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Optimization of Chicken Egg Distribution Cost Using Revised ASM Method (Case Study: Breeding Industry)

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ABSTRACT

PT. IA is a company engaged in the manufacture of animal feed, producing chicken eggs and broiler chicken farm. The problems at PT. IA is amount of distribution costs incurred by the company, so the method needed to optimize disttribution costs. The purpose of this research is to determine the optimal distribution costs of chicken eggs, compare the distribution cost of chicken eggs before and after optimization, and compare the ASM method with Stepping Stone method. The method use to solve the probelum is using ASM method. ASM method is one of a method that can use to find the optimal solution without have to find the starting solution to minimize costs. Allocation product with ASM Method is done from the smallest index and the largest amount of supply, until all demand is met and supply out of stock. Based on the research, it shown the revision of ASM method is not necessarly able to provide the optimal solution directly to unbalanced transportation problems or the accurance of additional activities. The minimum total cost with ASM method is Rp. 586.800.000, while after test the optimization using Stepping Stone method the result is Rp. 585.300.000. The difference cost before and after optimization using the revised ASM method is Rp. 93.300.000 or decrease of 13,7%.

Keywords: ASM Method, Stepping Stone Method, Transportation Model

Introduction

IA Ltd. is a company engaged in the manufacture of animal feed, producing chicken eggs and broiler chicken farm. The product to be researched is chicken eggs that unhatched in farm and need to carry out the distribution process so the chicken eggs can arrive in hatchery according to amount of demand. However, the differences in the distribution cost still quite expensive. Getting further the distance to the destination, more greater costs incurred by the company. So, the company need a method that can optimize distribution costs.

The method that can be used by company in solving distribution problems is the ASM method. ASM method or Abdul Quddoos, Shakeel Javaid and M. M. Khalid method is one of the methods in transportation model that can find the optimal solution without having to find an initial feasible solution to minimize costs or maximize profits [1].

Previous research about Revised ASM method by Quddoos et al. (2016) aims to get the optimal solution directly. But in some unbalanced problems, the ASM method sometimes does not provide an optimal solution directly. So the MODI method or

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Stepping Stone Method can be apply to get the optimal solution at the end. The results show that the Revised ASM method can achieve the optimal solution with a smaller number of iterations using the MODI method [2].

Previous research by Murugesan & Esakkiammal (2019) aims to show that the Revised ASM method can solve balanced and unbalanced transportation problems. The results show that ASM produces optimal solutions for some transportation problems, and there are close to optimal. ASM method is consider much better than using the VAM method [3].

Another study by Murugesan & Esakkiammal, (2020) aims to prove that the ASM method is optimal directly or very close to the optimal solution, beside that the ASM method has logical calculations and is easy to understand. The results show a total of 50 TP tested of which 20 TP were unbalanced transportation problems. The ASM method can be said to be apply much better than using other transportation methods [4].

This research is a extension from the previous research, which has been conducted by Devani & Chlarisya (2021) regarding Optimization of Chicken Egg Distribution Costs Using the Transportation Model with Stepping Stone Method [5]. Compared to the previous research, researcher used the feasible solution to solve transportion problem. That method need many iterations and steps. But, in this research, used a simple method with fewer iterations. The purpose of this research is to determine the optimal distribution sost of chicken eggs, compare the distribution socts of chicken eggs before and after optimization, and compare the ASM method with Stepping Stone method. Distribution costs that are considered quite expensive must be optimized, so the distribution costs incurred by the company can be minimize.

Methods

In this research, researcher discussed optimizing the distribution costs of chicken eggs using the revised ASM method. The data used in this research are chicken eggs demand data (car) from the period September 2020-February 2021, chicken eggs supply data (car) from the period September 2020-February 2021, distribution costs data and distance traveled (round trip). These data will be process as a basis for calculating the distribution costs of chicken egg using the ASM method and optimization testing using Stepping Stone method [6].

Transportation Model

The transportation model is the one of model that can be used to solve problems from program linear, such as optimizing product distribution from source location to several destination location [7]. If product distribution carried out randomly, it is consider not economic. So, need to do a good planning using transportation model [8].

