Supply Chain Management Supplier Selection Using Fuzzy-Data Envelopment Analisys (DEA)

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Abstract

This study aims to assess the efficiency of alternative suppliers. Best suppliers based on several criteria that most affect the performance of the supplier. This study assessed the efficiency of alternative suppliers based on some of the most influential criteria to determine the level of interest in influencing the performance criteria for the supplier. Fuzzy method is used to find the weights of criteria, whereas the method used to evaluate the efficiency of Data Envelopment Analysis (DEA). From the results of data processing and analysis concluded that the section of copper pipe, the best supplier is Myeong S.

1. Introduction

Supply chain is a network of companies that work together to create and deliver a product into the hands of end users. SCM is a method, tool or approach to management [1]. SCM is not a software but a lot of software that can be used to help manage the supply chain. Supply chain is an integrated process with a number of entities working together to obtain raw materials, transforming raw materials into finished products, while at the warehouse store and send it to the retailer and the customer [2]. Supply Chain Management (SCM) is the management of information, goods and services ranging from the earliest supplier to the ultimate consumer by using an integrated systems approach for the same purpose [3].

The company will always strive to improve its performance in producing the best products. Supplier selection plays an important role in determining the performance level of the industry. This is related to the function of the supplier as a supplier of raw materials and auxiliary materials in the production process [4]. The company simply selecting suppliers to meet raw material requirements only in terms of price and delivery, even though many criteria or variables that may affect the selection of the best supplier. So we need a method that can provide a solution to the best solution in the decision-making in determining which suppliers are the best supplier by using various combinations of methods or tools (tools) both quantitatively and qualitatively in a flexible and contextual [5].

In supplier selection, supplier performance is calculated using the ratio of weighted outputs to weighted inputs. The company's goal is to choose one or more suppliers of "n" candidate [4]. The concept of efficiency is technical effisiency which has changed the meaning of some inputs (such as labor, revenue) to the output with a high level of performance. Advantageous use of inputs to produce a certain amount of output. Efficiency is defined as well as a description of a system with good performance in maximizing the output from the input.

The main objective of the supplier selection process is to determine the efficiency of the suppliers who have consistently meet the needs of the company and minimize the risks associated with the procurement of raw materials and components. Supplier selection is the basic attributes of quality, delivery, performance history, and claims warrantee policy, capacity and production facilities, and the price [4]. Zhang suggested that the most important criteria is price, quality, delivery, capacity and production facilities, technical capabilities and financial position [6]. This study uses six important criteria in the supplier selection process, namely price, in lieu of experience supplying quality criteria, delivery, capacity and production facilities, financial position and geographic location .

Supplier Data Envelopment Analysis (DEA) proposed by Charnes, Cooper , and Rhodes (CCR) is a mathematical programming method to assess the relative efficiency of Decision Maker Unit (DMU) with inputs and outputs are homogeneous. Data Envelopment Analysis is a non-parametric linear programming based technique for measuring the relative efficiency of a set of similar units, usually associated with the decision-making process [7]. Data Envelopment Analysis is a non parametric method that allows the efficiency to be measured without special weights in the input and output or set the shape of the production function [4]. This study uses a Fuzzy-DEA. The advantages of Fuzzy-DEA method which is the development of

methods of Data Envelopment Analysis (DEA) is to perform the processing of the data that are imprecise or uncertain so that the cost and time of production becomes efficient. This study aims to assess the efficiency of the alternative suppliers that will be the suppliers of raw materials (raw materials) based on several criteria of the most influential of the many existing criteria to determine the level of interest in influencing the performance criteria that suppliers will eventually become known to the supplier which the best suppliers, who will be the supplier for a particular product.

2. Methods

Stages of data collection and processing is done in accordance with the procedures used in the study is using fuzzy method and DEA with the same stage of implementation but the way the application procedure adapted to the situation and conditions prevailing on the local system.

2.1. Fuzzy method

The steps in processing using Fuzzy method is (a) establish criteria for the selection of variables supplier. These variables are price, quality, delivery, capacity and production facilities, financial position and geographic location. (b) Determine the value of the level of the criteria by decision makers (desicion maker). Value that will be given is in the form of letters that will represent approximate figures. Linguistic scales according are: [6].

