Performance Analysis and Supplier Evaluation using Analytical Hierarchy Process and Technique for Order Preference by Similarity to Ideal Solution at the Shipyard Company

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***Abstract*—Performance assessment at shipyard companies only includes price criteria, product quality, and ownership of SKT as a registered supplier in the company. This performance assessment is considered not optimal so that there are problems caused by suppliers every year by different suppliers. Based on these problems, this research was conducted to determine the criteria and sub-criteria that have a major influence on supplier performance assessment by using metrics in the SCOR Model but also taking into account the company's needs and then assessing supplier performance based on predetermined criteria and sub-criteria. The weighting of the performance assessment criteria and sub-criteria is carried out by the AHP method and the supplier performance assessment is carried out by the TOPSIS method. The results obtained by the AHP method are that the quality criteria get the largest weight, namely 0.401, cost (0.288), reliability (0.215), responsiveness (0.215) and agility (0.107). The results of the sub-criteria weighting get the sub-criteria with the highest weight, namely price stability (0.381), delivery performance to commit date (0.412), responsiveness to complaints (0.750), upside source adaptability (0.425), quality of product (0.835). Based on the results of the consumable supplier performance assessment, the top 5 suppliers were obtained with supplier codes SEJA21CS, ACR23CS, IMP25CS, AFM12CS, KPRI20CS. Based on the results of the performance evaluation, it was found that there were 2 suppliers with very good assessment results, 7 suppliers with good assessment results, 10 suppliers with sufficient assessment results, 6 suppliers with poor assessment results, and 5 suppliers with very poor assessment results.**

***Keywords*—AHP; TOPSIS; SCOR Model; Supplier's performance; and Supply Chain Management**

I. INTRODUCTION

The shipbuilding industry is characterized by complex operations and ongoing processes, which require close collaboration, both upstream and downstream of the supply chain, becoming imperative to meet the needs of different customers. The high level of complexity that exists in the manufacturing process and assembly process requires a level of synchronization between suppliers and the shipyard itself (Vlachakis et al., 2016). In meeting the needs of various kinds of raw materials, shipbuilding companies generally have many suppliers and it is not uncommon for these suppliers to cause problems in the transaction process.

Problems in shipping goods from suppliers will cause stockouts and long lead times (Ramayanti & Ulum, 2017). The supplier is one of the business partners who plays a very important role in ensuring the availability of supply goods or raw materials needed by the company (Lukmandono et al., 2019). Problems in shipping goods from suppliers can cause huge losses to the shipbuilding industry. Shipyards that cannot complete their projects on time will receive penalties from consumers. Therefore, the company relies heavily on suppliers to meet the components needed in ship construction and ship repair.

Supplier assessments are carried out so that errors do not occur and have an impact on decreasing the company's productivity (Alvira & Rusdah, 2020). This is because raw materials are one of the factors that have a direct influence on the activities of the production process. The shipbuilding industry's need for various kinds of raw materials in the production process makes the company have many suppliers. The increasing dependence on suppliers, requires companies to be able to choose quality and trustworthy suppliers so as to form good cooperation with the company. This supplier performance assessment is carried out periodically to monitor the quality of supplier services so that companies can provide feedback to suppliers to improve their services and products or make decisions to continue cooperation or find new suppliers.

Supplier selection is not only seen on price criteria, but must also include other criteria such as good quality, timely delivery to adequate production capacity (Rimantho et al., 2017). Shipyard Company has assessed suppliers but only includes criteria for price, product quality and ownership of a Registered Certificate as a supplier registered with the company. The absence of a metric that composes a hierarchy of criteria used and the absence of a certain method of weighting has an impact on the assessment results that are less accurate in describing supplier performance. This has an impact on supplier negligence which is increasing due to the

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evaluation of supplier performance assessment at the company has not been carried out properly.

The problems that most often occur in the company during 2018 to 2020 based on supplier violation data are unilateral PO cancellations, delays in delivery of goods, goods that have been sent are not appropriate so that a return must be made, and the goods sent do not match the number of orders. The violations that occurred were carried out by different suppliers. This shipbuilding company has 135 suppliers registered with the company. The supplier must have SKT (Registered Certificate). This research was conducted on material suppliers who made transactions in 2020. The number of suppliers studied were 30 consumable suppliers, these suppliers are the suppliers who make the most transactions every year. Consumable materials are consumables or materials that do not have the possibility to be repaired or reused (Pratiwi, 2018). The meaning of this consumable definition can be interpreted as routine materials including plates, pipes, nuts, bolts, valves and so on.