There are two important things in transportation problems, first s products movement and then change the location of products from sources to different destinations. The difference in transportation costs from sources to destinations, need product delivery well structured [9]. The constraint of the transportation model are formulated as follows [10]:

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j \qquad (1)$$

Product allocation is well managed to minimize the total of distribution or transportation cost. There are constraints where if the demand is met, then the source will not allocate more than its capacity. Transportation problems can be amde in a table called transportation table. Source are written in rows and destinations in columns [11]. According to Suryaningtyas (2009) in transportation problems there are two types of problems, that are balanced transportation and unbalanced transportation. The transportation model can be said to be balanced if the total supplies and demands are equal [12] and the transportation model can be said to be unbalanced if the total supplies are not equal to the total demand.

The mathematical form if the transportation model is formulated as follows [13]:

$$\text{Min } Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij} \quad (2)$$

Constrains [14]:

$$\sum_{j=1}^{n} X_{ij} = a_i , \quad i = 1, 2, ..., m \quad (3)$$
$$\sum_{i=1}^{n} X_{ij} = b_j , \quad j = 1, 2, ..., m \quad (4)$$
$$x_{ij} \geq 0, i = 1,...., n, j = 1,...,m \quad (5)$$

Where [15]:
Z = Total cost of distribution
x_{ij} = Number of products form i to j
c_{ij} = Cost per unit from i to j
a_i = Quantity of offered product from i
b_j = Quantity of requested product by j
m = Number of soruce
n = Number of destination

After formulating the transportation model, made the basic assumptions in the transportation problems for this research. There are amount of transportation costs for allocation products on the route are proportional to the number of products distributed, and the amount of supply and demand are known. Next, solve transportation problems using the revised ASM method to calculate the distribution cost [16].

ASM Method

The ASM method or Abdul Quddoos, Shakeel Javaid and M. M. Khalid was introduced in 2012. The ASM method is one of the transportation methods that can find the optimal solution without having to find an fisible solution to minimize costs or maximize profits [17]. The ASM method focuses the reduced cost on rows and columns that have cost of 0, so it can determine the index of the number of 0 in the-*ii* row or the-*jj* column other than the number 0 is selected. Allocation products in this method is done from the smallest index [18]. The ASM method can be used to solve balanced transportation problems. While the unbalanced transportation problems requires an improvement called the revised ASM method.

According to Quddoos et al. (2012) the following are the steps in the ASM method [19]:

1. Create or make a transportation matrix table.
2. Reduce the cost entry of each row in the transportation table by the minimum of each row, after the new or reduced table is generated then reduce the cost entry of each column in the transportation table after reducing the cost entry of each row.
3. The reduced cost matrix will have one or more zero in each row or column. Select the first zero and check the (*i,j*) zero selected, count the total number of zero in row *i* and column *j*. After that select the next zero, calculate the total number of zero in the row and column in the same way.
4. Select the number of zero that have been calculated in the previous step, and allocate supply and demand to the cells. If there is more than one number of zero, then select one of them.
5. Delete rows or columns that already full for calculation, where the supply of the source will run out or the demand of the destination has been met. Check the result matrix, where there is at least have one zero in each row and column. If there is No. one zero in a row or column, repeat the second step.
6. Repeat the fourth step until all demands are met and all supplies out of stock, so finally obtain the optimal cost.

The following are the steps of solving using the latest modified method of the ASM method [2]:

1. Make a transportation table and check if the transportation problem already balanced or unbalanced.
2. If the problem is unbalanced, then one of the following two problems will come:
   a. If the total supply is more than the total demand, then a dummy column is added to make it balanced. The unit transportation cost for the dummy column cell is set to M where M > 0 which is very large but finite positive quantity.
   b. If the total demand more than the total supply, than a dummy row is added to make it balanced. The

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transportation cost for dummy row cell unit is set to M where M > 0 which a very large but finite positive quantity.

