Optimization of Crude Palm Oil Distribution Costs in PT. Perkebunan Nusantara III Using Vogel's Approximation Method, Russel Approximation Method and Stepping Stone Method

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Abstract. PT. Perkebunan Nusantara III is an Indonesian State-Owned Enterprise engaged in oil palm and rubber plantations. The company is headquartered in Medan, North Sumatra. In general, the distribution process of CPO is one of the most important aspects to be planned, because it will greatly affect the overall cost efficiency of the project. The increase in project costs is often caused by a CPO distribution process that is not optimal. The method used to solve the distribution optimization problem is Vogel's Approximation Method and Russel's Approximation Method to determine the initial solution and optimization test using the Stepping Stone method. From the results of the calculation of the Vogel's Approximation Method for the initial completion and continued by using the Stepping Stone Method is the method that gives optimal results. For the final settlement, a minimum fee of Rp. 34,417,014,501.

Keyword: Vogel's Approximation Method, Russel Approximation Method, Stepping Stone, Distribution Cost Optimization, Crude Palm Oil

1 Introduction

Transportation problems are problems that are often faced by every company in the distribution of goods. In distributing goods, of course, the company will incur significant transportation costs. To stay afloat in the face of its competitors, companies need a way to determine the distribution of goods from source to destination so that all the needs of each goal are met so that the company gets maximum profit [1].

In distributing Crude Palm Oil (CPO) to several destinations requires transportation costs that are not small in number because of the distance and conditions between different locations, then PT. Perkebunan Nusantara III requires a strategy to minimize transportation costs incurred by the company.

The transportation method is a method used in the distribution of sources that provide the same product to destinations optimally [2]. The allocation of this product must be arranged in such a way, because there are differences in the allocation costs from one source to a destination. There are several transportation methods that can be used to solve transportation problems including the completion of the initial solution, namely the North West Corner, Least Cost, Russel Approximation Method (RAM) and Vogel's Approximation Method (VAM) methods. The optimal solution is the Stepping Stone method and the Modified Distribution (MODI) method.

2 Literature review

2.1 Transportation Method

The method of transportation is a method used in the distribution of an item from sources to destinations optimally. The transportation problem was first formulated as a special procedure to obtain a minimum cost program in distributing homogeneous units of a product over a number of supply points (sources) to a number of demand points (destinations). All are placed at geographically different sources and destinations [3].

The specific characteristics of the transportation problem are [4]:

1. There are a number of sources and a certain number of destinations.
2. The quantity of commodities or goods distributed from each source and demanded by each destination is a certain magnitude.
3. Commodities sent or transported from a source to a destination are in accordance with the demand or capacity of the source.

4. The cost of transporting commodities from a source to a destination is of a certain magnitude.

Mathematically the transportation problem can be formulated as follows:

\[
\text{Minimalize } Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij}x_{ij} \quad (1)
\]

With obstacles:

\[
\sum_{j=1}^{n} x_{ij} = a_i \quad \text{for } i = 1, 2, 3, \ldots, m \quad \text{(Stock Obstacles)} \quad (2)
\]

\[
\sum_{i=1}^{m} x_{ij} = b_j \quad \text{for } j = 1, 2, 3, \ldots, n \quad \text{(Demand Obstacles)} \quad (3)
\]

Keterangan:

\[m\] = the place of origin of the goods transported
\[n\] = place of delivery of goods
\[x_{ij}\] = units sent from source \(i\) to destination \(j\)
\[c_{ij}\] = cost per unit from source \(i\) to destination \(j\)
\[a_i\] = supply capacity from source \(i\)
\[b_j\] = demand capacity from source \(j\)
\[i\] = \(1, 2, \ldots, m\)
\[j\] = \(1, 2, \ldots, n\)

2.2 Balanced Transportation

In the transportation model, if the total supply (supply) is equal to the total demand (demand), it is called a balanced transportation model. If the amount of available inventory is greater or less than the amount of demand, it is called an unbalanced model. The unbalanced transportation model must be balanced by adding dummy variable columns or dummy rows to balance supply and demand. The transportation cost for each column or row is IDR 0.