The method that can be used to get a good supplier, one of which is the Analythical Hierarchy Process (AHP) method. The AHP method is a method designed to rationally capture people's perceptions that are closely related to certain problems through procedures designed to arrive at a preference scale among various sets of alternatives (Falatehan, 2016). The AHP method is used to weight the criteria and sub-criteria.

The Technique for Order Preference by Similarity to Ideal Solution or commonly called TOPSIS is known as an MCDM method that has been widely accepted for supplier selection because of its simplicity and application and high sensitivity in problems with various criteria (Pekkaya, 2015). Therefore, after weighing the criteria and sub-criteria with the AHP method, the supplier performance assessment will use the TOPSIS method.

TOPSIS is a multi-criteria decision-making method or alternative choice which is the alternative that has the smallest distance from the positive ideal solution and the largest distance from the negative ideal solution from a geometric point of view using Eucliden's distance (Ramayanti, 2017). The concepts and calculations in the TOPSIS method are simple and easy to understand, and can determine the relative performance of each alternative decision so that it can be used to determine practical decisions.

Of the 30 suppliers who will be assessed, 19 suppliers have committed violations in 2020 with at least one violation. The ratio of violations committed by suppliers in 2020 can be seen in the attachment. Violations committed by more than half of the suppliers studied make researchers assume that supplier performance is not monitored properly by company management so that many suppliers commit violations. Another assumption that may be the reason for the occurrence of many violations from suppliers is the lack of strict sanctions from the company regarding violations that have been committed by suppliers.

The research "Performance Analysis and Supplier Evaluation Using Analytical Hierarchy Process and Technique for Order Preference by Similarity to Ideal Solution in Surabaya Private Shipyard Companies" is expected to be a consideration for managers in making better decisions regarding evaluating supplier performance assessments in companies. In addition, it is expected to assist in knowing the criteria and sub-criteria that affect the evaluation of supplier performance in accordance with the company's needs along with methods that can be used for periodic supplier performance assessments.

II. METHODOLOGY

The use of the SCOR Model to design supplier performance assessment criteria in this study is limited to the use of performance metrics. In the Supply Chain Council (2012) the performance section in the SCOR Model consists of 2 elements, namely performance attributes and metrics. The criteria and sub-criteria with the SCOR model that will be used in the supplier performance assessment with the SCOR model can be seen in the image below. The design of the model quotes from the International Journal of Production Economics (Lima, 2016) which focuses on the criteria of cost and delivery performance but has included the use of the attributes of cost, reliability, responsiveness and agility in each sub-criteria. These criteria were then re-discussed in a focus group discussion with the supply chain division of the company to consider other criteria needed by the company. The final criteria and sub-criteria used in the supplier performance assessment are summarized in Table I.

TABLE I. CRITERIA AND SUB-CRITERIA IN SUPPLIER PERFORMANCE ASSESSMENT

Criteria	Sub-Criteria
Cost	Price stability
	Flexible terms of payment
	Sourcing cost
	Return cost
	Material landed cost
Reliability	Delivery performance to commit date
	Perfect condition
	Orders delivered in full
	Documentation accuracy
Responsiveness	Responsivenes to complaints
	Source cycle time
Agility	Upside source adaptability
	Supplier risk rating
	Downside source adaptability
Quality	Quality of product
	Compliance to health & safety regulation

This study examines the application of supplier selection using the integration of the AHP and TOPSIS methods. This research is included in quantitative research, namely research with the aim of obtaining data in the form of numbers or qualitative data that is numbered (Sugiyono, 2011). In this quantitative study, the data collection was obtained from field

studies in the form of focus group discussions and interviews and the questionnaire data obtained were filled in by the respondents.

The research flow is as follows:

1. Identify the problem

Formulation of the problem to be discussed in the study. This study focuses on evaluating supplier performance assessment by determining the criteria and sub-criteria that are in accordance with the supply chain management division of the Surabaya shipbuilding company.

2. Literature study

The literature studied is about the SCOR Model, supplier performance evaluation, Analytical Hierarchy Process method and Technique for Order Preference by Similarity to Ideal Solution method.

3. Data collection

The required data is divided into 2, namely primary data and secondary data.

a. Primary data

The primary data used was obtained from the results of the Focus Group Discussion (FGD) conducted with the SCM Manager and several SPV SCM divisions at PT "X". Primary data includes: determination of criteria, priority assessment of suppliers.

b. Secondary Data

The secondary data used in this study are books (library materials), related research journals, and material procurement history, a brief history of the company, and company data related to research.