3. Then, proceed to the following steps:
   a. For case (a) identify the lowest element of each row and subtract each element from each row. Identify the lowest element of each column and subtract each element from each column, go to step 5.
   b. For case (b) identify the lowest element of each column and subtract from each element of each column. Identify the lowest elemnt of each row and subtrat from each element of each row, go to step 5.
4. Identify the lowest element of each row and subtract from each row. From the result table, identify the lowest elemnt of each column and subtract from each column.
5. From the reduced table, each row and column contains at least one zero. Now, select the first 0 and count the number of 0 exclude the selected 0 in the row and column. Repeat the process step for all 0 in the transportation table.
6. Now, select the cell that have zero where the index value is smallest and the largest possible supply in that cell. If there are still some number 0 from step 5, select the value 0 that can allocate the cell with the largest quantity by looking at the supply and demand of the cell. The maximum supply allow the quantity in that cell.
7. Delete a row or column, to consider the supply from a particular source is out of stock or the demand for a particular destination has been met. If at some step, the demand of the column has been met and the supply of the row has been out of stock, delete one of the remaining columns and rows to set the supply or demand as 0 for the next calculation.
8. Check if the reduced table contains at least one 0 in each row and column. If not, then repeat step 4. Otherwise go to step 9.
9. Repeat step 5 to step 8, until all demands have been met and all supplies have been out of stock.

Results and Discussions

Transportation problems in this research is unbalanced transportation, where the amount of supply is greater than the amount of demand. That's need to add destination activities or dummy columns, so the unbalanced problem become balanced transportation.

The following solution to the transportation problem using ASM method can see in Table 1, by creat a transportation matrix first:

Table 1. Transportation Matrix

Demand / Supply	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	*Dummy*	*Supply*
S_1	0	4.500.000	3.000.000	2.500.000	5.500.000	3.000.000	5.800.000	500.000	8.500.000	6.000.000	0	69
S_2	0	4.500.000	3.000.000	2.500.000	5.500.000	3.000.000	5.800.000	500.000	8.500.000	6.000.000	0	96
S_3	900.000	5.000.000	3.200.000	3.000.000	5.800.000	2.700.000	6.000.000	500.000	8.800.000	6.000.000	0	16
S_4	3.000.000	2.500.000	0	1.000.000	3.500.000	5.500.000	4.800.000	3.000.000	7.500.000	5.500.000	0	121
S_5	3.000.000	2.500.000	0	1.000.000	3.500.000	5.500.000	4.800.000	3.000.000	7.500.000	5.500.000	0	60
S_6	6.500.000	3.500.000	5.700.000	5.500.000	2.700.000	8.500.000	1.500.000	6.500.000	7.000.000	800.000	0	1
S_7	2.500.000	2.000.000	1.000.000	0	3.000.000	5.000.000	4.500.000	3.000.000	7.000.000	5.000.000	0	78
S_8	2.500.000	2.000.000	1.000.000	0	3.000.000	5.000.000	4.500.000	3.000.000	7.000.000	5.000.000	0	32
S_9	500.000	4.800.000	3.200.000	3.000.000	5.500.000	2.500.000	6.000.000	0	8.800.000	6.000.000	0	30
Demand	52	46	106	82	38	30	16	110	15	5	3	503

After creat the transportation matrix, the cost in the dummy column is changed. Where the transportation unit cost for the cell of dummy column is set to M where M > 0. So that the results are obtained in the following Table 2:

Table 2. Replacement of Dummy Values

Demand / Supply	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	*Dummy*	*Supply*
S_1	0	4.500.000	3.000.000	2.500.000	5.500.000	3.000.000	5.800.000	500.000	8.500.000	6.000.000	8.800.000	69
S_2	0	4.500.000	3.000.000	2.500.000	5.500.000	3.000.000	5.800.000	500.000	8.500.000	6.000.000	8.800.000	96
S_3	900.000	5.000.000	3.200.000	3.000.000	5.800.000	2.700.000	6.000.000	500.000	8.800.000	6.000.000	8.800.000	16
S_4	3.000.000	2.500.000	0	1.000.000	3.500.000	5.500.000	4.800.000	3.000.000	7.500.000	5.500.000	8.800.000	121
S_5	3.000.000	2.500.000	0	1.000.000	3.500.000	5.500.000	4.800.000	3.000.000	7.500.000	5.500.000	8.800.000	60
S_6	6.500.000	3.500.000	5.700.000	5.500.000	2.700.000	8.500.000	1.500.000	6.500.000	7.000.000	800.000	8.800.000	1
S_7	2.500.000	2.000.000	1.000.000	0	3.000.000	5.000.000	4.500.000	3.000.000	7.000.000	5.000.000	8.800.000	78
S_8	2.500.000	2.000.000	1.000.000	0	3.000.000	5.000.000	4.500.000	3.000.000	7.000.000	5.000.000	8.800.000	32
S_9	500.000	4.800.000	3.200.000	3.000.000	5.500.000	2.500.000	6.000.000	0	8.800.000	6.000.000	8.800.000	30
Demand	52	46	106	82	38	30	16	110	15	5	3	503

Next, reduction the row by identify the lowest element in each row and subtract from each element of each row with the smallest cost, the results in Table 3:

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Table 3. Row Reduction Result

Demand / *Supply*	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	*Dummy*	*Supply*
S_1	0	4.500.000	3.000.000	2.500.000	5.500.000	3.000.000	5.800.000	500.000	8.500.000	6.000.000	8.800.000	69
S_2	0	4.500.000	3.000.000	2.500.000	5.500.000	3.000.000	5.800.000	500.000	8.500.000	6.000.000	8.800.000	96
S_3	400.000	4.500.000	2.700.000	2.500.000	5.300.000	2.200.000	5.500.000	0	8.300.000	5.500.000	8.300.000	16
S_4	3.000.000	2.500.000	0	1.000.000	3.500.000	5.500.000	4.800.000	3.000.000	7.500.000	5.500.000	8.800.000	121
S_5	3.000.000	2.500.000	0	1.000.000	3.500.000	5.500.000	4.800.000	3.000.000	7.500.000	5.500.000	8.800.000	60
S_6	5.700.000	2.700.000	4.900.000	4.700.000	1.900.000	7.700.000	700.000	5.700.000	6.200.000	0	8.000.000	1
S_7	2.500.000	2.000.000	1.000.000	0	3.000.000	5.000.000	4.500.000	3.000.000	7.000.000	5.000.000	8.800.000	78
S_8	2.500.000	2.000.000	1.000.000	0	3.000.000	5.000.000	4.500.000	3.000.000	7.000.000	5.000.000	8.800.000	32
S_9	500.000	4.800.000	3.200.000	3.000.000	5.500.000	2.500.000	6.000.000	0	8.800.000	6.000.000	8.800.000	30
Demand	52	46	106	82	38	30	16	110	15	5	3	503

Next, reduction the columns by identify the lowest element in each column and subtract from each element. Each column with the smallest cost, the results in Table 4:

Table 4. Column Reduction Result

Demand / *Supply*	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	*Dummy*	*Supply*
S_1	0	2.500.000	3.000.000	2.500.000	3.600.000	800.000	5.100.000	500.000	2.300.000	6.000.000	800.000	69
S_2	0	2.500.000	3.000.000	2.500.000	3.600.000	800.000	5.100.000	500.000	2.300.000	6.000.000	800.000	96
S_3	400.000	2.500.000	2.700.000	2.500.000	3.400.000	0	4.800.000	0	2.100.000	5.500.000	300.000	16
S_4	3.000.000	500.000	0	1.000.000	1.600.000	3.300.000	4.100.000	3.000.000	1.300.000	5.500.000	800.000	121
S_5	3.000.000	500.000	0	1.000.000	1.600.000	3.300.000	4.100.000	3.000.000	1.300.000	5.500.000	800.000	60
S_6	5.700.000	700.000	4.900.000	4.700.000	0	5.500.000	0	5.700.000	0	0	0	1
S_7	2.500.000	0	1.000.000	0	1.100.000	2.800.000	3.800.000	3.000.000	800.000	5.000.000	800.000	78
S_8	2.500.000	0	1.000.000	0	1.100.000	2.800.000	3.800.000	3.000.000	800.000	5.000.000	800.000	32
S_9	500.000	2.800.000	3.200.000	3.000.000	3.600.000	300.000	5.300.000	0	2.600.000	6.000.000	800.000	30
Demand	52	46	106	82	38	30	16	110	15	5	3	503

