Distribution Cost Optimization Using Average Opportunity Cost Method and Average Total Opportunity Cost Method

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Abstract

Every company carries out distribution activities to distribute goods to consumers. PT Petrokimia Gresik is one of the providers of organic fertilizer called petragonik fertilizer. They must ensure that distribution from source to destinations does not occur scarcity of organic fertilizers. Selection of inappropriate distribution channels, very high transportation costs and to meet the number of different requests for each detination are factors that can hinder the process of distributing goods. The main aim of this research is to help PT Petrokimia Gresik in solving cost optimization problems related to the distribution of goods. The methods used in this research are Average Opportunity Cost Method (AOCM) and Average Total Opportunity Cost Method (ATOCM), then continued using Modified Distribution (MODI) for optimization test. Based on the research results, it is found that the initial cost of distribution using AOCM is smaller than ATOCM. So for the case of PT Petrokimia Gresik, the AOCM method is better than ATOCM. While the optimization test results get the minimum distribution cost of IDR194.350.000.

Keywords: *Average Opportunity Cost Method*, *Average Total Opportunity Cost Method*, Transportation Model

1. INTRODUCTION

The distribution system in Indonesia is growing very rapidly. A factor that greatly influences the success in selling goods or products of a company is the distribution problem. Distribution is important for a company that sells goods or products to consumers [1]. Distribution is part of marketing activities, where the delivery of goods from the source or company to the destination or the hands of consumers occurs [2]. The distribution process includes transportation costs, the amount of inventory and the amount of demand [3]. Choosing the right distribution channel will be able to minimize the distribution costs that must be borne by a company [4]. The company must be able to manage the costs to be incurred so that income is greater than expenses [5]. A distribution strategy is needed to calculate the minimal and costly transportation costs [6]. Therefore, the company needs a method to help solve the distribution problem so as to obtain the minimum possible distribution cost.

The distribution is done by applying a transportation model to obtation the minimum cost. The application of transportation models is expected to help solve cost problems in the distribution of goods [6]. Transportation models can organize the distribution of goods from a source to each destination by generating minimum costs [7]. The solution of the transportation model has two solutions, namely the initial feasible solution and the optimum solution. The initial feasible solution is to find an allocation of goods from each source to each destination. The optimum solution is to prove that the distribution process is optimal with minimal cost [9]. The solution methods for the inital feasible solution in this study are the *Average Opportunity Cost Method* (AOCM) and the *Average Total Opportunity Cost Method* (ATOCM). Meanwhile, the optimum distribution solution will be determined using the *Modified Distribution* (MODI) method.

The AOCM method for transportation problems has been discussed by Kamble and Bhausaheb [10] in their research. This study compared the AOCM method with the NWCM, LCM, and VAM methods and found that the AOCM method is close to the optimal solution and better than the comparison method.

While ATOCM has been studied by Azad et al. [11], where their research compares the ATOCM method with the LCM method, VAM, and several other methods. They conclude that the ATOCM method is better than other comparison methods. Furthermore, other research on the ATOCM has been studied by Islam et al. [12] and found that ATOCM is better than other methods, except that in this study no optimization test was carried out.

Based on Kamble and Bhausaheb [10], Azad et al. [11] and Islam et al. [12] we review two methods, AOCM and ATOCM for different cases. This research is expected to get optimization results in solving the distribution cost problem.

2. RESEARCH METHODS

The data in this study were taken from the research of Muhammad Dwi Naffiqi Nugraha, et al, which has 5 sources and 7 destinations [13]. This section describes the steps that will be taken to get the minimum distribution cost.

2.1 Transportation Model

The distribution problem will be solved using the transportation model approach. The transportation model can help determine the distributin path so that the minimum cost is obtained [14]. According to Basriati et al. [15] transportstion model is one form of model that can be used to solve problems related to the optimal distribution of goods of the same type, from a number of sources to a number of destinations. Allocation of goods must be managed properly to meet the availability of demand and inventory, as well as the transportation costs of each source and destination [16].