4. Determining Criteria and Sub-criteria with Expert Judgment

This process is carried out through FGD discussions with expert judgments by considering the proposed criteria and sub-criteria and the company's needs.

5. Questionnaire Preparation

Questionnaire I contain the importance of paired criteria and sub-criteria. In this questionnaire, there is a pairwise comparison matrix that contains the level of preference for several alternatives for each criteria and sub-criteria. The preference scale used is a scale of 1 which indicates the lowest level (equal importance) to a scale of 9 which indicates the highest level (extreme importance) as shown in Table II.

TABLE II. SCALE COMPARISON OF VALUES

Level of Interest	**Definition**	**Description**
1	Equally important	Both elements have the same effect
3	Slightly more important	Experience and judgment are a little more in favor of one element than its counterpart
5	More important	Experience and judgment are very biased towards one element compared to its partner
7	Very important	One element is very well liked and practically its dominance is very real compared to its partner element
9	Absolute more important	One element is shown to be absolutely preferable to its partner at the highest level of confidence
2,4,6,8	Middle Value	is given when there is doubt about the assessment between adjacent ratings
Return	$a_{ji} = 1/a_{ij}$	

Source : Saaty in Rimantho, 2017

In Table III, questionnaire II contains a supplier assessment evaluation scale with predetermined criteria and sub-criteria. The questionnaire model uses a Likert scale of 1-5 (Puspita, 2017).

TABLE III. LIKERT SCALE

Assessment description	Very bad	Bad	Adequate	Good	Very Good
Scale	5	4	3	2	1

6. Determining the Weight of Criteria and Sub-criteria with AHP

At this stage, the criteria and sub-criteria are weighted using the AHP method from the data that has been obtained in the questionnaire I. The steps for using the AHP method according to Wicaksono et al., (2015) are as follows:

a. Determination of the criteria and sub-criteria that will be used in the supplier assessment and have been adjusted to the needs of the company.

b. Arrangement of problems in a hierarchy

c. Problems are arranged starting from goals, criteria, sub-criteria, and at the lowest level there are possible alternatives that are used

d. Paired matrix arrangement for each level

e. Completion of pairwise comparison matrices by experts

f. Calculating the geometric mean

$$M = \sqrt[n]{(x_1)(x_2)\dots(x_n)}$$
$$GM = \sqrt[n]{(x_1)(x_2)\dots(x_n)} GM = \sqrt[n]{(x_1)(x_2)\dots(x_n)} \quad (2.1)$$

g. Calculating the normalization matrix

h. Calculating the eigenvalues of vector

i. Perform logical consistency (CI) calculations

$$CI = \frac{\lambda_{max} - n}{n-1} CI = \frac{\lambda_{max} - n}{n-1} \quad (2.2)$$

$$\lambda_{max} = \frac{\sum VB}{n}\lambda_{max} = \frac{\sum VB}{n} \quad (2.3)$$

$$CR = \frac{CI}{IR}CR = \frac{CI}{IR} \quad (2.4)$$

Notations:
$\lambda_{max}\lambda_{max}$ = largest eigenvalue
n = matrix size
VB= weighted normalized decision matrix value
CI= Consistency Index
IR= Index Random Consistency as shown in Table IV

TABLE IV. RANDOM INDEX VALUE

N	1	2	3	4	5	6	7	8	9	10
IR	0.00	0.00	0.58	0,90	1,12	1,24	1,32	1,41	1,45	1,49

Source : Saaty (1993)

j. Consistency testing, if the consistency ratio < 0.1, then the calculation results can be justified.

k. Develop a decision matrix

7. Evaluation of Supplier Performance with TOPSIS

The TOPSIS method is used to determine which alternative or supplier has the most potential in supplying raw materials. The first stage before the calculation is to build a decision matrix based on the supplier selection assessment questionnaire data (questionnaire II). The results of the weighting in the AHP calculation are used in constructing a weighted normalized matrix. Furthermore, calculations are carried out according to the technique for order preference by similarity to ideal solution method. Here are the steps in the calculation with the TOPSIS method:

a. Creating a normalized decision matrix

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}; \text{ dengan i = 1, 2, …, m; dan j= 1, 2, …, n} \quad (2.5)$$