Each row and column has one zero, select the first zero and count the number of zero exclude the selected one in the row or column. Where the first smallest index in cell x_{11}, so allocate as much as possible in that cell. After the supply or demand in particular row or column has been met, reallocate to the cell with the smallest index of 0. Check again the table at least has one 0 in each row and column. Continue until all supplies are out of stock and demand is met. The ASM method reduces row and column costs, so there are 0 values on matrix. It change the dummy costs from reduction results [20].

The following Table 5 shows the results of the transportation problem using the ASM method:

Table 5. Transportation Problem Results Using the ASM Method

Demand / Supply	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	Dummy	Supply
S_1	0 50	4.500.000	3.000.0000	2.500.000	5.500.000	3.000.000	5.800.000 12	500.000	8.500.000	6.000.000 4	0 3	69
S_2	0 2	4.500.000	3.000.000	2.500.000	5.500.000	3.000.000	5.800.000	500.000 94	8.500.000	6.000.000	0	96
S_3	900.000	5.000.000	3.200.000	3.000.000	5.800.000	2.700.000 16	6.000.000	500.000	8.800.000	6.000.000	0	16
S_4	3.000.000	2.500.000 15	0 106	1.000.000	3.500.000	5.500.000	4.800.000	3.000.000	7.500.000	5.500.000	0	121
S_5	3.000.000	2.500.000 31	0	1.000.000	3.500.000 10	5.500.000	4.800.000 4	3.000.000	7.500.000 15	5.500.000	0	60
S_6	6.500.000	3.500.000	5.700.000	5.500.000	2.700.000	8.500.000	1.500.000	6.500.000	7.000.000	800.000 1	0	1
S_7	2.500.000	2.000.000	1.000.000	0 78	3.000.000	5.000.000	4.500.000	3.000.000	7.000.000	5.000.000	0	78
S_8	2.500.000	2.000.000	1.000.000	0 4	3.000.000 28	5.000.000	4.500.000	3.000.000	7.000.000	5.000.000	0	32
S_9	500.000	4.800.000	3.200.000	3.000.000	5.500.000	2.500.000 14	6.000.000	0 16	8.800.000	6.000.000	0	30
Demand	52	46	106	82	38	30	16	110	15	5	3	503

$$Z = c_{11}x_{11} + c_{18}x_{18} + c_{111}x_{111} + c_{26}x_{26} + c_{28}x_{28} + c_{29}x_{29} + c_{210}x_{210} + c_{36}x_{36} + c_{42}x_{42} + c_{43}x_{43} + c_{52}x_{52} + c_{55}x_{55} + c_{57}x_{57} + c_{510}x_{510} + c_{610}x_{610} + c_{74}x_{74} + c_{82}x_{82} + c_{84}x_{84} + c_{98}x_{98}$$

$$Z = 0(52) + 500.000(14) + 0(3) + 3.000.000(14) + 500.000(66) + 8.500.000(15) + 6.000.000(1) + 2.700.000(16) + 2.500.000(15) + 0(106) + 2.500.000(3) + 3.500.000(38) + 4.800.000(16) + 5.500.000(3) + 800.000(1) + 0(78) + 2.000.000(28) + 0(4) + 0(30)$$

$$Z = \text{Rp. } 586.800.000$$

Minimum total cost with optimal solution using the ASM method is Rp. 586,800,000.

After determined the optimal solution of ASM method, the result of the ASM method will tested using the Stepping Stone method. This aims to check the optimality of the ASM method solution.

