Evaluation of Supplier Performance in Plastic Manufacturing Industry: A Case Study

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Abstract. The supplier is an essential element in the production process because it supplies raw materials. In the supply chain, supplier performance evaluation is an essential factor. This evaluation is used to assess supplier performance in improving company performance. This study aims to evaluate supplier performance using the integration of the Analytical Hierarchy Process (AHP) and Standardized Unitless Rating (SUR) methods. AHP is proposed for the determination of criteria weights, and SUR is used to evaluate supplier performance. Criteria weights on AHP are used in the SUR method to evaluate supplier performance. A case study was carried out in the plastic manufacturing industry in Indonesia. The criteria used include Quality (Q), Cost (C), Delivery (D), Flexibility (F), Responsiveness (R), Warranty and claim policies (W), and Environmental management system (E). The results showed that cost is the most critical criterion in evaluating supplier performance. The results also showed that AHP and SUR were effectively used to evaluate supplier performance.

Keywords: Evaluation, Supplier, Performance, AHP, SUR

1. Introduction

The raw material is an essential aspect of the production process's smoothness, and it is obtained from suppliers [1]. Suppliers influence production process activities because the production process's performance is influenced by supplier performance [2]. In the supply chain network, some aspects influence company performance [3], such as suppliers [4], production [5] [6], inventory [7] [8], and distribution [9] [10]. Supplier performance is one of some aspect that affects company performance [11]. It is necessary to evaluate supplier performance to improve company performance [12]. Supplier performance evaluation is an activity to measure supplier performance to reduce company risk [13]. This problem has received much attention from researchers, and it is one of the famous problems in the field of supply chain [14].

Several studies have been conducted to evaluate supplier performance. Some approaches have been proposed to solve this problem. Ohdar and Ray [15] and Awasthi, Chauhan and Goyal [16] have proposed A fuzzy multicriteria approach to solve this problem. Moreover, Yadav, Sharma and Singh [17] offered the extent of the fuzzy Technique for Order Preference by Similarity to Ideal Solution

(Topsis) method. Fuzzy- Analitycal Hierarchy Process (AHP) approach applied by Pang [18]. Data Envelopment Analysis (DEA) has been used by Liu, Ding and Lall [19] and Noorizadeh, Mahdiloo and Farzipoor Saen [20]. Recently, the Analytic Network Process was also implemented to solve this problem [21]. Furthermore, several hybrid methods have been proposed to evaluate supplier performance. Integration of fuzzy AHP and fuzzy Evaluation based on Distance from Average Solution was proposed by Stević, Vasiljević, Puška, Tanackov, Junevičius and Vesković [22]. dos Santos, Godoy and Campos [23] offered fuzzy entropy-Topsis. Integration of Fuzzy AHP- Topsis was applied by Chatterjee and Stević [24]. The combination of AHP and Standardized Unitless Rating (SUR) was implemented by Erfaisalsyah, Mansur and Khasanah [25]. Sasikumar and Vimal [26] proposed the fuzzy Vikor and fuzzy Topsis. The DEA and AHP were offered by Joo, Boehmke, Min and Bayazit [27].

Based on previous research, several hybrid procedures have been proposed to evaluate supplier performance. One of the exciting methods of research is the integration of AHP and SUR. However, to the best of our knowledge, only 1 study used AHP and SUR integration to evaluate supplier performance. Erfaisalsyah, Mansur and Khasanah [25] used this method to evaluate the textile industry suppliers' performance. This study attempts to apply AHP-SUR integration to evaluate the performance of the Plastic Manufacturing Industry supplier. Hence, this study aims to evaluate supplier performance using the integration of AHP and SUR methods in the Plastic Manufacturing Industry.

2. Methods

2.1. The proposed method to evaluate supplier performance

This study proposes the AHP and SUR integration methods to evaluate supplier performance. AHP is proposed to calculate the weight of the criteria in evaluating supplier performance. Furthermore, the criteria weights are used in the SUR method for supplier performance assessment. The supplier performance evaluation framework is presented in Figure 1.

