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TOCM-SDRM, an Initial Basic Feasible Solution Developed from SDRM for Transportation Cost Determination

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ABSTRACT: *TOCM-SDRM is an initial basic feasible solution developed from SDRM initial basic feasible solution to answer transportation problems. It is illustrated by several numerical examples and comparisons with pre-existing methods such as TOCM-SUM, SDRM, CAM, VAM and optimal solutions as references.*
Keywords: *TOCM-SDRM, SDRM, TOCM-SUM, CAM, VAM, Optimal Solution*

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I. Introduction

Transportation is the movement of passengers or goods from one place to another using vehicles moved by drivers or engines. In mathematics, transportation model is a location setting model to determine the delivery patterns of several source points to destination points. This model is used to minimize transportation cost.

Hiller and Gerald (2000) revealed that transportation model is an expansion of linear program issues. The standard form of the transportation model proposed by Hillier and Gerald (2000) is as follows.

Minimum:

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

$$\sum_{j=1}^{n} x_{ij} = s_i \; for \; i = 1,2,3, \dots, m \; (supply)$$

$$\sum_{j=1}^{m} x_{ij} = d_i \; for \; j = 1,2,3, \dots, n \; (demand)$$

$$x_{ij} \geq 0, \quad for \; i \; and \; j$$

For:

Z = destination function;
c_{ij} = cost related to each unit x_{ij};
x_{ij} = unit sent from source number $-$i to destination number$-$ j;
n = number of destinations;
m = number of sources;
s_i = number of supplies at source i;
d_j = number of demands at destination j;

Transportation model is divided into two: balanced and unbalanced. For unbalanced model, a dummy factor will be added in either supply or demand to make the values equal.

Khan, et al., (2015) proposed an initial solution method to determine the initial distribution allocation for transportation problems; they called it TOCM-SUM (Total Opportunity Cost Matrix). In their research, the method was compared with several others such as Vogel's Approximation Method (VAM), Size of the Matrix Method, Matrix Minima Method, and North West Corner Method. They discovered that TOCM-SUM

approaches optimum compared to other methods. Prajwal, et al., (2019) proposed an initial solution method called SDRM (*Supply-Demand Reparation Method*). Lakshami and Usha (2010) compared several initial solution methods such as *Vogel's Approximation Method* (VAM) and CAM (*Continuous Allocation Method).*
Based on the researches above, this study creates TOCM-SDRM method, which is the development of SDRM with some enhancement for more optimum results. The created method will be compared with some initial solution methods such as TOCM-SUM (*Total Opportunity Cost Matrix*), *Vogel's Approximation Method* (VAM), and CAM (*Continuous Allocation Method).* Here optimal solution will also be calculated for references.

II. Theoretical Review

2.1 TOCM-SDRM Method

In this research, TOCM-SDRM, which a combination between TOCM and SDRM, was used to determine the initial basic feasible solution for transportation problems. The algorithm for this combined method is as follows.

1. Draw the transportation tables.
2. Reduce rows and columns. Choose the smallest cost element in each row with the notation of C_{ik}, then perform row reduction by reducing each C_{ij} cost element row in each row with C_{ij} and placing it on the top right according to its cost element. This reduction of row is usually called as *Row Opportunity Cost Matrix* (ROCM).

$C_{ij}^{C_{ij}-C_{ik}}$, where $C_{ik} = \min\ (C_{i1}, C_{i2}, \dots, C_{in})$

The same operation is applied to any other rows. The same procedure is also applied to column reduction, i.e. by looking for the smallest cost element in each column with the notation of C_{ik}, then the column is reduced by reducing each C_{ij} cost element row in each row with C_{ik} and placing it on the top left according to its cost element. This reduction of column is usually called as *Column Opportunity Cost Matrix* (COCM).

