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Implementation of Q.S. Ahmad Modification Method to Unbalanced Transportation Problems: case study CV. Tiga Putra Mandiri West Java, Indonesia

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ABSTRACT:In transportation problems, there are several important things, namely the existence of sources, destinations, supply and demand, distribution costs, and a balance between the amount of inventory at the source and the amount of demand from the destination. The balance between the amount of supply and the amount of demand means that the transportation problem must be in balance. In its application, there are many cases where the amount of inventory is not the same as the amount of demand or it is called an unbalanced transportation problem. This final project discusses the solution to the unbalanced transportation problem using the modified method introduced by Q. S. Ahmad to obtain an initial feasible solution so that the distribution costs incurred are minimum. The modified method of Q. S. Ahmad consists of four reduction steps in which the Goyal method and the VAM method are applied. Then perform an optimality test on the initial feasible solution obtained to obtain the optimal solution. Furthermore, the results of the initial feasible solution from the Q. S. Ahmad Method - Optimality Test will be compared with the results of the initial feasible solution from the VAM Method - Optimality Test.

KEYWORDS: Unbalanced Transportation Problem, Initial Possible Solution, Q. S. Ahmad Modification Method, VAM, Optimal Solution

I. INTRODUCTION

In the industrial field, the transportation method is a method used to solve transportation problems or the distribution of units from several sources to one another several destinations with the principle of the most minimum cost, each of which has a certain supply capacity and each place destination has certain demand limits as well [1]. In the transportation problem [2-6] there are several important things in it, namely the source, destination, supply and demand, distribution costs, and the balance between the quantity inventory at source with the number of requests from 2 destinations. The balance between the amount of supply with the amount of demand means that the transportation problem must be in balance. In its application, there are many cases where the amount of inventory is not the same as the number of requests or it is called a transportation problem balanced.

To solve the problem of unbalanced transportation, balancing is done by adding pseudo variables, namely adding an origin or destination dummy according to the cause of the imbalance. The addition of a dummy causes the presence of distribution costs are zero for certain allocations, because in reality the allocation from the origin dummy to the destination dummy does not really exist. Generally, transportation problems are solved in two stages, namely determining the initial feasible solution and conducting tests the optimality of the initial feasible solution obtained. To determine the initial feasible solution, several methods can be used, including the North West Corner Method (NWCM), Least Cost Method (LCM), and Vogel's Approximation Method (VAM). Whereas for Optimality test can use the Stepping Stone (SS) Method and the Modified Method Distribution (MODI), and Potential Methods[7].

As time goes by, new methods emerge to determine the initial feasible solution. One of the methods proposed by Q. S. Ahmad [8]. The method proposed by Q. S. Ahmad focuses on determining the initial feasible solution to the unbalanced transportation problem. The method consists of four steps of

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reduction by applying the Goyal method and one step by applying the VAM method. The difference between this method and the method Another method is to reduce the initial table of the unbalanced transportation problem, then apply Goyal's method to balance the unbalanced transportation table, namely by replace or assume transportation costs on the dummy variable with the largest and non-zero cost which then applies the VAM method in the last step.

II. BASIC THEORY

2.1 Transportation Method

The transportation method is a method that can be used to solve transportation problem in the form of problems with the delivery or distribution of units from several sources to several destinations with the principle of the lowest shipping costs minimum. With each source having an inventory capacity or certain delivery (supply), while each destination has certain demands (demand) as well [9]. Here is a picture of the transportation problem network in general.

