory as in the stepping stone method.
✓ For variables originating from the box with the (+) sign, find the one with the minimum value. This box must exit the base and its value is allocated to the variable with the largest positive (the box that entered the base).
✓ Create a new table and go back to step 2. If all the values of $I_{ij} \leq 0$ then the process is stopped because the solution is optimal.

➢ *Total Opportunity Cost Matrix-Sum Approach (TOCM-SUM) Method*

The Total Opportunity Cost Matrix-Sum Approach method is a method discovered by Kirca and Satir in 1990 in which the cost matrix is changed to create a total opportunity cost matrix (TOCM). TOCM is formed through the sum of the row opportunity cost matrix (ROCM) and column opportunity matrix (COCM) where, for each row in the initial transportation cost matrix, ROCM results from subtracting the 2 lowest costs in that row, while COCM results from subtracting the 2 lowest costs in that column. Thus, through this method, an optimal solution to the transportation problem can be obtained.

The steps of the Total Opportunity Cost Matrix-Sum Approach (TOCM-SUM) method are as follows :

- *Selecting the smallest cost from each row (C_{ik}) and each column (C_{kj}).*

Where :

$$C_{ik} = min C_{i1}, C_{i2}, C_{i3}, C_{in}$$

$$i = 1,2,3, \ldots, m$$

$$C_{kj} = min C_{1j}, C_{2j}, C_{3j} C_{mj}$$

$$j = 1,2,3, \ldots, n$$

- *Perform Row Opportunity Cost Matrix (ROCM) and Coloumn Opportunity Cost Matrix (COCM).*

$$ROCM = C_i - C_{ik}$$

$$COCM = C_j - C_{kj}$$

Where :

$$C_i = cost\ in\ the\ i-th\ row$$

$$C_j = cost\ in\ the\ jth\ column$$

- *Orm a Total Opportunity Cost Matrix (TOCM) table using the equation :*

$$TOCM_{ij} = ROCM + COCM = (C_{ij} - C_{ik}) + (C_{ij} - C_{kj})$$

- *Calculate the distribution indicator using the equation :*

$$\Delta_{ij} = TOCM_{ij} - u_i - v_j$$

- *Dimana :*

$\Delta_{ij} = ijth\ distribution\ indicator$

$u_i = the\ i-th\ row\ largest\ cost\ element$

$v_j = jth\ column\ largest\ cost\ element$

- *Make the allocation to the maximum possible cell.*
- *Calculate the new distribution indicator*
- *Get the minimum cost*

III. RESULTS

PT Citra Van Titipan Kilat (TIKI) Makassar has 3 main outlets that will distribute goods to various places included in the Makassar city area. In this case, it is focused on areas that have 6 distribution points. The data used to calculate the minimum delivery cost is in the form of distribution costs, the amount of demand at each distribution point, the amount of shelter capacity and transportation units. Because the amount of demand < inventory, a dummy will be added to the demand of 10,900 obtained from reducing the amount of inventory by the amount of demand (107,000 - 96,100 = 10,900).

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The objective function to be optimized can be seen in the following equation.

$$\min Z = \sum_{i=1}^{4}\sum_{j=1}^{8} c_{ij}x_{ij}$$

With the constraint function for the source that will be used in this research is

$$\sum_{j=1}^{n} x_{ij} = a_{i\,,}\ i = 1,2,\dots,m$$

$$\sum_{j=1}^{8} x_{ij} = a_{i\,,}\ i = 1,2,3,4$$

$$x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17} = a_1$$

$$x_{21} + x_{22} + x_{23} + x_{24} + x_{25} + x_{26} + x_{27} = a_2$$

$$x_{31} + x_{32} + x_{33} + x_{34} + x_{35} + x_{36} + x_{37} = a_3$$

$$x_{41} + x_{42} + x_{43} + x_{44} + x_{45} + x_{46} + x_{47} = a_4$$

And the constraint function for the distribution objective is as follows

$$\sum_{i=1}^{m} x_{ij} = b_{j\,,}\ j = 1,2,\dots,n$$

$$\sum_{i=1}^{4} x_{ij} = b_{j\,,}\ j = 1,2,\dots,8$$

$$x_{11} + x_{21} + x_{31} = b_1$$

$$x_{12} + x_{22} + x_{32} = b_2$$

$$x_{13} + x_{23} + x_{33} = b_3$$

$$x_{14} + x_{24} + x_{34} = b_4$$

$$x_{15} + x_{25} + x_{35} = b_5$$

$$x_{16} + x_{26} + x_{36} = b_6$$

$$x_{17} + x_{27} + x_{37} = b_7$$

$$x_{ij} \geq 0$$

From the results of data collection, the following inventory and demand values are obtained as transportation costs from outlets to destinations listed in table 1.