According to Taha [17], an overview of the transportation model can be seen from the Figure 1.
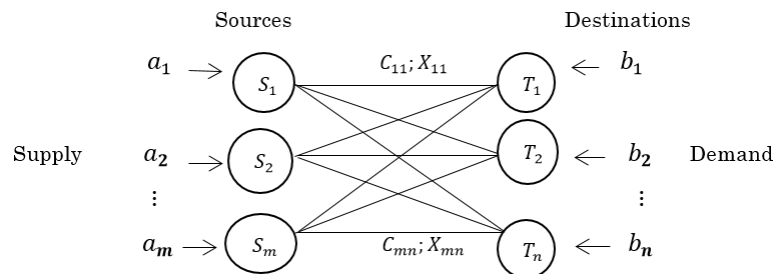

Figure 1. Bipartite graph of transportation model

Based on Figure 1, the transportation problem scheme consists of m sources and n destinations.

According to Siswanto [18],the transportation model is as follows:
Objective Function:

$$\text{minimize } Z = \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} X_{ij} \tag{1}$$

subject to

$$\sum_{i=1}^{m} X_{ij} = a_i$$

$$\sum_{j=1}^{n} X_{ij} = b_j$$

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

where
Z := Total transportatio cost,
a_i := Supply in source i, $i = 1,2,3,\dots,m$,
b_j := Demand from destination j, $j = 1,2,3,\dots,n$,
C_{ij} := Transportation cost per unit from sources i to destination j,
X_{ij} := Quantity of goods distributed from source i to destinaton j.

2.2 *Average Opportunity Cost Method*

Besad on Kamble and Bhausaheb [10], the average oppurtunity cost method (AOCM) is a transportation method to fimd the initial fisible solution by finding the largest average *penalty* value for each row and column. The following are the steps for solving using the AOCM method:

a. Reduced the rows in the transportation table by substracting each cost elemnt with the smallest cost and placing it to the upper right of the element.
b. Reduced the column in th transportation table in the same way and place it on the bottom right of the element.
c. Creat an AOCM (*Average Opportunity Cost Matrix*) table where the elements are the average values of the top right and botton right elements in Step a and b.
d. Calculate the *penalty for* each row and column. The *penalty* value is obtained by subtracting the second smallest value from the smallest value.
e. Selects the *penalty for* with the largest value in each row and column. If the values are the same, the highest value in the amount of inventory or demand is selected.
f. Next, the inventory or demand will be allocated to the element that has the least cost in the corresponding row or column. Then, the slected row or column will be shaded
g. If each row or each column is fulfilled. Step h will countinue. If not, repeat Steps d to f until the supply and demand are met.
h. Furthermore, the allocated values will be inserted into the original transportation table in the corresponding cells.
i. Then, the transportation costs generated from the table will be calculated.

2.3 *Average Total Opportunity Cost Method*

The steps for solving ATOCM are taken from research [11] as follows:

a. Reducing the rows in the transportation table, obtained from each element in the row is deducted by the cost with the smallest value in the row and placed on the top right of the element.
b. Reducing the transportation table column, obtained from each element in the column minus the cost with the smallest value in the column and placed at the bottom right of the element.
c. Create a the TOCT (*Total Opportunity Cost Table*), whose elements are the sum of the top and bottom right elements in Step a and Step b.
d. Find *Row Average Total Opportunity Cost* (RATOC) and *Column Average Total Opportunity Cost* (CATOC).
e. Next, the element with the highest value between RATOC and CATOC will be selected. If here are two or more RATOC and CATOC values tht have the same value, the element with the highest value in the supply or demand value will be selected.
f. Will be allocated $X_{ij} = \min(a_i, b_j)$ on the top left with the smallest entry (i, j) to the transportation table.
g. If each row or column is satisfied, proceed to Step h. If not, Step d to f will be repeated untill all supplies and demands have been met.
h. Next, the allocated values are inserted into the original transportation table in the cell which is in sync.
i. Then the transportation cost generated from the table will be calculated.

