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Application of Improved Zero Point Method and Modified Exponential Approach in Reducing Rice Distribution Cost of Perum Bulog Sub Divre Polman

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Abstract: The transportation model is a special system designed to overcome various challenges in bussines world in order to increase company profits by distributing lowest cost products. The minimum cost obtained using the Improved Zero Point Method is Rp. 2.354.805,27 and the Modified Exponential Approach is Rp.2.357.468,42. The optimality test using the MODI method is Rp. 2.354.805,27.

Keywords: *Transportation Model, Improved Zero Point Method, Modified Exponential Approach.*

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I. INTROUCTION

Transportation is the movement of people or goods from one area to another using tools driven by human or machines. Transportation equipment has a capacity limit that greatly affects the comfort of passengers and the durability of the equipment during the travel route so that to move people to another place or the distribution of an item cannot be done at once if it crosses the capacity threshold of the transportation equipment. This will also impact on the costs incurred during transportation use.[3]

The transportation problem can besolved by several methods in two steps, namely determining the solution initial and optimum solution [5]. There are several new methods proposed to overcome internal challenges minimize transportations costs. One of them is the Improved Exponential Approach proposed by Hidayat in 2016 and is a development of the Exponential Approach method by Vannam in 2013. This method provides convenience with few iterations. The allocation of the Improved Exponential Approach depends on the zeros that appear in the transportation table.[6]. The allocation is based on the minimum penalty value and in some cases the same penalty exponent occurs so that the minimum cost entry is not considered Therefore, it is proposed Modified Exponential Approach by Widia in 2022 to provide improvements of allocation.[4].

Improved Zero Point Method is one of the transportation methods that provides solutions on how to allocate the right goods at minimum cost. Methods included in the search for solutions in the discipline of Operations Research can be applied to understand how to effectively allocate goods.The Improved Zero Point Method proposed by Samuel in 2012 is a development of the Zero Point Method.[1]

Start by determining the initial solution to use Improved Zero Point Method and Modified Exponential Approach taking into account every request exiting supplies. Next, use the Danzing Method/MODI (Modified Distribution) to determine the optimum solution.

II. LITERATURE REVIEW

A. *Transportation Model*

- *Objective Function:*

Minimize

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

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➢ *Constraints:*

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

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

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

B. Improved Zero Point Method

Improved Zero Point Method is a development of the Zero Point Method which is very useful for solving various types of transportation problems. This method is improved with steps that are simpler, more efficient, and easier to understand. The step of the Improved Zero Point Method are as follows.

- Reduce each entry c_{ij} in the row and column with the smallest entry. The check that each column b_j is less than or equal to the number a_i in the row with entry c_{ij} whose reduced cost is zero and vice versa. If these conditions are met then proceed to step (c) if not then proceed to step (b).
- Cover all entry c_{ij} with the minimum possible horizontal and vertical lines.
- Select a cell in row i or column j in the transportation table that has zero reduced costs and fill the maximum possible in that cell so that it meets supply and demand.[2]

C. Modified Exponential Approach

The proposed new method to Improved Exponential Approach is a method called the Modified Exponential Approach. The steps in this method are:

Allocation of cell values with the maximum number, with $x_{ij} = \min(a_i, b_j)$ by paying attention to the allocation priority as follows:

- The entry c_{ij} is zero which has an exponent penalty of 0.
- The entry c_{ij} is zero which has an exponent penalty of 1.
- Select the cell that has the largest reduced entry c_{ij} and is called (i,j). Allocate the cell in row i or column j with entry c_{ij} when reduced.[4]

D. Modified Distribution

Modified Distribution is a development of the Stepping Stone with modified techniques. The steps in using the MODI Method are:

For each table with an initial feasible solution

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

$$\overline{c_{ij}} = U_i + V_j \text{ for all } (i,j)$$

Calculate the repair index $K_{ij} = U_i + V_j - c_{ij}$

III. RESULT

Perum Bulog Sub Divre Polman has 4 rice storage warehouses that will be distributed to 3 distcrits included in the working area (Polewali Mandar, Mamasa, and Majene). In this case, the focus is on the Majene Regency working area which has 8 distribution points for rice distribution. The data used to calculate the minimum cost of transportation is in the form of distribution costs, the amount of demand for each distribution point, the amount of wherehouse capacity and transportation unit.