${}_{c_{ij}-c_{kj}}C_{ij}$, $where\ C_{kj} = \min\ (C_{1j}, C_{2j}, \dots, C_{mj})$

3. Draw a table for *Total Opportunity Cost Matrix* (TOCM), that is:

$TOCM_{ij} = (C_{ij} - C_{kj})+(C_{ij} - C_{ikj})$

Where:

$TOCM_{ij}$ = *Total Opportunity Cost Matrix* from supply point i to supply point j.
C_{ij} = transportation loading cost from point i to demand point j.
C_{ik} = the smallest cost element in row $number -$ i, where $C_{ik} = \min\ (C_{i1}, C_{i2}, \dots, C_{in})$.
C_{kj} = the smallest cost element in column $number -$ j, where $C_{kj} = \min\ (C_{1j}, C_{2j}, \dots, C_{mj})$.

4. Choose supply or demand with the highest value and allocate it in the smallest cost in related rows or columns in TOCM table.
5. If there are two same costs in the cell, choose the one with the smallest supply or demand.
6. Repeat step number 4 until all supplies and demands are completed.
7. Calculate minimum cost by adding the multiplication results of goods allocation number and initial cost according to its allocation.

2.2 *Supply-Demand Reparation Method* (SDRM)

The research of Prajwal et al. in 2019 showed that SDRM is an effective method to obtain an Initial Basic Feasible Solution (IBFS) by calculating supply or demand in making allocations. The algorithm of SDRM in determining the initial solution for transportation problems is as follows.

1. Choose supply or demand with the highest value and allocate it in the smallest cost in the existing row or column.
2. Choose the next highest supply or demand, then repeat step 1.
3. Repeat step 1 and 2 until all supplies and demands are completed.
4. If there are two same costs in the cell, choose the one with the smallest supply or demand.

III. Discussion

3.1 Using TOCM-SDRM Method

Case 1: It is identified that a chicken egg company has the supplies of 10, 3, and 7. The supplies are distributed to sellers, whose demands are 4, 2, 6, and 8. The cost that must be paid calculated from initial solution methods of TOCM-SDRM and SDRM with the delivery cost can be seen in Table 1.

Table 1. Transportation Matrix

		Destination				
		Minimarket	Palm oil plantation	Market 1	Market 2	Supply
Places	Coop 1	4	19	22	11	10
	Coop 2	2	9	14	14	3
	Coop 3	6	6	16	14	7
demand		4	2	6	8	

<u>Iteration 1:</u> Reduce first row with 40, second row with 10, and third row with 60. Put the results on the top right.
<u>Iteration 2</u>: Reduce first column with the first, second column with 6, third column with 14, and fifth column with 11. Put the results on the bottom right, as you can see them in Table 2.

Table 2. Formation of Total Opportunity Cost Matrix

		Destination				
		Minimarket	Palm oil plantation	Market 1	Market 2	Supply
Places	Coop 1	$_{2}4^{0}$	$_{13}19^{15}$	$_{8}22^{18}$	$_{0}11^{7}$	10
	Coop 2	$_{0}2^{0}$	$_{3}9^{7}$	$_{0}14^{12}$	$_{3}14^{12}$	3
	Coop 3	$_{4}6^{0}$	$_{0}6^{0}$	$_{2}16^{10}$	$_{3}14^{8}$	7
demand		4	2	6	8	

<u>Iteration 3:</u> Sum the reduction results in iteration 1 and 2, then make a new matrix as shown in table 3.

Table 3. Total Opportunity Cost Matrix (TOCM)

		Destination				
		Minimarket	Palm oil plantation	Market 1	Market 2	Supply
Places	Coop 1	2	28	26	7	10
	Coop 2	0	10	12	15	3
	Coop 3	4	0	12	11	7
demand		4	2	6	8	

Table 4. Initial basic feasible solution using TOCM-SDRM Method

		Destination				
		Minimarket	Palm oil plantation	Market 1	Market 2	Supply
Places	Coop 1	4 / 2	28	26	6 / 7	10,6,0
	Coop 2	0	10	3 / 12	15	3,0
	Coop 3	4	2 / 0	3 / 12	2 / 11	7,5,3,0
demand		4,0	2,0	6,3,0	8,2,0	

Iteration 4: Choose supply or demand with the highest value, and allocate it in the smallest cost in the row or column.
Iteration 5: Repeat iteration 4 until all are completed.
Iteration 6: Calculate the minimum cost by totaling the calculation results of goods allocation and initial cost according to the allocation to obtain the following.
Initial solution cost with TOCM-SDRM method =4x4+11x6+6x2+14x3+14x2+16x3=212.