Notations:
$r_{ij}r_{ij}$= normalized matrix [i] [j]
$x_{ij}x_{ij}$= decision matrix [i] [j]

b. Create a weighted normalized decision matrix
The weighted normalized matrix calculation can be done with the following equation:

$$V_{ij} = W_j \times R_{ij} V_{ij} = W_j \times R_{ij} \quad (2.6)$$

Where:
V_{ii} = weighted normalized matrix
W_j = weighted of subcriteria

c. Determine the positive ideal solution matrix and negative ideal solution
To get the value of the positive ideal solution (A^+) by finding the maximum value in each column and the negative ideal solution (A^-) by finding the minimum value using the following equation:

$$\begin{aligned} A^+ &= \{\max Vij \mid j \in J), (\min Vij \mid j \in J'), i\} \\ A^+ &= \{\max Vij \mid j \in J), (\min Vij \mid j \in J'), i\} \quad (2.7) \\ &= 1, 2, 3, \dots, m \\ &= \{A1^+ A2^+ A3^+, \dots . An^+\} \end{aligned}$$

$$\begin{aligned} A^- &= \{\min Vij \mid j \in J), (\max Vij \mid j \in J'), i\} \\ A^- &= \{\min Vij \mid j \in J), (\max Vij \mid j \in J'), i\} \quad (2.8) \\ &= 1, 2, 3, \dots, m \\ &= \{A1^- A2^- A3^-, \dots . An^-\} \end{aligned}$$

d. Determine the distance between the values of each alternative with a positive and negative ideal solution matrix
Calculating the separation can be done using the following equation:

$$S^+ = \sqrt{\sum_{i=1}^{n}(Aij - Aj^+)^2} S^+ = \sqrt{\sum_{i=1}^{n}(Aij - Aj^+)^2} \quad (2.9)$$

With i = 1, 2, … m

$$S^- = \sqrt{\sum_{i=1}^{n}(Aij - Aj^-)^2} S^- = \sqrt{\sum_{i=1}^{n}(Aij - Aj^-)^2} \quad (2.10)$$

With i = 1, 2, … m

Notations:
S_i^+ = the ith alternative distance from the positive ideal solution
S_i^- = the ith alternative distance from the negative ideal solution
A_j^+ = element of positive ideal solution matrix
A_j^- = element of the negative ideal solution matrix
A_i^- = element of the negative ideal solution matrix
to the positive ideal solution (computing preference values for each alternative). The next step is to calculate the relative closeness to the positive ideal solution which can be calculated using the following formula:

$$C_i^+ = \frac{S_i^-}{S_i^- + S_i^+} C_i^+ = \frac{S_i^-}{S_i^- + S_i^+}, 0 \le C_i^+ \le 1 \le C_i^+ \le 1 \quad (2.11)$$

e. Performing Supplier rank.

8. Analysis and Discussion

Analyze the results of supplier assessment calculations so that the ranking of each supplier can be known which can then be a recommendation for the company as feedback to suppliers to be able to improve or develop their services.

III. RESULTS AND DISCUSSION

3.1. Results of Determining Criteria and Sub Criteria for Supplier Performance Assessment

Determination of criteria and sub-criteria in private shipbuilding companies is carried out by means of FGD (Focus Group Discussion) forums, FGDs are carried out with 5 expert judgments. The hierarchical structure of processes in AHP is divided into levels 0-3. The figure I is the process hierarchy structure in the AHP method.

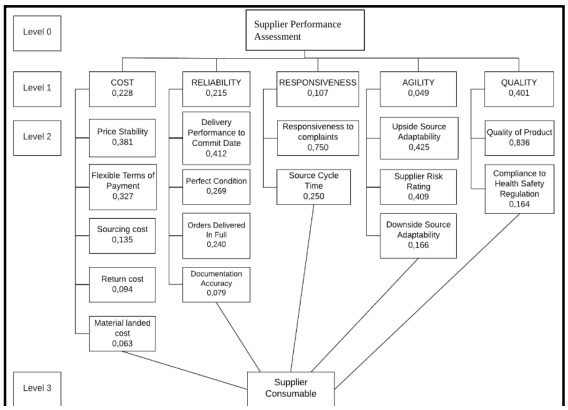

Figure I Hierarchy Structure of AHP

3.2. Weighting Between Criteria and Sub-criteria with Analytical Hierarchy Process (AHP) Method

After distributing the questionnaire weighting criteria and sub-criteria, the first step in the calculation using the AHP method is to calculate the mean geometric value (GM) from the questionnaire results that have been filled in by five experts previously using equation 2.1. The following is an example of calculating the mean geometry using pairwise comparison data from the cost and responsiveness criteria:

$$GM = \sqrt[5]{3x3x2x1x3}\ GM = \sqrt[5]{3x3x2x1x3} = 2{,}22$$

After obtaining the mean geometric results, the next step is to create a pairwise comparison matrix. The pairwise comparison matrix gives the weight of the criteria and sub-criteria based on the data obtained from the questionnaire. The pairwise comparison matrix for supplier selection based on the assessed criteria can be seen in Table V.