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 study is

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

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

$$x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{16} + x_{17} + x_{18} = a_1$$

$$x_{21} + x_{22} + x_{23} + x_{24} + x_{25} + x_{26} + x_{27} + x_{28} = a_2$$

$$x_{31} + x_{32} + x_{33} + x_{34} + x_{35} + x_{36} + x_{37} + x_{38} = a_3$$

$$x_{41} + x_{42} + x_{43} + x_{44} + x_{45} + x_{46} + x_{47} + x_{48} = a_4$$

And the constraint function for the distribution objective is a follows

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

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

$$x_{11} + x_{21} + x_{31} + x_{41} = b_1$$

$$x_{12} + x_{22} + x_{32} + x_{42} = b_2$$

$$x_{13} + x_{23} + x_{33} + x_{43} = b_3$$

$$x_{14} + x_{24} + x_{34} + x_{44} = b_4$$

$$x_{15} + x_{25} + x_{35} + x_{45} = b_5$$

$$x_{16} + x_{26} + x_{36} + x_{46} = b_6$$

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$$x_{17} + x_{27} + x_{37} + x_{47} = b_7$$

$$x_{18} + x_{28} + x_{38} + x_{48} = b_8$$

$$x_{ij} \geq 0$$

From the result of data collection, the amount of supply capacity and demand is obtained as follows as rice transportation costs from source to destination which are listed in Table 1.

Table 1: Transportation Table for Perum Bulog Sub Divre Polman

Source	**Objective**								**Supply**
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	
RGS	11.268	12.434	19.429	50.514	106.857	106.857	143.771	163.2	68.6
CPJ	71.885	69.942	95.2	130.171	184.571	184.571	223.428	240.914	88.85
PLW	58.285	104.914	130.172	165.143	219.542	219.542	258.4	275.885	54.42
AMS	120.457	118.514	149.6	180.685	237.028	237.028	273.942	293.371	38.43
Demand	54.42	11.98	26.52	26.83	38.65	15.94	13.85	23.68	250.3

Source: Processed Data, 2024

A. *Application of The Improved Zero Point Method*

The initial step is to add a dummy column because the transportation problem is not balanced or $\sum_{j=1}^{n} b_j < \sum_{i=1}^{m} a_i$. Next reduce each entry in the row with the smallest value in that row and check whether each column b_j is less than or equal to the number a_i in the row with entry c_{ij} whose recuded cost is zero and vice versa. From Table 2 it is know that rows a_2 and a_3 are greater than the number of b_j in the reduced column with a value of zero. Then close all zero-valued c_{ij} entries with horizontal and vertical lines.

Table 2: Additon of Dummy Columns & Draw Horizontal and Vertical Lines

Source	**Objective**									**Supply**
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**Dummy**	
RGS	0	0	0	0	0	0	0	0	0	68.6
CPJ	60.617	79.937	75.771	79.657	77.714	79.657	79.657	77.714	0	88.85
PLW	47.017	92.48	110.743	114.629	112.685	114.628	114.629	112.685	0	54.42
AMS	109.189	106.08	130.171	130.171	130.171	130.171	130.171	130.171	0	38.43
Demand	54.42	11.98	26.52	26.83	38.65	15.94	13.85	23.68	38.43	250.3

Source: Processed Data, 2024

The reduction results are obtained in the table above. Then repeat step above until all conditions are met. After the 4-iteration, the following improvement table is obtained. Selects a cell in the transport table that has zero reduce cost and fills that cell to the maximum possible extent.

Table 3: Allocation Result Improved Zero Point Method

Source	Objective									Supply
	A	B	C	D	E	F	G	H	Dummy	
RGS	11.268	12.434 11.98	19.429	50.514 26.83	106.857	95.2 15.94	143.771 13.85	163.2	0	68.6
CPJ	71.885	92.371	95.2 26.52	130.171	184.571 38.65	174.857	223.428	240.914 23.68	0	88.85
PLW	58.285 54.42	104.914	130.172	165.143	219.542	209.828	258.4	275.885	0	54.42
AMS	120.457	118.514	149.6	180.685	237.028	225.371	273.942	293.371	0 38.43	38.43
Demand	54.42	11.98	26.52	26.83	38.65	15.94	13.85	23.68	38.43	250.3

Source: Processed Data, 2024

The minimum value of Z using the Improved Zero Point Method is

$$Z = 2.354.805,27$$

B. *Optimality Test with Modified Distribution (MODI)*

To find out whether the value of Z is optimal, then the optimality test will be carried out using the Modified Distribution. First, a degeneration test is carried out with the condition that $m + n - 1$ is equal to the number of base cells in Table 3, it is known that $m = 9$ and $n = 4$ so that for further work the addition of basic variables with a valueof zero is carried out.

The minimum value of optimality test using MODI Method is a follow

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$$Z \;= 2.354.805{,}27$$

C. Application of Modified Exponential Approach

Because the transportation problem in this study is $\sum_{j=1}^{n} b_j < \sum_{i=1}^{m} a_i$ then a dummy column is added with the largest entry c_{ij} from the previously reduce table. Then, substract each entry c_{ij} in the row from the minimum entry c_{ij} value in each row.