2.4 *Modified DistributionMethod* (MODI)

The Modified Distribution (MODI) method will be used after the initial fisible solution has been obtained. According to Dimyati and Dimyati [14] MODI method is the development of the *stepping* stone method. The difference between MODI and the *stepping stone* mehod is that each non-base varaible does not have to find all of its closed paths (*loop*), except when moving to fill the table. According to Soplanit et al. [19] MODI method can be used if it meets the $m + n - 1$ condition where m is the number of rows and n is te number of columns. There is following equation that will be used in the MODI method,

$$U_i + V_j = C_{ij} \qquad (2)$$

where U_i is the value in each row cell, V_j the value of each column cell, and C_{ij} transportation cost for goods per unit.

According to Nufus and Nurdin [20], the steps for solving MODI are as follows:

a. All base variables will be searched for the value of U_i for each row cell and the value V_j for each column cell using equation (2) and determine the vakue of $U_i = 0$.

b. For non-base variables, the change in cost will be determined X_{ij} for each non-base varaible using the following equation:

$$X_{ij} = C_{ij} - U_i - V_j. \tag{3}$$

c. If the calculation obtained X_{ij} is alredy positive, meaning that the initial solution obtained previously is optimal. If the value X_{ij} obtained is still negative, we will continue by selecting X_{ij} the largest negative value to be use as *entering variable*.

d. Will be allocated the value to be used as *entering variabel* X_{ij} the same as the step on the *stepping stone* and repeat the first step until the value of X_{ij} are no longer negative.

3. RESULTS AND DISCUSSION

PT. Petrokimia gresik is one of the provied of organic fertilizer products called petroganic fertilizer. PT. Petrokimia Gresik is located at Jl. Jendral A. Yani Gresik, East Java. PT. Petrokimia Gresik has five distribution points, namely Wotan Panceng, Gresik industrial Estate, Panceng, Kebomas, and Wadeng. The destination areas that request fertilizer supplies are GMG Warehouse, Bojonegoro Warehouse, Pucuk Warehouse, Jenuh Warehouse, Palang Warehouse, Pusri Warehouse, and Weru Warehouse. The data in November 2020 distributed to warehouses that request the fertilizer stock amounting to IDR217.100.000 are given in Table 1.

Table 1. Transportation Model of Petroganic Fertilizer PT. Petrokimia Gresik

Sbr	Freight Cost (in thousands IDR)							Psd (tons)
	1	2	3	4	5	6	7	
1	40	40	55	50	50	45	45	
	X_{11}	X_{11}	X_{11}	X_{11}	X_{11}	X_{11}	X_{11}	1300
2	45	45	40	55	55	50	50	
	X_{11}	X_{11}	X_{11}	X_{11}	X_{11}	X_{11}	X_{11}	1030
3	40	50	40	40	45	40	35	
	X_{11}	X_{11}	X_{11}	X_{11}	X_{11}	X_{11}	X_{11}	910
4	40	55	50	55	45	50	50	
	X_{11}	X_{11}	X_{11}	X_{11}	X_{11}	X_{11}	X_{11}	780
5	35	45	40	45	50	40	40	
	X_{11}	X_{11}	X_{11}	X_{11}	X_{11}	X_{11}	X_{11}	780
Pmt (tons)	1110	1020	630	630	540	450	420	4800

Description:
Sbr   : Source
Psd   : Supplies
Pmt   : Inquiry
Source 1 : Wotan Panceng
Source 2 : Gresik Industrial Estate
Source 3 : Panceng
Source 4 : Kebomas
Source 5 : Wadeng
Objective 1 : GMG Warehouse
Destination 2 : Bojonegoro Warehouse
Destination 3 : Pucuk Warehouse
Objective 4 : Jenuh Warehouse
Objective 5 : Palang Warehouse