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Table 6. Test Results Using the Stepping Stone Method

Demand / Supply	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	Dummy	Supply
S_1	0 52	4.500.000	3.000.0000	2.500.000	5.500.000	3.000.000	5.800.000	500.000 14	8.500.000	6.000.000	0 3	69
S_2	0	4.500.000	3.000.000	2.500.000	5.500.000	3.000.000 14	5.800.000	500.000 66	8.500.000 12	6.000.000 4	0	96
S_3	900.000	5.000.000	3.200.000	3.000.000	5.800.000	2.700.000 16	6.000.000	500.000	8.800.000	6.000.000	0	16
S_4	3.000.000	2.500.000 12	0 106	1.000.000	3.500.000	5.500.000	4.800.000	3.000.000	7.500.000 3	5.500.000	0	121
S_5	3.000.000	2.500.000 6	0	1.000.000	3.500.000 38	5.500.000	4.800.000 16	3.000.000	7.500.000	5.500.000	0	60
S_6	6.500.000	3.500.000	5.700.000	5.500.000	2.700.000	8.500.000	1.500.000	6.500.000	7.000.000	800.000 1	0	1
S_7	2.500.000	2.000.000	1.000.000	0 78	3.000.000	5.000.000	4.500.000	3.000.000	7.000.000	5.000.000	0	78
S_8	2.500.000	2.000.000 28	1.000.000	0 4	3.000.000	5.000.000	4.500.000	3.000.000	7.000.000	5.000.000	0	32
S_9	500.000	4.800.000	3.200.000	3.000.000	5.500.000	2.500.000 14	6.000.000	0 30	8.800.000	6.000.000	0	30
Demand	52	46	106	82	38	30	16	110	15	5	3	503

$$Z = c_{11}x_{11} + c_{18}x_{18} + c_{111}x_{111} + c_{26}x_{26} + c_{28}x_{28} + c_{29}x_{29} + c_{210}x_{210} + c_{36}x_{36} + c_{42}x_{42} + c_{43}x_{43} + c_{49}x_{49} + c_{52}x_{52} + c_{55}x_{55} + c_{57}x_{57} + c_{610}x_{610} + c_{74}x_{74} + c_{82}x_{82} + c_{84}x_{84} + c_{98}x_{98}$$

$$Z = 0(52) + 500.000(14) + 0(3) + 3.000.000(14) + 500.000(66) + 8.500.000(12) + 6.000.000(4) + 2.700.000(16) + 2.500.000(12) + 0(106) + 7.500.000(3) + 2.500.000(6) + 3.500.000(38) + 4.800.000(16) + 800.000(1) + 0(78) + 2.000.000(28) + 0(4) + 0(30)$$

$$Z = \text{Rp. } 585.300.000$$

There is no more negative value, so the solution is already optimal in testing the ASM method using the Stepping Stone method.

The total minimum cost after being tested using the Stepping Stone method on the ASM method is Rp. 585,300,000. This costs show the same cost in previous research [5].

After ASM method test by using Stepping Stone method. It’s known that the ASM method in this research has not provided an optimal solution directly. Using the Stepping Stone method decrease the cost by Rp. 1,500,000 from Rp. 586,800,000. While the difference costs before and after optimize using ASM method, show that ASM method save distribution costs by Rp. 93,300,000 or 13.7%, from the previous costs of which is Rp. 680,100,000.

Conclusions

Based on the results of testing the revision ASM method using Stepping Stone method, it show that the ASM method can minimize distribution costs by Rp. 93,300,000 or 13.7% from the previous costs Rp. 680,100,000, but the results have not provide an optimal solution to some unbalanced problems or the addition of destination activities. So, it is necessary to test the optimal solution using the Stepping Stone method. However, the ASM method results is almost close to the optimal solution value. Data processing with the ASM method show the simple and shorten optimal solution problem solving than using the Stepping Stone method, but the Stepping Stone method shows more optimal results than the ASM method.

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Conflict of Interest
The authors declare no conflict of interest.

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