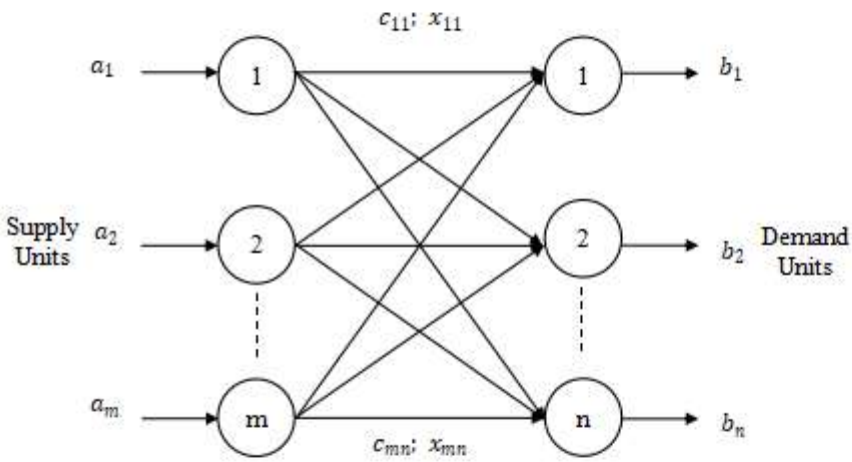

Figure 2.1: Transportation Problem Network in General

In general, the transportation problem is depicted through the network in Figure 2.1. From the place of origin (source) to the place of destination is connected by a route that brings units where supply (supply) at source i is a_i and demand (demand) at destination j is b_j , the number of units distributed is x_{ij} and the transportation cost or delivery from source i to destination j is c_{ij} . In Figure 2.1 there are m sources and n destinations, each represented by a point and an arc connecting source with the aim of describing the paths between source and destination. The arcs (i,j) connecting source i to destination j carry two pieces of information, namely the transportation or shipping costs per unit c_{ij} and the number of units shipped x_{ij} . The purpose of the model is to determine the value of x_{ij} which minimize total transportation or shipping costs while meeting all supply and demand constraints.

The transportation problem can be modeled mathematically by forming the function destination that shows the cost of transportation or delivery from source ito destination j, then the linear programming model for transportation problems can be formulated as following[9]: Purpose function:

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

With a constraint or constraint function:

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

$$\sum_{j=1}^{m} c_{ij} = b_j, \text{for} j = 1,2,\ldots,n$$

$x_{ij} \geq 0$ for all iand j

Information:
m: number of sources i (supply)
n : number of destinations j (demand)
a_i : number of units available in source i
b_j : the number of units demanded or needed for the purpose of j
x_{ij} : number of units to be sent from source i to destination j
c_{ij} : total transportation cost per unit from source i to destination j
Z : objective function; total transportation cost

In the transportation problem, the ability of sources to provide units($\sum_{i=1}^{m} a_i$) is not always equal to the number of requests from several destinations

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$(\sum_{j=1}^{n} b_j)$. There are three possibilities that occur in transportation problems, namely[10]:

1. $\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$
2. $\sum_{i=1}^{m} a_i \geq \sum_{j=1}^{n} b_j$
3. $\sum_{i=1}^{m} a_i \leq \sum_{j=1}^{n} b_j$

The following definitions relate to the initial feasible solution and the optimal solution to the transportation problem:

Definition 2.1 [11]A set x_{ij} 0, i= 1,2, …,m ;j= 1,2, …,n which satisfies constraint on the transportation problem is the initial feasible solution.

Definition 2.2[12]It is known that the set $\{x_{ij} \geq 0 | \sum_{j=1}^{n} x_{ij} = a_i, i = 1,2,\dots,m; \sum_{i=1}^{m} x_{ij} =$ bj,j=1,2,…,n is a feasible solution the beginning of the transportation problem. The initial feasible solution $x_{ij}^* \in X$ is said to be the optimal solution transportation problem (minimum case) if $\sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij}^* \leq \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij}$ for each $x_{ij} \in X$.

Theorem 2.1 [10]For any optimal solution to the transportation problem (P_1) is the optimal solution of the transportation problem (P).

Proof: Take any $X^0 = \{x_{ij}^0 \geq 0 | i = 1,2,\dots,m; j =$ 1,2,...,n is a solution optimal of the transportation problem (P_1) then

$$Z^* = \sum_{i=1}^{m}\sum_{j=1}^{n} (c_{ij} - u_i - v_j)x_{ij}$$
$$= \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij}^0 - \sum_{i=1}^{m}\sum_{j=1}^{n} u_i x_{ij}^0 - \sum_{i=1}^{m}\sum_{j=1}^{n} v_j x_{ij}^0$$
$$= \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij}^0 - \sum_{i=1}^{m} u_i \sum_{j=1}^{n} x_{ij}^0 - \sum_{j=1}^{n} v_j \sum_{i=1}^{m} x_{ij}^0$$
$$= Z - \sum_{i=1}^{m} u_i a_i - \sum_{j=1}^{n} v_j b_j$$