Objective 6   : Pusri Warehouse
Destination 7   : Weru Warehouse

Based on Table 1, the following transportation model can be formed:

$$\begin{aligned}
\text{minimize } Z = {} & 40X_{11} + 40X_{12} + 55X_{13} + 50X_{14} + 50X_{15} + 45X_{16} + 45X_{17} \\
& + 45X_{21} + 45X_{22} + 40X_{23} + 55X_{24} + 55X_{25} + 50X_{26} + 50X_{27} \\
& + 40X_{31} + 50X_{32} + 40X_{33} + 40X_{34} + 45X_{35} + 40X_{36} + 35X_{37} \\
& + 40X_{41} + 55X_{42} + 50X_{43} + 55X_{44} + 45X_{45} + 50X_{46} + 50X_{47} \\
& + 35X_{51} + 45X_{52} + 40X_{53} + 45X_{54} + 50X_{55} + 40X_{56} + 40X_{57}.
\end{aligned}$$

subject to

Supply:
$$X_{11} + X_{12} + X_{13} + X_{14} + X_{15} + X_{16} + X_{17} = 1300;$$
$$X_{21} + X_{22} + X_{23} + X_{24} + X_{25} + X_{26} + X_{27} = 1030;$$
$$X_{31} + X_{32} + X_{33} + X_{34} + X_{35} + X_{36} + X_{37} = 910;$$
$$X_{41} + X_{42} + X_{43} + X_{44} + X_{45} + X_{46} + X_{47} = 780;$$
$$X_{51} + X_{52} + X_{53} + X_{54} + X_{55} + X_{56} + X_{57} = 780.$$

Demand:
$$X_{11} + X_{21} + X_{31} + X_{41} + X_{51} = 1110:$$
$$X_{12} + X_{22} + X_{32} + X_{42} + X_{52} = 1020;$$
$$X_{13} + X_{23} + X_{33} + X_{43} + X_{53} = 630;$$
$$X_{14} + X_{24} + X_{34} + X_{44} + X_{54} = 630;$$
$$X_{15} + X_{25} + X_{35} + X_{45} + X_{55} = 540;$$
$$X_{16} + X_{26} + X_{36} + X_{46} + X_{56} = 450;$$
$$X_{17} + X_{27} + X_{37} + X_{47} + X_{57} = 420.$$
$$X_{ij} \geq 0 \text{ for all } i \text{ and } j \tag{4}$$

where X_{ij} is the amunt of petroganic fertilizer tht must be distributed from the source i to destination j, for $i = 1, 2, 3, 4, 5$ and $j = 1, 2, 3, 4, 5, 6, 7$.

a. Settlement using the *Average Opportunity Cost Method* (AOCM)
The initial transportation table AOCM can be constructed from Table 1 as seen in Table 2.

Table 2. initial transportation Data using AOCM

Sbr	Freight Cost (in thousands)							Psd (tons)
	1	2	3	4	5	6	7	
1	40	40	55	50	50	45	45	1300
2	45	45	40	55	55	50	50	1030
3	40	50	40	40	45	40	35	910
4	40	55	50	55	45	50	50	780
5	35	45	40	45	50	40	40	780
Pmt (tons)	1110	1020	630	630	540	450	420	4800

The final results using AOCM after 11 iterations can seen in Table 3.

