Application of improved Vogel's approximation method in minimization of rice distribution costs of Perum BULOG

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Abstract. This research was conducted at Perum BULOG Sub-Divre Medan which is the implementing institution of Raskin program for several regencies and cities in North Sumatera. Raskin is a program of distributing rice to the poor. In order to minimize rice distribution costs then rice should be allocated optimally. The method used in this study consists of the Improved Vogel Approximation Method (IVAM) to analyse the initial feasible solution, and Modified Distribution (MODI) to test the optimum solution. This study aims to determine whether the IVAM method can provide savings or cost efficiency of rice distribution. From the calculation with IVAM obtained the optimum cost is lower than the company's calculation of Rp945.241.715,5 while the cost of the company's calculation of Rp958.073.750,40. Thus, the use of IVAM can save rice distribution costs of Rp12.832.034,9.

Keywords: Improved Vogel’s Approximation Method, Modified Distribution Method, rice distribution cost.

1. Introduction

According to the General Guidelines Rice Subsidies for Poverty Communities In 2016, the rice subsidy program for low-income households or so-called “Beras Miskin” (rice for poor households) is an implementation of Presidential Instruction Number 5 of 2015 about Rice Supply and Distribution Chain Policy by the Government. In order to implement the rice subsidy program, a Coordinating Team was formed which consisted of several state institutions and one of them was Bulog. Perum Bulog is responsible for the supply and distribution of Rice Subsidy for Low Income Society from Bulog warehouse to Distribution Point. Distribution Point is a public facility as a place or location of Rice Subsidy for Low Income Society Subsidy from Perum Bulog to Distribution Officer of Rice Subsidy for Low Income Society in village office / hall, or other location agreed in writing by Regency / city with Bulog.

Perum BULOG Medan Regional Division as the rice program implementer spent considerable fund for rice distribution activity for some areas of Medan. To minimize the cost of this distribution it is necessary to do the planning in the distribution of rice so that the cost is very optimal. One method that can be used to optimize distribution costs is by transportation method.

Transportation problems aim to minimize the cost of transporting certain commodities from a number of sources to a number of destinations (Rao, 2009: 220). All optimal solution algorithms to solve transportation problems require a basic initial feasible solution to produce optimal solutions (Mathirajan, 2003). According to Hamdy A. Taha (2007), in general the Vogel Approach Method...
produces the best initial solution though not always. In 1990 a method was developed by Kirca and Satir called TOM (Total Opportunity-cost Method) to produce an initial feasible solution on transportation problems. TOM is an effective application of "Best Cell Method" along with some tie-breaking features in the Total Opportunity Cost (TOC) matrix. The reason behind VAM installation with TOC matrix is that VAM usually produces a better starting solution than other baseline feasible basic methods (Meenakshi et al., 2003). This study discusses the Improved VAM (IVAM) VAM which is developed by using TOC Matrix and will be implemented in rice distribution cost optimization for poor families in Bulog Sub Division of Medan.

2. Literature Review
2.1 Transportation Problems
Transportation problems are generally represented by the network in Figure 1.

![Figure 1. Representation of the Transportation Network Model](image)

The linear programming model that can represent transportation problems in this study is as follows

Minimization \( Z = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij} \)

Subject to

\[ \sum_{j=1}^{n} x_{ij} \leq a_i, \quad i = 1, 2, \ldots, m \] (Supply constraints)

\[ \sum_{i=1}^{m} x_{ij} \geq b_j, \quad j = 1, 2, \ldots, n \] (Demand constraints)

\( x_{ij} \geq 0 \).

If the total supply is equal to the total demand then the problem is said to be balanced for transportation problems.

2.2 Vogel’s Approximation Method
To get initial decent starting solution using Vogel’s Approximation Method (VAM). VAM is a better method than the method of Least Cost and North West Corner in searching for feasible baseline solutions early. The steps for VAM are:

Step 1 : For each row (column), specify penalty size by subtracting cost the smallest unit on the row (column) of the smallest unit cost thereafter on the line (columns) are the same.

Step 2 : Identify the row or column with the biggest penalty. Decide selection by any. Allocate as many variables as possible with the smallest unit cost in the selected row or column. Adjust the supply and demand, and remove the rows or columns that have been fulfilled. If a row and a column are met simultaneously, only one of two is selected, and if the remaining row (column) is zero supply (demand).

Step 3 : (a) If exactly one row or column with zero supply or demand is left to be selected then iteration stops.
   (b) If one row (column) with positive (demand) supply is left for selected, then specify the base variable on the row or column with the least-cost and stop iteration methods.
   (c) If all rows and columns that have not been selected have (residual) supply and demand, then specify the zero base variable with the least-cost and stop iteration methods.
(d) If not, then go back to step 1.