TABLE V. PAIRED MATRIX BETWEEN CRITERIA

Criteria	Cost	Reliability	Responsiveness	Agility	Quality
Cost	1	1,15	2,22	5,07	0,47
Reliability	0,87	1	2,69	3,84	0,49
Responsiveness	0,45	0,37	1	2,72	0,29
Agility	0,20	0,26	0,37	1	0,15
Quality	2,14	2,05	3,44	6,67	1
Total	4,66	4,83	9,71	19,31	2,40

The next step is to create a normalization matrix. Calculating the normalization value is to normalize the data by dividing the value of each element in the paired matrix by the total value of each column. The normalization calculation is carried out on all criteria as summarized in VI.

TABLE VI. NORMALIZATION MATRIX OF ASSESSMENT WEIGHTS BETWEEN CRITERIA

Cost	Reliability	Responsiveness	Agility	Quality	Total	eigen vector
0,21	0,24	0,23	0,26	0,19	1,14	0,228
0,19	0,21	0,28	0,20	0,20	1,07	0,215
0,10	0,08	0,10	0,14	0,12	0,54	0,108
0,04	0,05	0,04	0,05	0,06	0,25	0,04966
0,46	0,42	0,35	0,35	0,42	2,00	0,400
1,00	1,00	1,00	1,00	1,00		1,00

It can be seen in Table VI that the weight of the cost criterion value is 0.228 or 23%. The normalization and eigenvector calculations for all criteria are carried out with the same formula as the previous example so as to form the table.

The next step is to calculate the consistency value. The consistency value is used to check whether the questionnaire results get a consistency value < 0.1. Otherwise, the questionnaire results are considered inconsistent and need to be reassessed (Nadia, 2022). In Expert Choice software, the consistency ratio value can be seen in the inconsistency value which is located at the bottom of the weighting results.

$$\lambda \max = \frac{25{,}26457}{5} = 5{,}053$$

$$CI = \frac{5{,}053 - 5}{5 - 1} = 0{,}01325$$

Furthermore, calculating the value of the inconsistency ratio, the RI value can be seen in Table IV. The following is the result of calculating the CR value from the criteria that will be used in supplier assessment.

$$CR = \frac{0{,}01325}{1{,}12} = 0{,}01$$

From the results of these calculations, it was found that the CR value was 0.01, which means 0.1 or 10% so that it can be concluded that the results of the questionnaire are considered consistent. The following is a table of the results of the weighting between criteria and sub-criteria using the AHP method.

TABLE VII. RESULTS OF WEIGHTING BETWEEN CRITERIA AND SUB-CRITERIA USING THE AHP METHOD

Criteria	Criteria Weight	Sub-criteria	Local Weight	Global weight	Rank
Cost	0,228	Price stability	0,381	0,087	3
		Flexible terms of payment	0,327	0,075	5
		Sourcing Cost	0,135	0,031	9
		Return Cost	0,094	0,021	11
		Material Landed Cost	0,063	0,014	14
Reliability	0,215	Delivery Performance To Commit Date	0,412	0,089	2
		Perfect Condition	0,269	0,058	7
		Orders Delivered In	0,24	0,052	8

		Full			
		Documentation Accuracy	0,079	0,017	13
Responsiveness	0,107	Responsiveness to complaints	0,75	0,080	4
		Source Cycle Time	0,25	0,027	10
Agility	0,049	Upside Source Adaptability	0,425	0,021	11
		Supplier Risk Rating	0,409	0,020	12
		Downside Source Adaptability	0,166	0,008	15
Quality	0,401	Quality of product	0,836	0,335	1
		Compliance to health & safety regulation	0,164	0,066	6

3.3. Calculation of Supplier Performance Assessment Using TOPSIS Method

After calculating the weighting of criteria and sub-criteria using the AHP method, the next step is to evaluate suppliers using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method. In this study, the performance assessment of consumable suppliers, totaling 30 suppliers, will be carried out.