VH	: *Very High*	(0.9, 1.0, 1.0)
H	: *High*	(0.8, 0.9, 1.0)
MH	: *Medium High*	(0.6, 0.7, 0.8)
M	: *Medium*	(0.4, 0.5, 0.6)
ML	: *Medium Low*	(0.2, 0.3, 0.4)
L	: *Low*	(0, 0.1, 0.2)

Criteria	Decision Maker		
	D1	D2	D3
C1	H	H	H
C2	VH	H	VH
C3	VH	VH	VH
C4	H	H	VH

Table 1. Assessment Criteria by desicion Maker

(c) Calculate the eigenvalues using MATLAB software. Desicion makers will be asked to rank their respective positions according to the degree of influence in the decision to get the matrix A. Once the matrix A is met, then the matrix A will be completed by using MATLAB software to obtain eigenvalues particularly value the normalized eigenvectors to be used in the next stage. (d) Calculate the fuzzy ranking criteria and supplier performance by decision makers (desicion Maker) in the form of numbers. (e) Calculate the weight of fuzzy ranking criteria. Fuzzy ranking criteria and the performance of suppliers already in the form of numbers then the next step is to multiply the data with the value of the normalized eigenvectors obtained from MATLAB Software. It is used to obtain aggregate criteria weights and fuzzy performance. Determine the criteria weights are determined using fuzzy formula:

$w_i = (w_{i1}, w_{i2}, w_{jn})$

$w_{i1} = \text{Min}\{ w_{jk1}\}$

$w_{j2} = \frac{1}{k}\sum\{ w_{jk2}\}$

$w_{j3} = \text{Max}\{ w_{jk3}\}$

2.2. Data Envelopment Analisys Method

The model for "k" supplier can be defined as the following equation:

$$\max Z_k = \sum_{r=1}^{s} u_r y_{rj}$$

$$\text{St} = \sum_{i=1}^{m} v_i x_{ik} = 1$$

$$\sum_{r=}^{s} u_r y_{rj} - \sum_{i=}^{m} v_i x_{ij} \leq 0 \qquad (j = 1,2,\dots,n)$$

$$u_r, v_i \geq 0$$

Where:
k = unit began to be evaluated
s = number of output
m = number of inputs
y_{rj} = amount of output that is provided by unit j,r
x_{ij} = amount of input i used by unit j
u_r and v_i = weight given to output r and input i, r.
The steps in the method of DEA are: (1) Establish the input and output dimensions are derived from the ratio of output to input of each unit of product (desicion Making Units/DMU). (2) Change the input and output data into a linear programming formulation that refers to the DEA CCR formula. (3) Calculate the relative efficiency of DMU using software XLDea. (4) Determine the best supplier.

3. Analysis

3.1. Calculating eigen values

Matrix A is processed by using the software Matlab 1.7 is used to determine the eigenvalues and eigen vector determining normalization.

		D1	D2	D3
	D1	1	3	2
A=	**D2**	0.67	2	2
	D3	½	½	2

Research conducted by Srekumar and Mahapatra (2009), it has been found that the eigenvalues of the matrix A is 3.1333, while the value of the eigen vector is equal to 1.000, 0.4799 and 0.3468.

Normalization of the eigen vector of 0.5474, 0.2627 and 0.1899 are also related to the value of the consistency index of 0.0667 and consistency ratio of 0.1149. The weight of the three decision makers (decision maker), namely D1, D2 and D3 at 0.5474, 0.2627 and 0.1899.

3.2. Calculating Weight Criteria

Table 2 Weighting Criteria Part Copper Pipe

No.	Criteria	Weight	Rating
1.	Price	(0.1709, 0.3151, 0.5474)	1
2.	Delivery	(0.1709, 0.3063, 0.5474)	2
3.	Exp. suppliers	(0.1709, 0.3063, 0.5474)	3
4.	Fac. & Kaps Prod	(0.1519, 0.2397, 0.4379)	4
5.	Geog. location	(0.1095, 0.1730, 0.2190)	5
6.	Financial Position	(0.0525, 0.1890, 0.4379)	6

3.3. Data Envelopment Analysis (DEA) Analisys to determine the best supplier

Linear programming formulation that is used in Data Envelopment Analisys (DEA) for Material "Copper pipe".

1. Supplier I, Myeong S

$Z= 112.344.514,89\ y_1 + 0,5443\ y_2 + y_3$

Subject to :

$112.344.514,89y_1+0,5443y_2 + y_3 - 0,1714x_1 - 0,5443x_2 - 0,8848x_3 \leq 0$

$135.172.271,40y_1+0,6371y_2 + y_3 - 0,0770x_1 - 0,6371x_2 - 0,8619x_3 \leq 0$

$209.878.933,20y_1+y_2 + y_3 - 0,7792x_1 - x_2 - 0,95337x_3 \leq 0$

$136.213.010,85y_1+0,92y_2 + 0,99y_3 - 0,9968x_1 - 0,92x_2 - 0,5777x_3 \leq 0$

$242.624.130,05y_1+0,2843y_2 + y_3 - 0,9963x_1 - 0,2843x_2 - 0,8619x_3 \leq 0$

$0,1714x_1 + 0,5443x_2 + 0,8848x_3 = 1$

2. Supplier II, Kazo Ind

$Z= 135.172.271,40y_1 + 0,6371y_2 + y_3$

Subject to :