Table 3. Final Results using AOCM

Sbr	Freight Cost (in thousands)							Psd (tons)
	1	2	3	4	5	6	7	
1	40	40	55	50	50	45	45	
	280	1020						1300
2	45	45	40	55	55	50	50	
			630		400			1030
3	40	50	40	40	45	40	35	
				630			280	910
4	40	55	50	55	45	50	50	
	780							780
5	35	45	40	45	50	40	40	
	50				140	450	140	780
Pmt (tons)	1110	1020	630	630	540	450	420	4800

Based on Table 3, the values obtained Z i.e:
$Z = (40 \times 280) + (40 \times 1020) + (40 \times 630) + (55 \times 400) + (40 \times 630) + (35 \times 280)$
$\quad + (40 \times 780) + (35 \times 50) + (50 \times 140) + (40 \times 450) + (40 \times 140)$
$\quad = 197750 \times 1000$
$Z = 197.750.000$

So, the initial solution to the cost of distributing petroganic fertilizer at PT. Petrokimia Gresik using AOCM is obtained in the amount of IDR197.750.000.

b. Settlement using the *Average Total Opportunity Cost Method* (ATOCM)
The initial transportation table for ATOCM can also be constructed from Table 1 to obtain Table 4.

Table 4. Initial Transportation Data using ATOCM

Sbr	Freight Cost (in thousands)							Psd (tons)
	1	2	3	4	5	6	7	
1	40	40	55	50	50	45	45	1300
2	45	45	40	55	55	50	50	1030
3	40	50	40	40	45	40	35	910
4	40	55	50	55	45	50	50	780
5	35	45	40	45	50	40	40	780
Pmt (tons)	1110	1020	630	630	540	450	420	4800

The final results using ATOCM after 11 iterations can seen in Table 5.

Table 5. Final Results using ATOCM

Sbr	Freight Cost (in thousands)							Psd (tons)
	1	2	3	4	5	6	7	
1	40	40	55	50	50	45	45	1300
	330	620			260	90		
2	45	45	40	55	55	50	50	1030
		400	630					
3	40	50	40	40	45	40	35	910
				630	280			
4	40	55	50	55	45	50	50	780
	780							
5	35	45	40	45	50	40	40	780
						360	420	
Pmt (tons)	1110	1020	630	630	540	450	420	4800

Based on Table 5 , The value Z i.e:

$$Z = (40 \times 330) + (40 \times 620) + (50 \times 260) + (45 \times 90) + (45 \times 400) + (40 \times 630)$$
$$+(40 \times 630) + (45 \times 280) + (40 \times 780) +(40 \times 420)$$
$$= 198450 \times 1000$$
$$Z = 198.450.000.$$

So, the initial solution to the cost of distributing petroganic fertilizer at PT. Petrokimia Gresik using ATOCM is IDR. 198.450.000.

c. Optimization Teat using *Modified Distribution* (MODI)
Testing using MODI can be done if it meets (m+n-1) where m is the number of rows snd n is the number of columns. In this study, these conditions have been met so that the optimization test can be continued.

1) Optimizing petroganic fertilizer transportation cots with an initial fisible solution using the *Average Opportunity Cost Method* (AOCM)

Based on Table 3, we will calculate the index value in each filled row column for the first iteration using Equatio 2. Next, calculate the cost change for each empty cell in the first iteration using Equation 3. X_{ij} for each empty cell of the first iteration using Equation 3. untuk setiap sel kosong iterasi pertama dengan menggunakan Persamaan 3.

Iteration I is not optimal, because there are negative results. X_{ij} which is negative. Then continue to find the index value for iteration II, until there are no more nEgative results. X_{ij} which is negative. After iterating 2 times, he optimal results using AOCM with the optimal test MODI are obtained in Table 6.