The first step in performing calculations is to construct a normalized decision matrix. A normalized decision matrix is used to reduce the range of data and make it easier to perform TOPSIS calculations (Dwiyana, 2017). An example of calculating the normalized value (Rij) on alternative A1 is in accordance with equation 2.8 in sub-criteria C1 or sourcing cost as follows:

$$r_{ij} = \frac{3}{\sqrt{3^2 + 4^2 + 5^2 + 4^2 + 4^2 + \cdots + 4^2}}$$

$$r_{ij} = r_{ij} = 0{,}14237$$

The next step is to calculate the sub-criteria weighted normalization matrix by multiplying the normalization matrix by the sub-criteria weighted value. An example of calculating the weighted normalization value for the sub-criteria against alternative A1 with equation 2.9 is as follows:

$$V_{ij} = 0{,}19612 \times 0{,}0308$$

$$V_{ij} = 0{,}00604$$

After obtaining the weighted normalization matrix, the next step is to find the value of the positive ideal solution (A+) and the negative ideal solution (A-). To get the value of the positive ideal solution (A+) by finding the maximum value in each column and the negative ideal solution (A-) by finding the minimum value with equations 2.10 and 2.11.

The next step is to calculate the alternative distance from the positive ideal solution (S+) and the alternative distance from the negative ideal solution (S-). The results of alternative calculations for positive ideal points and negative ideal points can be seen in Table VIII.

The last step is to sort the alternatives from the largest value C_i^+ to the smallest. The order of suppliers is prioritized based on the TOPSIS method, namely the one that has the closest value to the most positive solution and the farthest from the negative optimal solution. Here are the suppliers with the highest rank.

TABLE VIII. SUPPLIER RANK RESULTS

Rank	Code Supplier	PO 2022	offense ratio	S^+	S^-	C_i^+
1	SEJA21CS	55	-	0,00227	0,02616	0,9201
2	ACR23CS	53	-	0,00230	0,02623	0,9194
3	IMP25CS	51	-	0,0038	0,0253	0,8698
4	AFM12CS	60	2%	0,0039	0,0252	0,8672
5	KPRI20CS	48	-	0,0042	0,025	0,8557

3.4. Supplier Performance Evaluation

The final result of the performance assessment will classify suppliers into categories of assessment and recommended actions as can be seen in Table VIII. The recommendations for action refer to previous research by Khusairi (2015) which is then combined with the assessment category in previous research by Sari (2017) are summarized in Table IX.

TABLE IX. CLASSIFICATION OF SUPPLIER

C_i^+	Rating Category	Recommended Action
< 4	Very bad (Unacceptable)	Removed from supplier list
4 – 5.9	Bad (Needs Improvement)	Complaint letter
6 – 7.9	Enough (Average)	Complain directly
8 – 8.9	Good (Above average)	Keep being a supplier
9.0 – 10	Very good (Excellent)	Featured suppliers

Source : Sari, 2017 dan Khusairi 2015

The results of supplier performance assessments that have been carried out using the TOPSIS method are further categorized based on Table V. The results of supplier performance assessments that have been sorted from the highest to the lowest values and have been categorized based on recommended actions is presented in Table X.

TABLE X. RESULTS OF SUPPLIER PERFORMANCE EVALUATION

Supplier code	C_i^+	Category Assessment	Recommendation Action
A21	0,9201	Excellent	Featured

Supplier code	C_i^+	Category Assessment	Recommendation Action
			supplier
A23	0,9194	Excellent	Featured supplier
A25	0,8698	Above average	Keep being a supplier
A12	0,8672	Above average	Keep being a supplier
A20	0,8557	Above average	Keep being a supplier
A16	0,8534	Above average	Keep being a supplier
A7	0,8406	Above average	Keep being a supplier
A2	0,8235	Above average	Keep being a supplier
A6	0,807	Above average	Keep being a supplier
A18	0,7927	Average	Direct Complain
A8	0,7702	Average	Direct Complain
A13	0,7638	Average	Direct Complain
A14	0,7619	Average	Direct Complain
A27	0,757	Average	Direct Complain
A26	0,7555	Average	Direct Complain
A28	0,7404	Average	Direct Complain
A24	0,7255	Average	Direct Complain
A22	0,6864	Average	Direct Complain
A30	0,6549	Average	Direct Complain
A5	0,5028	bad (needs improvement)	Complaint letter
A4	0,5002	bad (needs improvement)	Complaint letter
A17	0,4746	bad (needs improvement)	Complaint letter
A11	0,4364	bad (needs improvement)	Complaint letter
A15	0,4228	bad (needs improvement)	Complaint letter
A10	0,4078	bad (needs improvement)	Complaint letter
A9	0,3731	Very bad (Unacceptable)	Removed from supplier list
A19	0,3556	Very bad (Unacceptable)	Removed from supplier list
A29	0,2888	Very bad (Unacceptable)	Removed from supplier list
A3	0,2553	Very bad (Unacceptable)	Removed from supplier list
A1	0,2355	Very bad (Unacceptable)	Removed from supplier list

Based on the results of the grouping of supplier performance assessment categories, it shows that there are still some suppliers who get scores below the average value. Therefore, the researcher provides recommendations for actions that the company can take against suppliers based on the assessment category obtained after evaluating the supplier's performance in Table X.