2.3 Total Opportunity-cost Method
According to Mathirajan and Meenakshi (2003), TOM is an effective application of "best cell methods" along with some tie-breaking features on the total opportunity cost (TOC) matrix. TOC matrix is generated by adding a "cost-matrix row" line (cost opportunity matrix row: for each row, the smallest cost of the row is subtracted with each element on the same row) and "cost opportunity column matrix" (cost opportunity column matrix: for each columns of the original transport cost matrix, the smallest cost of the column is subtracted with each element in the same column). When applying the "best cost method" (least cost method) to TOC matrix.

2.4 Improved Vogel's Approximation Method
According to Serdar and Serkan (2011), VAMs are improved by using the TOC matrix and on alternative allocation costs. The algorithm is to apply the TOC matrix and consider the three highest penalty fees and calculate alternative allocation costs in VAM procedures. Then choose the least of them. Detailed steps are:
Step 1 : Balance the transport problem if total supply> total or total demand supply <total requests.
Step 2 : Create a TOC matrix
Step 3 : Declare penalty fees for each row and column by subtracting the lowest cell cost on the row or column for the lowest cost of the next cell on the same row or column.
Step 4 : Select a row or column with the highest three penalty charges.
Step 5 : Calculate three transportation costs for the three rows or columns selected on step 4 by allocating as much as possible to a viable cell with the lowest transportation cost.
Step 6 : Select the smallest transportation cost of the three allocations in step 5.
Step 7 : Repeat steps 3-6 until all needs are met.
Step 8 : Calculate the total transportation cost for a reasonable allocation by using the original transportation cost matrix that has been balanced.

2.5 Modified Distribution Method
Having determined the initial feasible baseline solution of Improved Vogel's Approximation Method (IVAM) appears likely to be a solution that is not yet optimal, hence another scheme is needed to improve the solution already obtained. The MODI method is considered because the MODI method allows faster index calculation of the improvement for each cell not used without counting all closed paths (Justice K., 2015). Because of this operation, MODI saves time that can be considered from other methods to improve initial feasible basic solutions. MODI works by searching unused routes with the largest path repair index. Once identified, closed paths are tracked out to produce the maximum number of units that can be distributed. In the application, calculate the value for each line example \( u_1, u_2, u_3 \) if there are three rows and for each column example \( u_1, u_2, u_3 \) in the transport table. With notation,

\[
\begin{align*}
  u_i &= \text{"value set for line" } i \\
  v_j &= \text{"value assigned to column" } j \\
  c_{ij} &= \text{"charge on cell" } ij \text{ "(shipping cost from supply i to destination j)"}
\end{align*}
\]

Quoted from Justice K. (2015), the steps of MODI are summarized as follows:
Step 1 : Develop an initial feasible basic solution using IVAM.
Step 2 : Calculate the values \( u_i \) and \( v_j \) for each row and column by applying the formula \( u_i + v_j = c_{ij} \) on each cell that has an allocation.
Step 3 : Calculate the cost change, \( k_{ij} \), for each blank cell using \( c_{ij} - u_i - v_j = k_{ij} \).
Step 4 : Allocate as many empty cells as possible that will result in a decline the best value at the cost in the most negative \( k_{ij} \). Allocate by stepping-stone flow for selected cells.
Step 5 : Repeat steps 2 through 4 until all \( k_{ij} \) are positive or zero.

3. Discussion and Research Result
The data used in this paper is data on the quantity of rice stocks in Perum BULOG warehouse in July 2013, the amount of rice distributed, and the cost of transport from the warehouse to the distribution point contained in "Application of Transportation Methods in Optimizing Rice Distribution Cost of
Poor (RASKIN) on Perum Bulog Divre Medan ",(Simbolon dkk, 2014). Data can be seen in the following table:

**Table 1** Amount of RASKIN Supply

| No | Warehouse  | Location | Total Rice Supply (kg) |
|----|------------|----------|------------------------|
| 1  | Mustafa    | Medan    | 3,318,270.00           |
| 2  | Jemadi     | Medan    | 2,895,437.71           |
| 3  | Mabar      | Medan    | 3,379,212.29           |
| 4  | L. Deli    | Medan    | 385,170.00             |
| 5  | T. Tinggi  | T. Tinggi| 1,294,575.00           |
|    |            |          | Total 11,272,665.00    |

