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Combination of TOCM-SUM and CAM Methods for Determining the Transportation Problem Cost Using and Obtaining the Best Supplier Using AHP Method

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ABSTRACT : *Transportation method is a transportation plan for moving to a certain number of demand points from a certain number of sources that aim to determine production cost and to optimize transportation cost. For the initial solution we used a new method namely combination of TOCM-SUM and CAM methods, then we verify the optimization of transportation cost using stepping stone method. The development of science and technology lead market became massively growth and impacted many types of companies such as retail companies. The most important part that must be done by retail companies is to choose the right supplier, because choosing the right supplier will be able to reduce purchasing costs and able to increase the company's competitiveness. For determine the best supplier we used Analytical Hierarchy Process (AHP) method.*
KEYWORDS : *Transportation, combination of TOCM-SUM and CAM method, stepping stone method, transportation cost, AHP method.*

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I. INTRODUCTION

The transportation model is a model to determine the location and the delivery pattern from several sources points to several demand points and find the minimum cost of transportation problem. The purpose of resolving the transportation problem is to determine how many units have to send from the source to each destination, so the demand from each destination is satisfied and total shipping gets minimum cost [1]. Kirca and Satir (1990) have developed Total Opportunity Cost Matrix (TOCM-SUM) by changing the cost of matrix. Basically, the TOCM-SUM method is formed by adding row reduction and column reduction. The Matrix Minima Method (MMM) with several rules on TOCM-SUM to produce an initial solution. Islam and Udin (2012) proposed a new method called Total Opportunity Cost Table (TOCT) to determine the initial distribution solution. The research will be conducted using the TOCT method which is compared with Vogel's Approximation Method (VAM), North West Corner Method (NWCM), and Matrix Minima method. Khan et al (2015) proposed a new initial solution method called Total Opportunity Cost Matrix (TOCM-SUM) to determine the initial distribution allocation. In the research, the calculation of TOCM-SUM was compared with the VAM, NWCM, Matrix Minima method, and size of the matrix method. Prajwal et al (2019) proposed an initial solution method called the Continuous Allocation Method (CAM). In the research conducted, the calculation of the initial solution was compared with the VAM and Supply-Demand Reparation Method (SDRM).

The development of science and technology lead market became massively growth and impacted many types of companies such as retail companies. Retail companies are required to serve consumer demand both in terms of price, quality, and service. By judging from the above statements, the most important part that must be done by retail companies is to choose the right supplier, because choosing the right supplier will be able to reduce purchasing costs and able to increase the company's competitiveness. Selection of the best supplier can be done by analyzing multi-criteria contained in the company. Supplier selection can be done by analyzing the multi-criteria which indicated in the company. One method to determine the right supplier is Analytical Hierarchy Process (AHP) method [8]. Ozkan and Nergis (2011) conducted discusses the criteria in supplier

selection and determines the most potential supplier. Determining a purpose by human's judgment is still subjective. Chan (2003) proposed the chain interaction method, which is a method for solving problems related to supply chains. The interaction method can be applied to supplier selection through the identification of buyer-supplier interactions. Akarte (2011) identified 18 criteria for supplier assessment which were categorized into four sections, namely product development, manufacturing capability, quality capability, cost, and delivery. A systematic approach to this research using the AHP method which allows combining real criteria, non-real criteria and checking the consistency of decision making. The approach taken has been implemented in a web-based prototype.

Based on the previous research, this paper proposes a new method namely the research conducted by Khan et al (2015) and Prajwal et al (2019). The proposed method is called combination of TOCM-SUM and CAM methods to find the initial solution. Furthermore, optimization will be tested using the stepping stone method. Decision making is one of the most important activities in companies. Making the right decisions have an important effect on companies' profit and success**.** We use Analytic Hierarchy Process (AHP) method to determine the best supplier.

II. ALGORITHM OF COMBINATION OF TOCM –SUM AND CAM METHODS

Combination of TOCM-SUM and CAM methods is a new method to determine the completion of the initial solution and still related to transportation problems. The detail steps of combination of TOCM-SUM and CAM methods are below.

1. Construct the matrix of a transportation problem from a given problem.
2. Perform row reduction (ROCM) and column reduction (COCM). Choose the smallest cost element in each row which is denoted by c_{ij}, then perform row reduction by subtracting each cost element (cij) in each row by c_{ik} and placing it on the top right according to the cost element.