3.2 Using SDRM Method

Iteration 1: Choose supply or demand with the highest value and allocate it in the smallest cost of the existing row or column.
Iteration 2: Chose the next highest supply or demand, then do the same step as in iteration 1.
Iteration 3: Continue until all supplies and demands are completed, then outcome as in table 4 will be obtained.

Table 5. Initial basic feasible solution using SDRM method

		Destination				
		Minimarket	Palm oil plantation	Market 1	Market 2	Supply
Places	Coop 1	4 4	 19	 22	6 11	10,6,0
	Coop 2	 2	 9	3 14	 14	3,0
	Coop 3	 6	2 6	3 16	2 14	7,5,3,0
demand		4,0	2,0	6,3,0	8,2,0	

Iteration 4: Totaling the multiplication results and transportation cost to get the following.
Initial solution cost with SDRM=4x4+11x6+6x2+14x3+14x2+16x3=212.

Case 2: It is identified that a chicken egg company has the supplies of 10, 4, 11, and 5. The eggs are distributed to sellers with the demands of 6, 7, 7, and 10. The cost that must be paid can be seen in Table 5.

Table 6. Transportation Matrix

		Destination				
		Minimarket	Palm oil plantation	Middlemen	Market 2	Supply
Places	Coop 1	4	19	22	11	10
	Coop 2	1	9	14	14	4
	Coop 3	6	6	16	14	11
	Coop 4	5	7	9	10	5
demand		6	7	7	10	

IV. Results

Using TOCM-SDRM method compared with initial solution methods of TOCM-SUM, SDRM, CAM and VAM as well as optimal solution, the proposed solution produced a relatively good result, as seen in table 7.

Table 7. Comparison between some initial solution methods and optimal solution

Solution being used	Total of transportation cost	
	Problem 1	Problem 2
Matrix size	3x4	4x4
TOCM-SUM	221	283
CAM	228	277
VAM	217	247
SDRM	212	267
TOCM-SDRM	212	245
Optimal Solution	204	245

For a clearer illustration, refer to the comparison chart below.

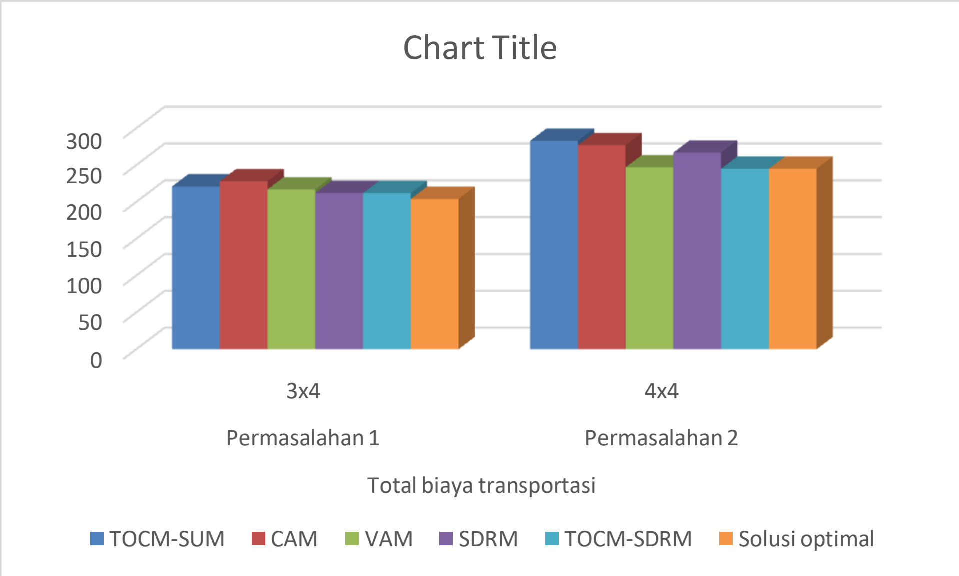

Figure 1, the results of the comparison between several methods.

V. Conclusion

As seen from the figure and table above, the development of SDRM into TOCM-SDRM provides a good result, approaching the optimal solution.

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