In Table X, it can be seen that there are two suppliers that fall into the category of leading suppliers. Suppliers A21 and A23 scored 0.9201 and 0.9194 so that they became the best suppliers with almost perfect scores in each category. While in the good assessment category there are 7 suppliers, namely suppliers A25, A12, A20, A16, A7, A2, and A26 these suppliers are still worthy of being the company's main supplier because they have never committed a violation. The recommended action for this supplier is awarding a certificate as the best supplier and the results of the performance assessment that have been carried out by the company so that suppliers always try to do their best in cooperation with the company. Suggestions from the results of interviews with experts are recommendations for action to suppliers with a very good and good assessment category in the form of the supplier will be the first reference when there is a demand for goods so that the cooperation continues and the supplier will get income from the company.

There are 10 suppliers who get a sufficient rating, namely suppliers A18, A8, A13, A14, A27, A26, A28, A24, A22, and A30. Some of these suppliers have committed a one-time violation. Because it is still early in nature or has never committed a violation before so that the recommended action taken if the supplier commits a violation is not too formal, namely by making a direct complaint or giving a direct

warning to the dispatching officer who comes to the warehouse (if sent directly from the supplier / not sent by a third party) and also on the contact contacted when ordering.

In the bad rating category, there are 6 suppliers, namely suppliers A5, A5, A17, A11, A15, and A10. This supplier has committed more than one violation which means that the complaint from the company has not been conveyed properly, therefore the recommended action for suppliers in this category is sending a letter of complaint to the supplier. This letter contains complaints from the company due to violations committed by suppliers so that they are not repeated because they can harm the company. According to the results of interviews with experts, the company will take action to reduce orders from suppliers who have violated many times and will block purchases from those suppliers.

The last category in Table X is a very poor rating category with a total of 5 suppliers, namely suppliers A9, A19, A29, A3, and A1. The recommended action for suppliers who get a very bad rating category is to be removed from the supplier list. This supplier is considered to have been negligent in maintaining good cooperation with the company. Suppliers who fall into the very bad rating category have violated more than three times which indicates that the supplier cannot respond properly to complaints from the company if the supplier makes a mistake, so the researcher recommends action to remove the supplier from the company's supplier list. The removal of a supplier from the company's supplier list means that the supplier will not be given an order again, but if the supplier still wants to be a partner, the supplier will be treated like a new supplier and will be assessed like a new supplier.

3.5. Action Recommendations

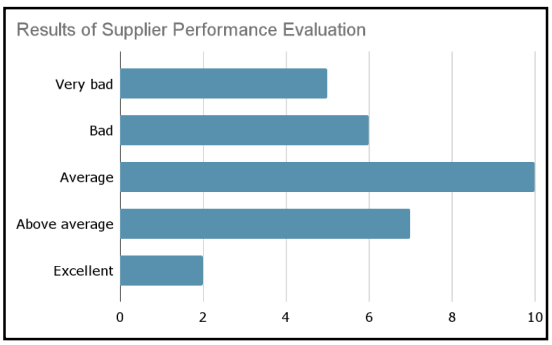

Figure II Supplier Performance Assessment Results

After seeing the number of suppliers who get scores below the average, the researcher proposes to make SOPs (Standard Operating Procedures) or contracts that contain violations that suppliers should not do and the consequences and sanctions that will be obtained if the supplier violates them.

If the company still wants to cooperate with suppliers whose performance is not too good, the author proposes to hold repair activities for these suppliers. The audit points and improvements can refer to the sub-criteria that have been determined so that improvements and audits are more focused. It can also be prioritized especially for the greatest weight of each of these sub-criteria. Companies can send the results of supplier performance assessments on a regular basis so that they can be a reminder or warning to suppliers whose performance results are poor so that suppliers have the opportunity to improve their performance. On the other hand, the performance assessment report can be a certificate of appreciation for the best suppliers who have collaborated with the company. The purpose of this activity is expected to help suppliers to improve their performance after not repeating the same mistakes after carrying out repair activities.