   $C_{ij}^{C_{ij}-C_{ik}}$, where $C_{ik} = min\,(C_{i1}, C_{i2}, \dots, C_{in})$ (1)

   Apply the same operation to every other row. Then apply the same procedure to reduce the column by finding the smallest cost element in each column which is denoted by C_{kj}, then perform column subtraction by subtracting each cost element (c_{ij}) in each column by C_{kj} and placing it on the bottom-left according to the cost element.

   ${}_{c_{ij}-c_{kj}}C_{ij}$, where $C_{kj} = \ min\,(C_{1j}, C_{2j}, C_{3j}, \dots, C_{mj})$ (2)
3. Forming the Total Opportunity Cost Matrix (TOCM) table, as per below formula

   $TOCMij \ = \ (C_{ij} - C_i) \ + \ (C_{ij} - C_{kj})$ (3)
4. Select the cell with the smallest value in the TOCM table and allocate the maximum value to that cell to start the allocation process. If there are two or more smallest values, select the smallest supply or demand.
5. If the supply or demand allocation is met, then the row or column can be deleted.
6. Repeat step (4) until supply or demand are met.

III. ANALYTICAL HIERARCHY PROCESS (AHP)

According to Saaty (1994), AHP method will be matched if it is used to help making a decision which involves a comparison of several criteria and the method will be obtaining the most valuable alternative. In this paper, after obtaining the initial solution's value, the best supplier will be searched using the AHP method. AHP is a method to assist in the preparation of a priority from various options using various criteria. There are four basic principles in AHP, and the principles included decomposition, comparative judgment, synthesis of priority, and logical consistency. Furthermore, the AHP steps to find the best supplier are hierarchical arrangement, priority arrangement, pairwise comparison matrix preparation, index, and ratio consistency test. In the pairwise comparison of matrix steps, each value has been defined as shown in Table 1.

Table 1 Comparison scale

Intensely of Importance	Definition
1	Equally important
3	Moderately more important
5	Strongly more important
7	Very strong more important
9	Extremely more important
2,4,6,8	Intermediate more important
Reciprocal	$a_{ji} = \frac{1}{a_{ij}}$ (If the *i* element has one of the above numbers when had been comparing to the *j* element, then *j* element has a reciprocal value with the *i* element.)

IV. NUMERICAL SIMULATION

This research will be held in Sumberasri, Curahjati, and Jatirejo village which is located in Banyuwangi district, East Java. This research used primary data and the researcher will do an interview process to lime's distributor. This research needs at least three distributors of lime to gain more valid data. The distributor delivers lime from their village to another city such as Jember, Surabaya, Semarang, and Bali, also making a questionnaire for the farmers.

1. The first step is to find an initial solution which combined of TOCM-SUM and CAM methods, the detail steps are below.

i. Construct the transportation table

Table 2 Transportation table

	1	2	3	4	Supply
A	2,3	3,5	5	3,4	11
B	2	3,6	5,5	3,5	13
C	2	3,4	4,5	4	16
Demand	5	8	11	16	

ii. Making row and column reduction as per equation (1) and equation (2). The results of row and column reduction are described in Table 3.

Table 3 The results of row reduction and column reduction

	1	2	3	4	Supply
A	0 2,3 0,3	1,2 3,5 0,1	2,7 5 0,5	1,1 3,4 0	11
B	0 2 0	1,6 3,6 0,2	3,5 5,5 1	1,5 3,5 0,1	13
C	0 2 0	1,4 3,4 0	2,5 4,5 0	2 4 0,6	16
Demand	5	8	11	16	

iii. The next step is to build Total Opportunity Cost Matrix (TOCM) table as per equation (3) and shown in Table 4.

Table 4 TOCM-SUM table

	1	2	3	4	Supply
A	0,3	1,3	3,2	1,1	11
B	0	1,8	4,5	1,6	13
C	0	1,4	2,5	2,6	16
Demand	5	8	11	16	

iv. Choose the smallest value on TOCM-SUM table to start the allocation processes. The smallest value on the TOCM-SUM table is 0. Because there are two smallest values in Table 5, then we have to choose the smallest supply or demand and allocate 5 units to the cell. Adjust supply and demand and delete the first column. Iteration 1 is shown in Table 5.

Table 5 Iteration 1 of the combined method

	1	2	3	4	Supply
A	0,3	1,3	3,2	1,1	11
B	5 0	1,8	4,5	1,6	13
C	0	1,4	2,5	2,6	16

Demand	5	8	11	16	

The allocation process has been stopped when all supply and demand are met. It stopped at iteration 6 and shown in Table 6.