Tabel 6. Optimal Results of ACOM Method using MODI Method

Sbr	Freight Cost (in thousands)							Psd (tons)
	1	2	3	4	5	6	7	
1	40	40	55	50	50	45	45	
	280	1020						1300
2	45	45	40	55	55	50	50	
	400		630					1030
3	40	50	40	40	45	40	35	
				630			280	910
4	40	55	50	55	45	50	50	
	240				540			780
5	35	45	40	45	50	40	40	
	190					450	140	780
Pmt (tons)	1110	1020	630	630	540	450	420	4800

Based on Table 6, the value results are Z as follows:

$Z_2 = (40 \times 280) + (40 \times 1020) + (45 \times 400) + (40 \times 630) + (40 \times 630) + (35 \times 280)$
$+ (40 \times 240) + (45 \times 540) + (35 \times 190) + (40 \times 450) + (40 \times 140)$
$= 194350 \times 1000$
$Z_2 = 194.350.000.$

So that the cost solution for the distribution of petroganic fertilizer of PT. Petrokimia Gresik obtained from MODI is IDR.194.350.000 and is the optimal solution.

2) Optimizig petroganic fertilizer transportation costs with an initial fisible sulution using the *Average Total Opportunity Cost Method* (ATOCM)

Based on Table 5, calculate the index value in each filled row and column for the first iteration using Equation 2. Next, calculate the change in cost X_{ij} for each empty cell of the first iteration using Equation 3. Iteration I is not optimal. Because there are negative results. X_{ij} which isnegative. Then continue to find the index value for iteration II, until there are no more negatuve results. X_{ij} which is negative. After iterating 3 times, the optimal results using ATOCM with the optimal test using MODI are obtained in pada Table 7.

Based Table 7, the value results are Z as follows:

$Z_3 = (40 \times 680) + (40 \times 620) + (45 \times 400) + (40 \times 630) + (40 \times 630) + (35 \times 280)$
$+ (40 \times 240) + (45 \times 540) + (35 \times 190) + (40 \times 450) + (40 \times 140)$
$= 194350 \times 1000$
$Z_3 = 194.350.000.$

So that the cost solution for te disribution of petroganic fertilizer of PT. Petrokimia Gresik obtained from MODI is IDR.194.350.000 and is the optimal solution.

Tabel 7. Optimal Results of ATCOM Method using MODI method

Sbr	Freight Cost (in thousands)							Psd (tons)
	1	2	3	4	5	6	7	
1	40	40	55	50	50	45	45	
	680	620						1300
2	45	45	40	55	55	50	50	
		400	630					1030
3	40	50	40	40	45	40	35	
				630			280	910
4	40	55	50	55	45	50	50	
	240				540			780
5	35	45	40	45	50	40	40	
	190					450	140	780
Pmt (tons)	1110	1020	630	630	540	450	420	4800

5. CONCLUSION

The solution of the petroganic fertilizer distribution problem PT. Petrokimia Gresik, results in that initial fisible solution for the minimum cost of fertilizer distribution using the Average Opoortunity Cost Method (AOCM) get a smaller cost than the distribution cost using the Average Total Opportunity Cost Method (ATOCM). So it can be councleded that AOCM is better than ATOCM for case of PT. Petrokimia Gresik above. The optimal fertilizer distribution cost obtained using modified distribution (MODI) is IDR194.350.000.