In interviews with experts, researchers also discussed solutions or recommended actions that can be applied to suppliers in violations that often occur in companies.

The problems that most often occur in the company during 2018 to 2020 based on supplier violation data are unilateral PO cancellations, delays in delivery of goods, goods that have been sent are not appropriate so that a return must be made, and the goods sent do not match the number of orders (as can be seen in Figure II). The violations that occurred were carried out by different suppliers. Therefore, in this chapter the author will also recommend several recommendations for actions based on violations committed by suppliers. This action recommendation comes from previous research, suggestions from researchers and expert judgment opinions from interviews after evaluating supplier performance.

In the case of shipments that exceed the predetermined schedule, the company can make a policy if the supplier is late in sending the material, it will receive sanctions in the form of fines or others.

In the second top order there are cases of goods sent that do not match the number of orders. According to Rossa (2018), recommendations for improvement for suppliers who send orders with quantities that do not match the order are to improve further coordination with suppliers. This coordination is in the form of more intensive communication regarding the ordered material such as confirming to the company when delivery will take place (Yanti, 2016).

In the third place in the violation that is often done by suppliers is the case that the goods sent are returned to the supplier. This happens due to defects or damage to the goods received by the company. According to Putri (2018) recommendations for repairs for suppliers who make mistakes in shipping so that the goods sent are defective and must be returned are to pay more attention to the handling and keeping system on the way, for example, storage of products made from easily broken can be like a lamp, can be given a place made of foam so that the lamp does not rub against each other and avoid the lamp breaking when the goods reach the company. It would be even better if the supplier checks at the time of production (machines, tools, materials) then the goods must be checked in the quality section before being sent to the buyer by attaching the results of the inspection to each shipment so that defective or damaged products when they arrive at the company can be minimized (Yanti, 2016).

The last case is the unilateral cancellation of the PO (Purchase Order) by the supplier. This is usually done by the

supplier because of a sudden order from the company so that the supplier cannot fulfill the order or because the supplier does not have the ability to fulfill the order. According to the researcher, the recommendation for improvement in this case is that the company orders from suppliers who are considered capable of accepting sudden orders, so that things like this can be minimized.

In the interview with the expert, it was agreed that the recommended action was appropriate and could be applied in the company.

IV. CONCLUSION

4.1 Conclusions

The conclusions based on the research are:

a) Based on the results of the FGD that had been carried out with 5 experts, it was decided to use the 4 criteria of the SCOR Model, namely cost, reliability, responsiveness and agility and 1 new criterion proposed by the experts, namely the quality criteria. As for the sub-criteria, there are 11 sub-criteria from the SCOR Model and 5 sub-criteria from the suggestions of the experts. The 11 sub-criteria that will be used from the SCOR Model are: sourcing cost, return cost, material landed cost, orders delivered in full, delivery performance to commit date, documentation accuracy, perfect condition, source cycle time, upside source adaptability, downside source adaptability, supplier risk rating from previous research (Lima, 2016). The five sub-criteria that will be used from the expert's proposal are: price stability, flexible terms of payment, responsiveness to complaints, quality of product, compliance to health & safety regulation.

b) The result of pairwise comparisons between criteria with the AHP method is that the quality criteria get the largest weights (0.401), cost (0.288), reliability (0.215), responsiveness (0.215) and agility (0.107). The results of the sub-criteria weighting get the sub-criteria with the highest weight, namely price stability (0.381), delivery performance to commit date (0.412), responsiveness to complaints (0.750), upside source adaptability (0.425), quality of product (0.835).

c) Based on the results of the performance assessment of consumable suppliers with selected criteria and sub-criteria with the TOPSIS method, the top 5 suppliers with supplier codes SEJA21CS, ACR23CS, IMP25CS, AFM12CS, KPRI20CS. Based on the results of the performance evaluation, it was found that there were 2 suppliers with very good assessment results, 7 suppliers with good assessment results, 10 suppliers with sufficient assessment results, 6 suppliers with poor assessment results, and 5 suppliers with very poor assessment results.

4.2 Suggestions

a) This research provides an alternative policy for companies to be able to apply the selected criteria and sub-criteria because they have been adjusted to the company's needs so that supplier performance assessments can be carried out optimally.

b) Companies can also apply recommendations for actions that have been recommended by researchers so that they can assist in improving supplier performance in the hope that suppliers who have bad and very bad scores can be reduced afterwards.

c) In future research, it is expected that researchers can evaluate supplier performance with other methods such as traffic light systems, analytic network processes and others.

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