In Figure 1, the supplier performance evaluation begins by creating a supplier evaluation team and determining supplier performance evaluation criteria. Furthermore, the team conducts a Focus Group Discussion (FGD) to determine the criteria' level of importance with a pairwise comparison. The weighting of supplier evaluation criteria is based on the AHP method proposed by Saaty [28]. Pairwise comparison using the rating scale is presented in Table 1. The results of pairwise comparisons for each criterion are presented in a matrix, which is then normalized. The calculation of the criteria weight in AHP is carried out by normalization conducted by dividing the column value by the number of columns in the matrix [29]. In the AHP stage, the final step of this method is to calculate consistency. The calculation of the Consistency Ratio (CR) is presented in equation (1).

Table 1. Pairwise comparison scale

Scale	Definition
1	Identical importance
3	Medium importance
4	Strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Intermediate scale

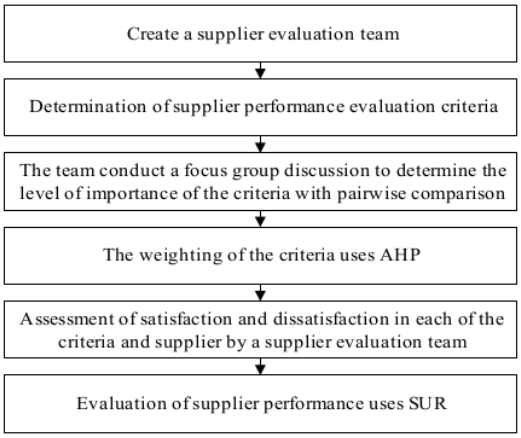

Fig. 1. Supplier performance evaluation framework

Table 2. satisfaction and dissatisfaction

Value	Dissatisfaction (X)	Satisfaction (Y)
0,10 – 0,20	Extremely dissatisfied	slightly Satisfied
0,21 – 0.40	Less and dissatisfied	Satisfied
0,41 – 0,60	Not satisfied	Somewhat satisfied
0,61 – 0,80	Moderately dissatisfied	Quite Satisfied
0,81 – 0,90	Slightly dissatisfied	Very Satisfied

The weights criteria from AHP are used by the SUR method to assess the supplier performance. In the SUR method, the decision-maker needs to determine the value of satisfaction and dissatisfaction on each supplier's criterion. Assessment of satisfaction and dissatisfaction use an interval between 0.1 - 0.9 (see table 2). x_{ij} shows dissatisfaction for supplier i criteria j, and y_{ij} describes satisfaction in supplier i criteria j. The results of the satisfaction and dissatisfaction assessment are used to determine the average value of the level of satisfaction (a_{ij}) (see equation (2)), the value of the level of doubt (r_{ij}) (equation (3)), the average value of the performance criteria for j ($\bar{a}_j$) (equation (4)). Furthermore, this stage needs to determine the maximum ($a_{\max j}$) and minimum ($a_{\min j}$). values. The SUR assessment is presented in equation (5). The best supplier performance is based on the highest SUR value.

$$CR = \frac{CI}{RI} \tag{1}$$

$$a_{ij} = \frac{(x_{ij}+y_{ij})}{2} \tag{2}$$

$$r_{ij} = \left|x_{ij} - y_{ij}\right| \tag{3}$$

$$\bar{a}_j = \frac{\sum_{j=1}^{m} a_{ij}}{m} \tag{4}$$

$$SUR_i = \sum_{j_i}^{n} \left[\frac{a_{ij} - \bar{a}_j}{a_{\max j} - a_{\min j}}\right] x\left[1 - r_{ij}\right] x \left[\frac{W_j}{\sum_{j=i|W_i|}^{n}}\right] \tag{5}$$

The notation used in this paper is presented as follows:

CR : Consistency Ratio
CI : Consistency Index
RI : Relative Index
i : Supplier i ... (i = 1,2,3, ..., m)
j : Criteria j ... (j = 1,2,3, ... n)
m : Number of suppliers
n : Number of Criteria
y_{ij} : Satisfaction level on supplier i criteria j
x_{ij} : Level of dissatisfaction on supplier criteria i j
a_{ij} : The average value of satisfaction in the j-th criteria for the i-th supplier
r_{ij} : The level of doubt in the assessment results
$\bar{a}_j$: The average value for the j-criteria for the i-th supplier
W_{ij} : AHP weighting results for each criterion
W_j : Total weight for each criterion
$a_{\max j}$: The maximum value of the assessment for the criteria of the j and m suppliers
$a_{\min j}$: The minimum value of assessment for the criteria of the j and m suppliers

2.2. A Case study

A case study was conducted in the Plastic Manufacturing Industry in Indonesia. The supplier performance evaluation team, consisted of purchasing managers, purchasing staff, and warehouse managers. The team determined the criteria used for evaluating supplier performance. Table 3 shows seven criteria used to evaluate supplier performance.

Furthermore, the team conducted an FGD to create seven criteria pairwise comparison matrix. The results of the FGDs in the seven criteria are presented in table 4. Three suppliers were evaluated in this case study. The team conducted an assessment of the satisfaction and dissatisfaction of each criterion for each supplier. The results of the assessment from the supplier performance evaluation team are presented in Table 5.

Table 3. Criteria for evaluating supplier performance

Criteria	Reference
Quality (Q)	Erfaisalsyah, Mansur and Khasanah [25], Li, Fun and Hung [12], Valipour Parkouhi and Safaei Ghadikolaei [30]
Cost (C)	Erfaisalsyah, Mansur and Khasanah [25], Li, Fun and Hung [12], Valipour Parkouhi and Safaei Ghadikolaei [30]
Delivery (D)	Erfaisalsyah, Mansur and Khasanah [25], Li, Fun and Hung [12], Valipour Parkouhi and Safaei Ghadikolaei [30]
Flexibility (F)	Erfaisalsyah, Mansur and Khasanah [25], Li, Fun and Hung [12]
Responsiveness (R)	Erfaisalsyah, Mansur and Khasanah [25], Li, Fun and Hung [12]
Warranty and claim policies (W)	Dickson [31]
Environmental management system (E)	Erfaisalsyah, Mansur and Khasanah [25]

Table 4. Pairwise comparison results for seven criteria

Criteria	Q	C	D	F	R	W	E
Q	1	1	1	3	5	7	9
C	1	1	1	3	3	5	8
D	1	1	1	1	3	3	5
F	1/3	1/3	1	1	2	2	5
R	1/5	1/3	1/3	1/2	1	4	5
W	1/7	1/5	1/3	1/2	1/4	1	3
E	1/9	1/8	1/5	1/5	1/5	1/3	1

Table 5. Results of the assessment of satisfaction and dissatisfaction in each criterion for each supplier

Performance Criterion (j)														
Criteria	**Q**		**C**		**D**		**F**		**R**		**W**		**E**	
Weight	**0.285**		**0.243**		**0.187**		**0.12**		**0.091**		**0.049**		**0.025**	
Supplier(i)	**xi1**	**yi1**	**xi2**	**yi2**	**xi3**	**yi3**	**xi4**	**yi4**	**xi5**	**yi5**	**xi6**	**yi6**	**xi7**	**yi7**
1	0.5	0.8	0.6	0.9	0.7	0.9	0.7	0.9	0.7	0.8	0.6	0.8	0.7	0.9
	0.65	0.3	0.75	0.3	0.8	0.2	0.8	0.2	0.7	0.1	0.7	0.2	0.8	0.2
2	0.7	0.9	0.7	0.9	0.5	0.8	0.5	0.8	0.6	0.8	0.6	0.9	0.5	0.8
	0.8	0.2	0.8	0.2	0.65	0.3	0.65	0.3	0.65	0.2	0.75	0.3	0.65	0.3
3	0.7	0.8	0.6	0.7	0.7	0.8	0.6	0.9	0.7	0.8	0.6	0.7	0.6	0.9
	0.75	0.1	0.65	0.1	0.75	0.1	0.75	0.3	0.75	0.1	0.65	0.1	0.75	0.3
$a_{max\,j}$	0.8		0.8		0.8		0.8		0.75		0.75		0.8	
$a_{min\,j}$	0.65		0.65		0.65		0.65		0.65		0.65		0.65	
$\bar{a}_j$	0.73		0.73		0.73		0.73		0.7		0.7		0.73	