Table 6 Iteration 6 of the combined method

	1	2	3	4	Supply
A	0,3	3 1,3	3,2	8 1,1	11
B	5 0	1,8	4,5	8 1,6	13
C	0	5 1,4	11 2,5	2,6	16
Demand	5	8	11	16	

Based on Table 6, it will obtained the transportation cost

$$Z = (3 \times 3{,}5) + (8 \times 3{,}4) + (5 \times 2) + (8 \times 3{,}5) + (5 \times 3{,}4) + (11 \times 4{,}5)$$
$$= 142{,}2.$$

After the initial solution has been reached, then we continue to verify the transportation cost using stepping stone method to find out the value has been optimal or not. The result of stepping stone method is 142,2 and gets the same result with the combination of TOCM-SUM and CAM methods.

2. Making the right decisions using AHP method. This research using data from a questionnaire given to the farmers. The suitable criteria for this study are quality, price, location, and service. The steps of AHP method are given.

i. Hierarchical arrangement.
From the above criteria, several alternatives (supplier) will be determined such as Sumberasri supplier (denoted as A), Curahjati supplier (denoted as B), and Jatirejo supplier (denoted as C).

ii. Make a pairwise matrix comparison.
Table 8 describes alternative A and the value is obtained from Saaty's scale.

Table 8 Pairwase normalization matrix supplier from alternative A

	Quality	Price	Location	Service
Quality	1	2	3	5
Price	1/2	1	2	3
Location	1/3	1/2	1	2
Service	1/5	1/3	1/2	1
∑	61/30	23/6	13/2	11

iii. Index and ratio consistency test.
In the first step, we will search for normalization comparison and eigen vector. Normalization matrix is obtained from pairwise comparison matrix which is the value from severally cell be divided with the sum value of every column (∑). In Table 9 can be seen the calculation of the normalization matrix.

Table 9 Normalization matrix of alternative A

	Quality	Price	Location	Service
Quality	30/61	12/23	6/13	5/11
Price	15/61	6/23	4/13	3/11
Location	10/61	3/23	2/13	2/11
Service	6/61	2/23	1/13	1/11

After that, we will find out vector priority. The value of vector priority will be used to find eigen maximal (t) and will be used to know ratio consistency. For an example of calculating the vector value is as follows.

$$V_1 = \frac{1}{n}\sum_{i=1}^{n}\frac{a_{1i}}{w_i}$$
$$V_1 = \frac{1}{4}\left(\frac{30}{61}+\frac{12}{23}+\frac{6}{13}+\frac{5}{11}\right).$$

Therefore the eigen value can be obtained as follows
$t = (w_1 \times v_1) + (w_2 \times v_2) + \cdots + (w_n \times v_n)$
$t = \left(\frac{61}{30} \times 0{,}4824\right) + \left(\frac{23}{6} \times 0{,}2718\right) + \left(\frac{13}{2} \times 0{,}1575\right) + (11 \times 0{,}0883)$
$t = 0{,}98088 + 1{,}0419 + 1{,}02375 + 0{,}9713$
$t = 4{,}01783.$

After the vector priority has been obtained, so the next step is to determine the consistency index and ratio test.

$$CI = \frac{t-n}{n-1} = \frac{4{,}01783-4}{3} = CI = 0{,}0059.$$

If the value of CI is zero, it means the matrix is consistent. Because the value of CI that has been obtained is not equal to zero, then the value of CR must be calculated in order to see the limits of the inconsistency can be accepted or not.

$$CR = \frac{CI}{RI}$$
$$CR = \frac{0{,}0059}{0{,}9}$$
$$CR = 0{,}0066.$$

Table 10 The weight of AHP method criteria

	Alternatif A	Alternatif B	Alternatif C
Quality	0,4824	0,5117	0,4949
Price	0,2718	0,2378	0,2423
Location	0,1575	0,1725	0,1770
Service	0,0883	0,0780	0,0857

Table 10 is described the criteria for alternative A, alternative B, and alternative C. The value of quality is 0.4824, price criteria is 0.2718, location criteria is 0.1575, and service criteria is 0.0883. From these values, the highest value of alternative A is on the quality criteria. The steps for alternative B and alternative C are the same as for alternative A. The highest value in alternative B is quality, as well as alternative C.

V. CONCLUSION

The purpose of transportation problems is to make optimize transportation costs. According to this research transportation cost using the combined of TOCM-SUM and CAM method is 142.2 and the result of optimal solution using stepping stone method has the same cost as the combined of TOCM-SUM and CAM method. After the initial solution has been obtained, the best supplier will be determined using AHP method to reduce purchasing costs. So we get the best supplier given to alternative A because it has the highest quality of weight and matches with the farmer's priority concern.

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