This means that $\sum_{i=1}^{m} u_i a_i$ and $\sum_{j=1}^{n} v_j b_j$ are independent of X^0 where $X^0 = \{x_{ij}^0 \geq 0 | i =$ 1,2,...,m;j=1,2,...,n so that any optimal solution of The transportation problem (P_1) is also any optimal solution of the transportation problem (P). ■

Theorem 2.2 [10]If $X^0 = \{x_{ij}^0 \geq 0 | i = 1,2,\dots,m; j = 1,2,\dots,n\}$ initial feasible solution from the transport problem (P) and $(c_{ij} - u_i - v_j) \geq 0$ for all i and j with ui and vj is a real number, such that the minimum of the transportation problem (P1) value 0, then $\{x_{ij}^0 \geq 0\}$ is the optimal solution of the transport problem P.

Proof: Taken any $\{x_{ij}^0 \geq 0 | i = 1,2,\dots,m; j = 1,2,\dots,n\}$ initial feasible solution of transportation problem (P), means meeting the transportation problem constraints (P), namely:

$$\sum_{i=1}^{n} x_{ij}^0 = a_i, \quad i = 1,2,\dots,m$$
$$\sum_{j=1}^{m} x_{ij}^0 = b_j, \quad j = 1,2,\dots,n$$
$$x_{ij}^0 \geq 0, \quad i = 1,2,\dots mandj = 1,2,\dots n$$

Since $(c_{ij} - u_i - v_j) \geq 0, \forall i,j$ and u_i, v_j are real numbers and it is known that (P_1) minimizes $Z^* = \sum_{i=1}^{m}\sum_{j=1}^{n}(c_{ij} - u_i - v_j)x_{ij}^0 = 0$
with obstacles

$$\sum_{i=1}^{n} x_{ij}^0 = a_i, \quad i = 1,2,\dots,m$$
$$\sum_{j=1}^{m} x_{ij}^0 = b_j, \quad j = 1,2,\dots,n$$
$$x_{ij}^0 \geq 0, \quad i = 1,2,\dots mandj = 1,2,\dots n$$

This means that

Min $\sum_{i=1}^{m}\sum_{j=1}^{n}(c_{ij} - u_i - v_j)x_{ij}^0 = 0$

$\Leftrightarrow$ min $\left(\sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij}^0 - \sum_{i=1}^{m}\sum_{j=1}^{n} u_i x_{ij}^0 - \sum_{i=1}^{m}\sum_{j=1}^{n} v_j x_{ij}^0\right) = 0$

$\Leftrightarrow$ min $\left(\sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij}^0 - \sum_{i=1}^{m} u_i \sum_{j=1}^{n} x_{ij}^0 - \sum_{j=1}^{n} v_j \sum_{i=1}^{m} x_{ij}^0\right) = 0$

$\Leftrightarrow$ min $\left(Z - \sum_{i=1}^{m} u_i a_i - \sum_{j=1}^{n} v_j b_j\right) = 0$

$\Leftrightarrow$ min $\left(Z - \left(\sum_{i=1}^{m} u_i a_i + \sum_{j=1}^{n} v_j b_j\right)\right) = 0$

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$$\Leftrightarrow Z - \left(\sum_{i=1}^{m} u_i a_i + \sum_{j=1}^{n} v_j b_j\right) = 0$$

$$Z = \sum_{i=1}^{m} u_i \sum_{j=1}^{n} x_{ij}^0 + \sum_{j=1}^{n} v_j \sum_{i=1}^{m} x_{ij}^0$$

$$= \sum_{j=1}^{n} \sum_{i=1}^{m} (u_i + v_j) x_{ij}^0$$

Because the one that minimizes costs is $c_{ij} - u_i - v_j = 0$, then $c_{ij} = u_i + v_j$ so $Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}^0$ fulfill

$$\sum_{i=1}^{n} x_{ij}^0 = a_i, \qquad i = 1,2,\ldots,m$$

$$\sum_{j=1}^{m} x_{ij}^0 = b_j, \qquad j = 1,2,\ldots,n$$

$$x_{ij}^0 \geq 0, \qquad i = 1,2, \ldots m and j = 1,2, \ldots n$$

$$Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}^0$$

This means that $\{x_{ij}^0 \geq 0 | i = 1,2, \ldots, m; j = 1,2, \ldots, n\}$ is the optimal solution of the problem transportation (P_1).