REFERENCES

1. Saputri, Z., E., and Nasution, Y., N., 2019, Comparison of Revised Distribution Method Results and Stepping Stone Method with Determination of Initial Value Using North West Corner Method in Minimizing (Case Study: Distribution of 3 Kg LPG Gas Tubes at PT. Tri Pribumi Sejati), *Exponential Journal*, **Volome**: 10 **pp**. 59-66.
2. Ratnasari, Y., Yuniarti, D., and Purnamasari, I., 2019, Goods Distribution Optimization using Vogel's Approximation Method and Stepping Stone Method (Case Study: Distribution of 3 Kg LPG Gas Tubes at PT. Tri Pribumi Sejati), *Exponential Journal*, **Volume**: 10 **pp**. 165-174.
3. Arofah, I and Gesthantiara, N., N., 2021, Optimization of Goods Distribution Costs using Transportation Models, *JMT Journal of Mathematics and Applied Sciences*, **Volume:** 3 **pp**. 1-9.
4. Aida, F., N., and Rahmanda, W., 2020, Analysis of Fertilizer Distribution Transportation Costs Using Lingo Software, *JRSI Journal of Industrial Systems Engineering*, **Volume**: 5 **pp**. 135-145.
5. Meflinda, A., and Mahyarni, 2011, *Operations Research*. Pekanbaru: UNRI Press.
6. Karnila, W., Syarifuddin, H., and Dewi, M., P., Optimization of Rice Welfare Distribution Cost using Zero Suffix Method and ASM Method, Journal of Mathematics, **Volume:** 4 **pp**. 56-60.
7. Wasono, 2018, Comparison of the Results of the Least Cost Method and Vogel's Approximation Method (VAM) in Minimizing the Cost of Distributing 3 Kg Lpg Gas Tubes at PT Tri Pribumi Sejati Samarinda, *Proceedings of the National Seminar* on *Mathematics and Applied*.
8. Pranati, N., M., A., Jaya, A., I., and Sahari, A., 2018, Optimization of Ceramic Transportation Costs using the Stepping Method Transportation Model (Case Study: PT. Indah Bangunan), **Volume:** 15 **pp**. 48-57.
9. Ardhyani, I., W., 2017, Optimizing Animal Feed Distribution Costs using Transportation Methods (Case Study at PT. X Krian), Teknika *Enginering Science Journal*, **Volume:** 1, **pp**. 95-100.

10. Kamble, S., V., and Bhausaheb, G., K., 2019, A New Method to Obtain an Initial Basic Feasible Solution of Transportation Problem with the Average Opportunity Cost Method, *International Journal Engineering and Advanced Technology*, **Volume:** 9 **pp**. 206-209.

11. Azad, S., Hossain, M., and Rahman, M., 2017, An Algorithmic Approach to Solve Transportation Problems with the Average Total Opportunity Cost Method, *International Journal Scientific and Research Publication*, **Volume:** 7 **pp**. 266-270.

12. Islam, M., A., Haque, M., M., and Uddin, M., S., 2012, Extremum Difference Formula on Total Opportunity Cost: a Transportation Cost Minimization Technique, *Prime University Journal*, **Volume:** 6 **pp**. 125-130.

13. Dwi, M., Nugraha, N., Jihadi, M., and Shanty, ., M., 2021, Optimization Analysis of Petroganik Fertilizer Distribution at PT Petrokimia Gresik, Journal of Business Management and Entrepreneurship, **Volume:** 1 **pp**. 110-116.

14. Dimyati, T., T., and Dimyati, A., 2011, *Operations Research: Decision Making Models*, Sinar Baru Algesindo, Bandung.

15. Basriati, S., Safitri, E., and Yustari, W., 2019, Application of Improved Exponential Approach Method to Obtain Optimum Solution for Commodity Distribution (Case Study: PT. Tirta Sumber Mekarsari), *Journal of Mathematics and Statistics Science*, **Volume:** 5 **pp**. 119-128.

16. Hendriawan, S., Nugraha, M., and Fauzi, 2020, Application of Stepping Stone Method in Lingo Software to Find Cost Optimization (Case Study of PT. ASM Mobil), *Journal Integrated System*, **Volume:** 3 **pp**. 49-58.

17. Taha, H., A., 2017, *Operations Research An Introdction*, *Tenth Edition,* England: Pearson Education, London.

18. Siswanto, 2007, *Operations Research,* Erlangga, Bogor.

19. Soplanit, P., P., G., Dundu, A., K., T., and Mangare, J., B., 2019, Material Distribution Cost Optimization with a Combination of NWC (North West Corner) and MODI (Modified Distribution) Methods on Bridge Construction Projects in North Sulawesi, *Journal of Civil Statics*, **Volume:** 7 **pp**. 1633-1640.

20. Nufus, H., and Nurdin, E., 2016, *Linear Program*, Cahaya Firdaus, Pekanbaru.