2.3 Vogel's Approximation Method

The Vogel's Approximation method is a method that allocates by minimizing the opportunity cost in selecting boxes for an allocation. The steps for Vogel's Approximation Method are as follows:

1. Calculate the opportunity cost for each row and column. The opportunity cost for each row \(i\) is calculated by subtracting the smallest \(c_{ij}\) value in that row from the \(c_{ij}\) value one level larger in the same row. The opportunity cost column is obtained in a similar way. These fees are a penalty for not selecting the box with the minimum cost.
2. Select the row or column with the largest opportunity cost (if there are twin values, choose arbitrarily). Allocate as much as possible to the box with the minimum \( c_{ij} \) value in the selected row or column.

3. Adjust supply and demand to show allocations made. Eliminate all rows and columns where supply and demand has been exhausted.

4. If all supply and demand have not been met, go back to step 1 and calculate the new opportunity cost again.

5. The process is continued in the same way until all requests are fulfilled.

### 2.4 Russell Approximation Method

The RAM method is a method whose allocation starts by determining the value for each row that is still possible to be allocated and the value for each column that may be allocated. The steps of the Russell Approximation Method are as follows:

1. Determines the highest distribution cost \( c_{ij} \) for each row and column.

2. Then calculate the difference in distribution costs of each cell with the formula \( \Delta C_{ij} = c_{ij} - u_i - v_j \).

3. Then the value is calculated for each cell that is allocated by selecting the cell with the largest negative value and making the allocation to that cell.

4. The process is continued in the same way until all requests are fulfilled.

### 2.5 Stepping Stone Method

Stepping stone method or stepping stone method which is a follow-up step from the initial solution method to get the optimal solution. The Stepping stone method changes the product allocation to get the optimal allocation using trial and error or trial and error. The steps of the Stepping Stone Method are as follows:

1. Select an unused blank cell that you want to evaluate.

2. Find the closest path (horizontal and vertical movement only) of this unused rectangle through the quadrilateral's footing back to the original unused rectangle. There is only one closest path for each unused cell in a given solution. Although we can use stepping stone paths or unused cells arbitrarily, the closest paths are only the cells we use as stepping stones and unused cells that are judged.

3. The plus sign (+) and minus (-) appear alternately at each corner of the cell from the nearest path, starting with a plus sign in an empty cell. Mark the rotation clockwise or vice versa.

4. Add up the unit costs in a rectangle with a plus sign as a sign of additional costs. The cost reduction is obtained by adding up the unit costs in each negative cell.
5. Repeat steps 1 to 4 for other blank cells, and compare the evaluation results of these blank cells. Choose the most negative evaluation value (meaning the greatest cost reduction), if there is no negative value in the empty cell evaluation, it means that the solution is optimal.

6. Change the path to the selected cells by allocating the smallest number of units from the cells marked with minus and adding them to cells marked with plus.

7. Repeat steps 1 s / d 6 until an index of improvement or evaluation of empty cells has no negative value is obtained.

3 Result and Discussion

3.1 Data collection
In distributing CPO from each POM to the company at PT. Perkebunan Nusantara III Medan, the data is made into a transportation table which can be seen in Table 1.

Table 1 Transportation table PT. Perkebunan Nusantara III

3.2 Initial Solution Completion with VAM
The Vogel's Approximation method is done by calculating the opportunity cost for each row or column. The following is a table of the results of the completion of the VAM method which can be seen in Table 2.
According to Table 2, total transportation cost is:

\[
Z = (178 \times 4.091.890) + (178 \times 7.676.667) + (178 \times 4.992.750) + (178 \times 2.773.003) + \\
(208 \times 15.058.532) + (195 \times 221.977) + (195 \times 1.998.340) + (167 \times 14.969.060) + \\
(167 \times 4.303.253) + (167 \times 4.360.897) + (160 \times 15.123.803) + (201.71 \times \\
11.562.850) + (171.38 \times 22.212.590) + (157.53 \times 21.298.713) + (151.88 \times \\
19.115.440) + (93.10 \times 16.316.713) + (148.09 \times 3.992.510) + (148.09 \times \\
2.496.030) + (102.97 \times 47.077) + (28.86 \times 30.692.850) + (97 \times 3.493.720) + \\
(68.04 \times 12.429.603) + (310 \times 13.516.797)
\]

\[Z = 34.551.775.160\]