Table 1 Transportation Table for PT. Citra Van Titipan Kilat (TIKI) Makassar

	Bontoala	Rappocini	Panakkukang	Tamalanrea	Manggala	Tamalate	Dummy	Persediaan
Gerai Ahmad Yani	8	17	15	25	29	17	0	35000
Gerai Panakkukang	10	10	8	20	16	18	0	40000
Gerai Manggala	25	30	19	12	29	44	0	32000
Permintaan	18700	16800	19100	14700	12500	14300	10900	107000

Source: Data processed, 2024

➢ *Aplication of Danzing / Modified Distribution (MODI) Method*

The first step for the danizing method is to apply the northwest rule to the transportation table, so that the following data can be obtained.

Table 2 First Iteration of the Danzing / Modified Distributin (MODI) Method

	Bontoala	Rappocini	Panakkukang	Tamalanrea	Manggala	Tamalate	Dummy	Persediaan
Gerai Ahmad Yani	8 18700	17 16300	15	25	29	17	0	35000
Gerai Panakkukang	10	10 500	8 19100	20 14700	16 5700	18	0	40000
Gerai Manggala	25	30	19	12	29 6800	44 14300	0 10900	32000
Permintaan	18700	16800	19100	14700	12500	14300	10900	107000

Source: Data processed, 2024

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With the minimum total cost Z is

$$Z = Rp\ 1.796.000$$

Then the initial solution and improvement indexes from table 2 will be calculated.

Initial Solving ($U_i + V_j = c_{ij} \rightarrow U_1 = 0$)

$$(U_1 + V_1 = 8 \rightarrow V_1 = 8)$$

$$(U_1 + V_2 = 17 \rightarrow V_2 = 17)$$

$$(U_2 + V_2 = 10 \rightarrow U_2 = 7)$$

$$(U_2 + V_3 = 8 \rightarrow V_3 = 15)$$

$$(U_2 + V_4 = 20 \rightarrow V_4 = 27)$$

$$(U_2 + V_5 = 16 \rightarrow V_5 = 23)$$

$$(U_3 + V_5 = 29 \rightarrow U_3 = 6)$$

$$(U_3 + V_6 = 44 \rightarrow V_6 = 38)$$

$$(U_3 + V_7 = 0 \rightarrow V_7 = -6)$$

Improvement index ($(i,j) = c_{ij} - U_i - V_j$)

$$(1,3) = 15 - 0 - 15 = 0$$

$$(1,4) = 25 - 0 - 27 = -2$$

$$(1,5) = 29 - 0 - 23 = 6$$

$$(1,6) = 17 - 0 - 38 = -21$$

$$(1,7) = 0 - 0 + 6 = 6$$

$$(2,1) = 10 + 7 - 8 = 9$$

$$(2,6) = 18 + 7 - 38 = -13$$

$$(2,7) = 0 + 7 + 6 = 13$$

$$(3,1) = 25 - 6 - 8 = 11$$

$$(3,2) = 30 - 6 - 17 = 7$$

$$(3,3) = 19 - 6 - 15 = -2$$

$$\mathbf{(3,4) = 12 - 6 - 27 = -21}$$

Since (3,4) is the most negative value of the improvement index, a stepping stone will be performed on column (3,4) → (3,5) → (2,5) → (2,4) → (3,4). This calculation is done until the sixth iteration, thus obtaining the data in table 3.

Table 3 Final Result of Danzing/Modified Distribution (MODI) Method

	Bontoala	Rappocini	Panakkukang	Tamalanrea	Manggala	Tamalate	Dummy	Persediaan
Gerai Ahmad Yani	8 18700	17	15 2000	25	29	17 14300	0	35000
Gerai Panakkukang	10	10 16800	8 10700	20	16 12500	18	0	40000
Gerai Manggala	25	30	19 6400	12 14700	29	44	0 10900	32000
Permintaan	18700	16800	19100	14700	12500	14300	10900	107000

Source: Data Processed, 2024

With the minimum total cost Z is

$$Z = Rp\ 1.174.300$$

Then the initial solution and improvement indexes from table 3 will be calculated.