$112.344.514,89y_1+0,5443y_2 + y_3 - 0,1714x_1 - 0,5443x_2 - 0,8848x_3 \leq 0$

$135.172.271,40y_1+0,6371y_2 + y_3 - 0,0770x_1 - 0,6371x_2 - 0,8619x_3 \leq 0$

$209.878.933,20y_1+y_2 + y_3 - 0,7792x_1 - x_2 - 0,95337x_3 \leq 0$

$136.213.010,85y_1+0,92y_2 + 0,99y_3 - 0,9968x_1 - 0,92x_2 - 0,5777x_3 \leq 0$

$242.624.130,05y_1+0,2843y_2 + y_3 - 0,9963x_1 - 0,2843x_2 - 0,8619x_3 \leq 0$

$0,0770x_1 + 0,6371x_2 + 0,8619x_3 = 1$

3. Supplier III, Eldiya Intr

$Z= 209.878.933,20y_1+y_2 + y_3$

Subject to :

$112.344.514,89y_1+0,5443y_2 + y_3 - 0,1714x_1 - 0,5443x_2 - 0,8848x_3 \leq 0$

$135.172.271,40y_1+0,6371y_2 + y_3 - 0,0770x_1 - 0,6371x_2 - 0,8619x_3 \leq 0$

$209.878.933,20y_1+y_2 + y_3 - 0,7792x_1 - x_2 - 0,95337x_3 \leq 0$

$136.213.010,85y_1+0,92y_2 + 0,99y_3 - 0,9968x_1 - 0,92x_2 - 0,5777x_3 \leq 0$

$242.624.130,05y_1+0,2843y_2 + y_3 - 0,9963x_1 - 0,2843x_2 - 0,8619x_3 \leq 0$

$0,7792x_1 + x_2 + 0,95337x_3 = 1$

4. Supplier IV, Adi Jaya

$Z = 136.213.010,85y_1+0,92y_2 + 0,99y_3$

Subject to :

$112.344.514,89y_1+0,5443y_2 + y_3 - 0,1714x_1 - 0,5443x_2 - 0,8848x_3 \leq 0$

$135.172.271,40y_1+0,6371y_2 + y_3 - 0,0770x_1 - 0,6371x_2 - 0,8619x_3 \leq 0$

$209.878.933,20y_1+y_2 + y_3 - 0,7792x_1 - x_2 - 0,95337x_3 \leq 0$

$136.213.010,85y_1+0,92y_2 + 0,99y_3 - 0,9968x_1 - 0,92x_2 - 0,5777x_3 \leq 0$

$242.624.130,05y_1+0,2843y_2 + y_3 - 0,9963x_1 - 0,2843x_2 - 0,8619x_3 \leq 0$

$0,9968x_1 + 0,92x_2 + 0,5777x_3 = 1$

5. *Supplier* V, Budhi Wiguna

$Z = 242.624.130,05y_1+0,2843y_2 + y_3$

Subject to :

$112.344.514,89y_1+0,5443y_2 + y_3 - 0,1714x_1 - 0,5443x_2 - 0,8848x_3 \leq 0$

$135.172.271,40y_1+0,6371y_2 + y_3 - 0,0770x_1 - 0,6371x_2 - 0,8619x_3 \leq 0$

$209.878.933,20y_1+y_2 + y_3 - 0,7792x_1 - x_2 - 0,95337x_3 \leq 0$

$136.213.010,85y_1+0,92y_2 + 0,99y_3 - 0,9968x_1 - 0,92x_2 - 0,5777x_3 \leq 0$

$242.624.130,05y_1+0,2843y_2 + y_3 - 0,9963x_1 - 0,2843x_2 - 0,8619x_3 \leq 0$

$0,9963x_1 + 0,2843x_2 + 0,8619x_3 = 1$

Efficiency scores		Scale efficiencies	Returns-to-scale	CCR score	NIRS score
Myeong S	1,0000	1,0000	constant	1,0000	1,0000
Kazo Ind	1,0000	1,0000	constant	1,0000	1,0000
Eldiya Intr	1,0000	1,0000	constant	1,0000	1,0000
Adi Jaya	1,0000	1,0000	constant	1,0000	1,0000
Budhi Wiguna	1,0000	1,0000	constant	1,0000	1,0000

Table 3 Table Scores Copper

Efficient unit has a value score of 1.0000 and 1,000 valued suppliers marked in blue. From the above table it can be seen that the above five suppliers have a score equal to 1 and the color blue, so the fifth suppliers efficiently. Return-to-scale shows the constant and decreasing from existing suppliers. Return-to-scale shows the description of the characteristics of each supplier area where there is not constant then be written decreasing and constant if the efficiency score of 1.0000. From the above table it can be seen that the above five suppliers have a score equal to 1 then the return-to-scale shows the constant information.