### 3.3 Optimal Solution Solution with Stepping Stone Method

Based on the results table, the initial solution using the VAM method was followed by an optimality test using the Stepping Stone method. The following is a table of the final results using the Stepping Stone method, which can be seen in Table 3.
According to Table 3 using Stepping Stone method, total transportation cost is:

\[ Z = (178 \times 4.091.890) + (178 \times 7.676.667) + (178 \times 4.992.750) + (178 \times 2.773.003) + (208 \times 15.058.532) + (195 \times 221.977) + (195 \times 1.998.340) + (167 \times 14.969.060) + (167 \times 4.303.253) + (167 \times 4.360.897) + (160 \times 15.123.803) + (201.71 \times 11.562.850) + (171.38 \times 22.212.590) + (157.53 \times 21.298.575) + (151.88 \times 19.115.440) + (93.10 \times 18.812.743) + (148.09 \times 3.992.510) + (102.97 \times 47.077) + (28.86 \times 30.692.850) + (97 \times 3.493.720) + (68.04 \times 12.429.603) + (310 \times 13.516.797) + (311 \times 2.496.030) \]

\[ Z = 34.417.014.501 \]

3.4 Initial Solution Completion with RAM

The RAM method is done by calculating the difference between the highest distribution costs for each row and column. The following is a table of the results of the completion of the RAM method can be seen in Table 4.
According to Table 4, total transportation cost is:

\[ Z = (178 \times 4.091.890) + (178 \times 7.676.667) + (211,1 \times 2.772.433) + (178 \times 2.994.980) + (178 \times 1.998.340) + (208 \times 17.278.540) + (167 \times 4.148.510) + (160 \times 14.984.700) + (160 \times 154.743) + (201,71 \times 11.562.850) + (171,38 \times 22.212.590) + (157,53 \times 16.305.825) + (157,53 \times 4.992.750) + (151,88 \times 19.115.440) + (97 \times 3.446.643) + (68,04 \times 12.476.680) + (310 \times 13.516.797) \]

\[ Z = 34.682.143.105 \]

### 3.5 Optimal Solution with Stepping Stone Method

Based on the results table, the initial solution using the RAM method is followed by an optimality test using the Stepping Stone method. The following is a table of the final results using the Stepping Stone method, which can be seen in Table 5.
According to Table 5 using Stepping Stone method, total transportation cost is:

\[
Z = (178 \times 4,091,890) + (178 \times 7,676,667) + (178 \times 2,772,433) + (178 \times 2,994,980) + (178 \times 1,998,340) + (195 \times 2,220,317) + (15,658,822 \times 2) + (22,212,590) + (151,88 \times 19.115.440) + (93,10 \times 18.859.820) + (148,09 \times 3.992.510) + (28,86 \times 30.645.773) + (108 \times 47.077) + (97 \times 3.446.643) + (68,04 \times 12.476.680) + (310 \times 11.020.767) + (311 \times 2.496.030)
\]

\[
Z = 34,418,912,175
\]

### 4 Conclusion

From the results of the discussion of the total transportation costs obtained for the initial solution using the VAM method of Rp. 34,551,775,160 and the RAM method of Rp. 34,682,143,105, it can be concluded that the VAM method is the right method for the initial solution because it produces minimum costs compared to the RAM method. Based on the optimality test using the Stepping Stone method from the initial solution with the Vogel's Approximation method, the results of transportation costs are Rp. 34,417,014,501 and for the initial solution with the Russel Approximation method, the results of transportation costs are Rp. 34,418,912,175.

The results of the CPO distribution costs carried out by PTPN III in 2019 amounted to Rp. 36,470,751,747. While the research results obtained after using the VAM - Stepping Stone method obtained a transportation cost of Rp. 34,417,014,501 and by using the RAM - Stepping Stone method, the transportation cost was Rp. 34,418,912,175. So it can be seen that using the...
VAM - Stepping Stone method is more efficient because the company has decreased transportation costs by 5.631% with a difference of Rp. 2,053,737,246.

REFERENCES