3. Results and Discussion

In this study, the results of weighting seven criteria for supplier performance evaluation are shown in Figure 2. This figure shows that Quality (Q) has the highest weight followed by the criteria of Cost (C), Delivery (D), Flexibility (F), Responsiveness (R), Warranty, and claim policies (W), and Environmental management system (E). The quality of raw material is the most important criterion because it has a factor that affects the quality of the finished product. This study's results are following the research conducted by Li, Fun and Hung [12]. In this study, the environmental management system was not a company priority in evaluating suppliers. These results confirm the findings of a study conducted by Erfaisalsyah, Mansur and Khasanah [25].

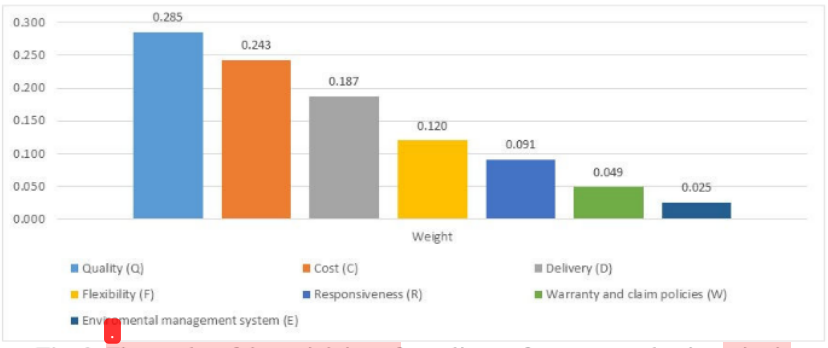

Fig. 2. The results of the weighting of supplier performance evaluation criteria

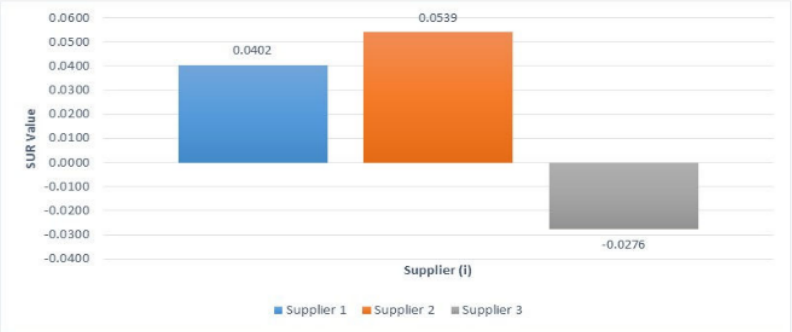

Fig. 3. The results of the SUR for each supplier

The weights of supplier performance evaluation criteria are used to assess supplier performance. The results of supplier performance assessment using the SUR method can be seen in Figure 3. These results show that supplier 2 has the highest performance, followed by supplier 1, and the lowest performance is supplier 3.

4. Conclusion

This study aimed to evaluate the performance of suppliers in the Plastic Manufacturing Industry. This research was successful in using the integration of AHP and SUR methods in evaluating supplier performance. The results showed that Quality (Q) has the highest weight followed by the criteria of Cost (C), Delivery (D), Flexibility (F), Responsiveness (R), Warranty, and claim policies (W), and Environmental management system (E). The results of the study are also can show supplier performance ratings. This study has limitations on the criteria used. Further research needs to add several other criteria that follow the company's needs in measuring supplier performance.

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