From Theorem 3.3 then $\{x_{ij}^0 \geq 0 | i = 1,2, \ldots, m; j = 1,2, \ldots, n\}$ is the optimal solution of transportation problems (P).■

2.2 Q. S. Ahmad Modification Method

The unbalanced transportation problem can be transformed into a balanced transportation problem by adding a dummy column/row with zero cost. Method proposed by Q. S. Ahmad consists of four steps of reduction and one step of the VAM method. The four reduction steps proposed, Q. S. Ahmad applies the Goyal method in the second step [8]. To harness the full potential of VAM to find solutions good initial feasibility of the unbalanced transportation problem, Goyal[13] suggested that the transportation costs to or from the dummy column/row should be replaced/assumed the same with the largest, non-zero unit of transportation cost before applying the VAM method. With this modification, the unit allocation to the dummy column/row is given the lowest priority and the column/row penalty cost/opportunity cost is considered. in each iteration. Therefore, it often results in an initial feasible solution at a lower cost. Q. S. Ahmad subtracts the smallest element from each column in the unbalanced transportation problem cost matrix before applying Goyal's technique or method. Then after applying the Goyal method, in the third and fourth steps Q. S. Ahmad subtracted the rows and columns before applying the VAM method in step last

Below are the steps to determine the initial feasible solution to unbalanced transportation problem using the Q. S. Ahmad method [8]:

Step 1: Formulate the existing problem in the form of a transportation problem by constructing the problem transportation into the initial table of transportation problems

Step 2: Choose the smallest c_{ij} cost in the initial table of the transportation problem unbalanced of all the elements in the initial table of unbalanced transportation problems Step 3: Subtract all the elements in the initial table of the unbalanced transportation problem with the smallest c_{ij} cost selected on previous step

Step 4: After obtaining the unbalanced transportation problem table the results of the first cost reduction then choose the largest c_{ij} cost of all the elements in the table

Step 5: Add a dummy column/row variable to balance the unbalanced transport problem table by applying Goyal's method to the transportation problem table unbalanced Step 5, namely by replacing or assuming zero cost with the largest c_{ij} cost selected in the previous step as an element for the dummy column/row variable

Step 6: Choose the smallest c_{ij} cost in each row and then subtract all elements in each row with the smallest c_{ij} cost are selected for each row. In this step, the transportation problem table is obtained second cost reduction result

Step 7 : Choose the smallest c_{ij} cost in each column and then subtract all elements in each column with the smallest c_{ij} cost selected for each column. In this step, the transportation problem table is obtained third cost reduction result

Step 8 : Apply the VAM method to the result transport problem table cost reduction in the previous step to obtain a table of initial feasible solutions to the balanced transportation problem

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Step 9 : Enter the values that have been allocated in the initial feasible solution table obtained in the previous step into the initial table of the unbalanced transportation problem by adding a dummy column/row variable with a zero cost element for calculate transportation costs $Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij}\, x_{ij}$ incurred

The steps of the Q. S. Ahmad method are completed after obtaining the transportation costs Z in Step 9. In working on the Q. S. Ahmad method to determine the initial feasible solution there are integers that are smaller, have zero elements in each row or column in the final matrix, and fewer iterations for achieve optimality compared with iterations of the initial feasible solution by the later VAM method optimized. Then after obtaining Z, then the optimality of the results is carried out The initial feasible solution obtained is whether it is optimal or not.

III. DISCUSSION

This section discusses the application of the Q. S. Ahmad method to determine the initial feasible solution in the distribution of CV.Tiga Putra Mandiri with brand King Katul who is in Ds. Rangdu, Pusakajaya District, Subang Regency, West Java, owned by Mr. Wartono. Data retrieval includes the amount of inventory in each warehouse, the number of requests from each consumer, and distribution costs per kilogram from each warehouse to each consumer. Rice bran distribution costs from each warehouse to each customer differ according to the distance presented in the table as follows:

Table 3.1 Rice bran delivery costs (Rp/kg)

Consumer / Warehouse	New Hope	CPI	Tulung Agung	Supply
ND Jaya	150	140	300	50
Sandi Jaya	150	140	300	55
TK	170	165	330	50
RW	165	160	320	30
PRJ	155	145	310	20
STE	165	155	320	50
Permintaan	90	90	30	210 / 225

The remaining inventory of products that are not delivered will be stored in the warehouse.