Initial Solving ($U_i + V_j = c_{ij} \rightarrow U_1 = 0$)

$$(U_1 + V_1 = 8 \rightarrow V_1 = 8)$$

$$(U_1 + V_3 = 15 \rightarrow V_3 = 15)$$

$$(U_1 + V_6 = 17 \rightarrow U_6 = 17)$$

$$(U_2 + V_3 = 8 \rightarrow V_3 = -7)$$

$$(U_2 + V_2 = 10 \rightarrow V_2 = 17)$$

$$(U_2 + V_5 = 16 \rightarrow V_5 = 23)$$

$$(U_3 + V_3 = 19 \rightarrow U_3 = 4)$$

$$(U_3 + V_4 = 12 \rightarrow V_4 = 8)$$

$$(U_3 + V_7 = 0 \rightarrow V_7 = -4)$$

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Improvement index $((i,j) = c_{ij} - U_i - V_j)$

$$(1,2) = 17 - 0 - 17 = 0$$

$$(1,4) = 25 - 0 - 8 = 17$$

$$(1,5) = 29 - 0 - 23 = 6$$

$$(1,7) = 0 - 0 + 4 = 4$$

$$(2,1) = 10 + 7 - 8 = 9$$

$$(2,4) = 20 + 7 - 8 = 19$$

$$(2,6) = 18 + 7 - 17 = 8$$

$$(2,7) = 0 + 7 + 4 = 11$$

$$(3,1) = 25 - 4 - 8 = 13$$

$$(3,2) = 30 - 4 - 17 = 9$$

$$(3,5) = 29 - 4 - 23 = 2$$

$$(3,4) = 44 - 4 - 17 = 23$$

Because all improvement index values are positive, the total shipping cost in the 6th iteration is the most optimal at Rp 1,174,300.

- *Aplikasi Metode Total Opportunity Cost Matrix-Sum Approach (TOCM-SUM)*

The first step will be to calculate the value of ROCM (Row Opportunity Cost Matrix) and COCM (Coloumn Opportunity Cost Matrix). Which then the calculation results can be tabulated into table 4.

Table 4 ROCM and COCM table

	Bontoala	Rappocini	Panakkukang	Tamalanrea	Manggala	Tamalate	Dummy	Persediaan
Gerai Ahmad Yani	8_{0}^{8}	17_{7}^{17}	15_{7}^{15}	25_{13}^{25}	29_{13}^{29}	17_{0}^{17}	0_{0}^{0}	35000
Gerai Panakkukang	10_{2}^{10}	10_{0}^{10}	8_{0}^{8}	20_{8}^{20}	16_{0}^{16}	18_{1}^{18}	0_{0}^{0}	40000
Gerai Manggala	25_{17}^{25}	30_{20}^{30}	19_{11}^{19}	12_{0}^{12}	29_{13}^{29}	44_{27}^{44}	0_{0}^{0}	32000
Permintaan	18700	16800	19100	14700	12500	14300	10900	107000

Source: Data Processed, 2024

After getting the ROCM and COCM tables, the TOCM value will be calculated by summing the ROCM and COCM values. So it can be tabulated into table 5

Table 5 TOCM Table

	Bontoala	Rappocini	Panakkukang	Tamalanrea	Manggala	Tamalate	Dummy	Persediaan
Gerai Ahmad Yani	8	24	22	38	42	17	0	35000
Gerai Panakkukang	12	10	8	28	16	19	0	40000
Gerai Manggala	42	50	30	12	42	71	0	32000
Permintaan	18700	16800	19100	14700	12500	14300	10900	107000

Source: Data Processed, 2024

Through the data in table 5, the distribution indicators will be calculated to obtain the most optimal shipping costs. The calculation is carried out as many as 9 distribution indicators, which can then be tabulated in table 6

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Table 6 Final Result of TOCM-SUM Approach Method

	Bontoala	Rappocini	Panakkukang	Tamalanrea	Manggala	Tamalate	Dummy	Persediaan
Gerai Ahmad Yani	8 18700	17 2000	15 X	25 X	29 X	17 14300	0 X	35000
Gerai Panakkukang	10 X	10 14800	8 12700	20 X	16 12500	18 X	0 X	40000
Gerai Manggala	25 X	30 X	19 6400	12 14700	29 X	44 X	0 **10900**	32000
Permintaan	18700	16800	19100	14700	12500	14300	10900	107000

Source: Data Processed, 2024

With the minimum shipping cost Z is

$Z = Rp\ 1.188.000$

IV. CONCLUSION

- Based on the results of calculations using the danzing / modified distribution (MODI) method, the minimum total shipping cost is Rp 1,174,300. And by using the total opportunity cost matrix-sum approach (TOCM-SUM) method, the minimum total shipping cost is IDR 1,188,000. with the difference from the results of the two methods amounting to IDR 13,700.
- Based on the results of the minimum cost comparison, the Danzing / Modified Distributin (MODI) method is the most optimal and recommended method.

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