Table 4: Replacement Dummy Costs

Source	**Objective**									**Supply**
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**Dummy**	
RGS	0	0	0	0	0	0	0	0	130.171	68.6
CPJ	60.617	79.937	75.771	79.657	77.714	79.657	79.657	77.714	130.171	88.85
PLW	47.017	92.48	110.743	114.629	112.685	114.628	114.629	112.685	130.171	54.42
AMS	109.189	106.08	130.171	130.171	130.171	130.171	130.171	130.171	130.171	38.43
Demand	54.42	11.98	26.52	26.83	38.65	15.94	13.85	23.68	38.43	250.3

Source: Processed data, 2024

Checks whether each column b_j is less than or equal to the number a_i in the row with entry c_{ij} whose reduced cost is zero and vice versa. Then draw horizontal and vertical lines on all entry c_{ij} with a value of zero. After the 6-iteration, the following improvement table is obtained.

Table 5: Repair Table

Source	**Objective**									**Supply**
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**Dummy**	
RGS	24.091	0.777	1.943	0	0	0	0	0	130.171	68.6
CPJ	6.994	0	0	1.943	0	1.943	1.943	0	29.143	88.85
PLW	0	22.149	41.578	43.521	41.577	43.52	43.521	41.577	35.749	54.42
AMS	26.418	0	33.027	23.314	23.314	23.314	23.314	23.314	0	38.43
Demand	54.42	11.98	26.52	26.83	38.65	15.94	13.85	23.68	38.43	250.3

Source: Processed data, 2024

Determining the penalty exponent (the number of zero valued entry c_{ij} from each row i and column j), let's say e_{ij}, in cell with zero valued entry c_{ij}. This determination does not include c_{ij} entries for which the exponential penalty value will be determined. Repeart the above procedure for all zero-valued entry c_{ij} in the table. Based on Table 5, the e_{ij} value obtained in the corresponding rows and columns are :

$$e_{14} = e_{15} = e_{16} = e_{17} = e_{18} = 4$$

$$e_{22} = e_{23} = e_{28} = 3$$

$$e_{31} = 0$$

$$e_{42} = e_{49} = 1$$

Allocate the maximum number of cell values with $x_{ij} = \min(a_i, b_j)$ and pay attention to the allocation priority. The first allocation is carried out on x_{31} according to the allocation priority where the e_{31} has an exponential penalty of 0. The allocation is listed in Table 6.

Table 6: Allocation Result Modified Exponential Approach

Source	Objective									Supply
	A	B	C	D	E	F	G	H	Dummy	
RGS	11.268	12.434 11.98	19.429	50.514 26.83	106.857	95.2 15.94	143.771 13.85	163.2	0	68.6
CPJ	71.885	92.371	95.2 26.52	130.171	184.571 38.65	174.857	223.428	240.914 23.68	0	88.85
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AMS	120.457	118.514	149.6	180.685	237.028	225.371	273.942	293.371	0 38.43	38.43
Demand	54.42	11.98	26.52	26.83	38.65	15.94	13.85	23.68	38.43	250.3

Source: Processed data, 2024

The minimum value of Z using the Modified Exponential Approach is:

$$Z = 2.357.468,4$$

D. Optimality Test with Modified Distribution (MODI)

Next, the completion of the Modified Exponential Approach is carried out by an optimality test using the Modified Distribution as follows.

Table 7: Allocation Result Modified Distribution

Source	Objective									Supply
	A	B	C	D	E	F	G	H	Dummy	
RGS	11.268	12.434 (**11.98**)	19.429	50.514 (**26.83**)	106.857 (**0**)	95.2 (**15.94**)	143.771 (**13.85**)	163.2	0	68.6
CPJ	71.885 (**0**)	92.371	95.2 (**26.52**)	130.171	184.571 (**38.65**)	174.857	223.428	240.914 (**23.68**)	0	88.85
PLW	58.285 (**54.42**)	104.914	130.172	165.143	219.542	209.828	258.4	275.885	0	54.42
AMS	120.457	118.514 (**0**)	149.6	180.685	237.028	225.371	273.942	293.371	0 (**38.43**)	38.43
Demand	54.42	11.98	26.52	26.83	38.65	15.94	13.85	23.68	38.43	250.3

Source: Processed data, 2024

The minimum value of optimality test using MODI Method is a follow.

$$Z = 2.354.805,27$$

IV. CONCLUSION

From the calculation result, the minimum cost of the Improved Zero Point Method is obtained as **Rp.2.354.805,27** and the Modified Exponential Approach obtained a minimum cost of **Rp.2.357.468,42** with optimality test using MODI (Modified Distribution) Method obtained the result of **Rp. 2.354.805,27** but with a different number of iterations. The Improved Zero Point Method is performed in 4 iterations while the Modified Exponential Approach was conducted for 8 iterations

From the result of the minimum cost comparison, the Improved Zero Point Method is more efficient because the minimum cost is obtained with fewer iterations.

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