**Table 2** Amount of RASKIN Distribution

| No | Warehouse  | Point of Distribution | Total Rice (kg) |
|----|------------|-----------------------|-----------------|
| 1  | Mustafa    | Langkat               | 524,865.00      |
|    |            | Medan                 | 2,739,405.00    |
| 2  | Jemadi     | D. Serdang            | 347,777.71      |
|    |            | Sergai                | 129,390.00      |
|    |            | Langkat               | 2,418,270.00    |
| 3  | Mabar      | Langkat               | 218,730.00      |
|    |            | Binjai                | 166,440.00      |
| 4  | L. Deli    | D. Serdang            | 2,648,982.29    |
|    |            | Medan                 | 208,410.00      |
|    |            | Binjai                | 521,820.00      |
| 5  | T. Tinggi  | T. Tinggi             | 334,575.00      |
|    |            | Sergai                | 960,000.00      |
|    |            | Total                 | 11,272,665.00   |

**Table 3** Freight Cost RASKIN from Warehouse to Point of Distribution (Rp/kg)

| From/To  | Mustafa | Jemadi | Mabar | L. Deli | T. Tinggi |
|----------|---------|--------|-------|---------|-----------|
|          | Medan   | Binjai | T. Tinggi |
| Mustafa  | 71,22   | 71,62  | 73,00 | 76,16   | 102,44    |
| Jemadi   | 77,73   | 81,69  | 84,45 | 111,4   | 73,50     |
| Mabar    | 100,39  | 99,60  | 103,69| 105,95  | 94,53     |
| L. Deli  | 94,53   | 93,74  | 97,30 | 100,07  | 89,00     |
| T. Tinggi| 90,98   | 90,98  | 90,98 | 90,98   | 90,98     |
|          | Langkat | D. Serdang | Sergai |
| Mustafa  | 91,13   | 87,12  | 94,53 |
| Jemadi   | 90,73   | 86,33  | 93,74 |
| Mabar    | 94,69   | 89,89  | 97,30 |
| L. Deli  | 97,45   | 92,66  | 100,07|
| T. Tinggi| 119,45  | 90,98  | 89,00 |
In the other hand basic solution is feasible early with IVAM through three iteration. There is TOC matrix and solution with IVAM.

| From/To | Destination |
|---------|-------------|
|          |             |
|          |             |
|          |             |
|          |             |
|          |             |

| Demand | 3,001,815.00 | 688,260.00 | - | 3,161,865.00 |

| Supply | 3,161,865.00 | 2,996,760.00 | 3,089,390.00 | 11,272,665.00 |

| Penalty 9 | 1,294,577.00 |

In the other hand basic solution is feasible early with IVAM through three iteration. There is TOC matrix and solution with IVAM.
Use MODI to perform optimality tests. The basic variables $x_{12}, x_{14}, x_{24}, x_{25}, x_{26}, x_{31}, x_{35}, x_{41}, x_{45}, x_{53}, x_{56}$.

The amount of rice allocation obtained by using Improved Vogel's Approximation Method is 688,260 kg from Mustafa to Binjai, 2,630,010 kg from Mustafa to Langkat, 531,855 kg from Jemadi to Langkat, 2,234,192.71 kg from Jemadi to D. Serdang, 129,390 kg from Jemadi to Sergai, 3,001,815 kg from Mabar to Medan, 377,397.29 kg from Mabar to D. Serdang, 385,170 kg from L. Deli to D. Serdang, 334,575 from Tebing Tinggi to Tebing Tinggi and 960,000 kg from Tebing Tinggi to Sergai with total rice distribution cost is Rp 945,241,715,5. Representation in graphical form of optimum solution obtained from optimality test results is shown in Image 4.1.
Figure 2 Optimal solution of optimality test results

4. Conclusion

The determination of the optimal solution in the minimization of rice distribution cost on Bulog is done by finding the initial feasible basic solution using Improved Vogel's Approximation Method (IVAM). The steps used in IVAM are the same as the steps on the VAM but with the addition of TOC Matrices. The optimal solution of rice distribution problem in Bulog Divre Medan with 5 (five) warehouses and 6 (six) distribution points in journal Simbolon et al. (2014) The amount of rice allocation obtained by using Improved Vogel's Approximation Method is 688,260 kg from Mustafa to Binjai, 2,630,010 kg from Mustafa to Langkat, 531.855 kg from Jemadi to Langkat, 2,234,192.71 kg from Jemadi to D. Serdang, 129,390 kg from Jemadi to Sergai, 3,001.815 kg from Mabar to Medan, 377,397.29 kg from Mabar to D. Serdang, 385,170 kg from L. Deli to D. Serdang, 334,575 from Tebing Tinggi to Tebing Tinggi and 960,000 kg from Tebing Tinggi to Sergai with total rice distribution cost is Rp 945.241.715.5. The solution obtained from IVAM is the most optimal solution in terms of number of iterations and rice distribution costs.

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