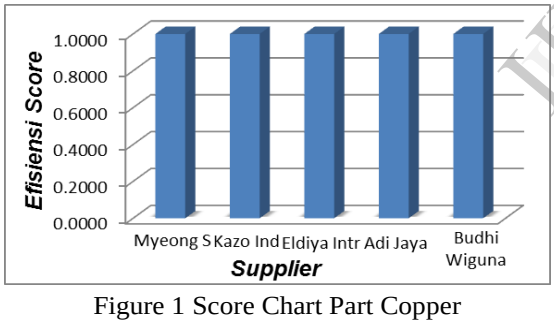

Figure 1 Score Chart Part Copper

CCR Score values obtained from the multiplication between efficiency and scale efficiency scores. Because the value of efficiency and scale efficiency scores with the same value (1.000), the value was well worth the CCR Score one (1.000). NIRS Score (Non-increasing returns to scale) is part of the model xlDEA, which will show the value that each supplier of the output characteristics of xlDEA. Figure 1 Score Chart Part Copper, it can be seen that all the suppliers that are worth 1,000 so that the supplier of Myeong S, Kazo Ind, Intr Eldiya, Adi Jaya and the Budhi Wiguna efficient. This is in accordance with the table score and score frequencies which show that the results are xlDEA efficient processing with efficient value of 1.000.

Score frequencies	
up to 0.10	0
0.10+ to 0.20	0
0.20+ to 0.30	0
0.30+ to 0.40	0
0.40+ to 0.50	0
0.50+ to 0.60	0
0.60+ to 0.70	0
0.70+ to 0.80	0
0.80+ to 0.90	0
0.90+ to 1.00	5

Table 4 Score Frequency

Supplier who is in the interval ranging from 0 to 0.1 a 0. 0:10 interval, amounting to 0.9 0. Supplier who is in the interval ranging from 0.90 to 5 1:00 a supplier. Frequency fifth supplier as in Figure 2.

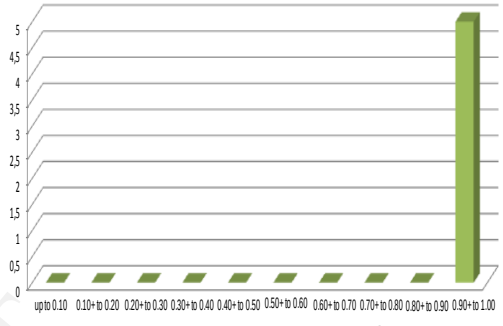

Figure 2 *Frequencies Chart of* Copper

3.4. Determination of the Best Supplier

In processing the results using Data Envelopment Analisys (DEA), worth 1.000 or five suppliers means streamlined. Penentukan best suppliers based on the output of Data Envelopment Analisys (DEA) is combined with the output of a fuzzy method. The highest weight on the fuzzy output is used as a reference for determining the best supplier.

Table 5 Best Supplier For Copper Pipe

No	*Supplier*	Price (Rp)	*Best Supplier*
1	Myeong S	112.344.514,89	**Myeong S**
2	Kazo Ind	135.172.273,40	
3	Eldiya Intr	209.878.933,20	
4	Adi Jaya	136.213.010,85	
5	Budhi Wiguna	242.624.130,05	

The highest weighting criteria is price criteria. Then the decision contained in table 5. The price offered by Myeong S is the most affordable prices than the prices offered by other suppliers of Rp 112,344,514.89. The best supplier weeks to Copper Pipe is Myeong S.

4. Cocclusion

Level of importance that affect the performance criteria Copper Pipe suppliers. Rank order criteria are price, quality perormansi supplier (supplier experience), Delivery, Facility Prod. & Kaps,

Geographic Location and Financial Position. Penentukan supplier 2 best done merging method and the method of fuzzy Data Envelopment Analisys methods (DEA). Data processing results Analisys Envelopment (DEA) worth 1,000 which means that the supplier is efficient, then the decision is taken in selecting the best supplier based on consideration of the highest weighting criteria. The results of processing produces the best supplier is Myeong S.

5. References

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