After being solved using the Q. S. Ahmad method, the results are in the form of an initial solution table which is shown in Table 3.2.

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Table 3.2 Table of InitialFeasibleSolution

<table>
<tr><td colspan="2">From \ To</td><td colspan="4">CONSUMER</td><td rowspan="2">Supply (a_i)</td></tr>
<tr><td colspan="2"></td><td>New Hope</td><td>CPI</td><td>Tulung Agung</td><td>Dummy</td></tr>
<tr><td rowspan="6">W A R E H O U S E</td><td>ND Jaya</td><td>150
0</td><td>140
20</td><td>300
30</td><td>0
x_{14}</td><td>50</td></tr>
<tr><td>Sandi Jaya</td><td>150
55</td><td>140
x_{22}</td><td>300
x_{23}</td><td>0
x_{24}</td><td>55</td></tr>
<tr><td>TK</td><td>170
5</td><td>165
x_{32}</td><td>330
x_{33}</td><td>0
45</td><td>50</td></tr>
<tr><td>RW</td><td>165
30</td><td>160
x_{42}</td><td>320
x_{43}</td><td>0
x_{44}</td><td>30</td></tr>
<tr><td>PRJ</td><td>155
x_{51}</td><td>145
20</td><td>310
x_{53}</td><td>0
x_{54}</td><td>20</td></tr>
<tr><td>STE</td><td>165
x_{61}</td><td>155
50</td><td>320
x_{63}</td><td>0
x_{64}</td><td>50</td></tr>
<tr><td colspan="2">Demand (b_j)</td><td>90</td><td>90</td><td>30</td><td>45</td><td>255</td></tr>
</table>

Then calculate the transportation costs incurred. From Table 3.2 obtained optimal allocation as follows: $X_{11} = 0,\ X_{12} = 20,\ X_{13} = 30,\ X_{14} = 0, X_{21} = 55,\ X_{22} = 0,\ X_{23} = 0,\ X_{24} = 0,\ X_{31} = 5,\ X_{32} = 0,\ X_{33} = 0,\ X_{34} = 45,\ X_{41} = 30,\ X_{42} = 0,\ X_{43} = 0,\ X_{44} = 0, X_{51} = 0,\ X_{52} = 20,\ X_{53} = 0,\ X_{54} = 0,\ X_{61} = 0,\ X_{62} = 50,\ X_{63} = 0,\ X_{64} = 0$ So that the total transportation costs are:

$$Z = \sum_{i=1}^{6} \sum_{j=1}^{4} c_{ij} x_{ij}$$

$$= (150 \times 0) + (140 \times 20) + (300 \times 30) + (150 \times 55) + (170 \times 5) + (0 \times 45) + (165 \times 30) \times (145 \times 20) \times (155 \times 50)$$

$$= 0 + 2800 + 9000 + 8250 + 850 + 0 + 4950 + 2900 + 7750$$

$$= 36500$$

By using the Q. S. Ahmad method, the transportation cost is Rp. 36,500, - for every 255 kilograms. So that the transportation costs incurred for 255 tons is IDR 36,500,000,-.

IV. CONCLUSION

From the completion and the results obtained, it can be concluded that the Q. S. Ahmad method has advantages and disadvantages in the process of its use to determine the initial feasible solution. The advantage of the Q. S. Ahmad method is that the initial feasible solution results obtained are more minimum or close to optimal than the initial feasible solution results. using the VAM method. In addition, in the required iteration optimization test of Q. S. Ahmad Method – Optimal Test is less than iterations in VAM Method - Optimal Test. On the other hand, the Q. S. Ahmad method also has drawbacks, namely steps the solution to the problem of unbalanced transportation is longer and the time it takes longer than the VAM Method, and can only be used for transportation problems unbalanced with a small matrix.

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