

Designing Vendor Performance Assessment: Integrated Methods of Vendor Performance Indicators and Analytical Hierarchy Process

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Abstract: Vendor is an essential component in the supply chain. Selection of the best supplier can improve the company's quality and competitiveness. PT. X is an Engineering, Procurement, and Construction company that manufactures industrial equipment. In the production process, carbon steel plate is one type of raw material the company needs. The best suppliers for carbon steel plates are needed since it is a raw material with a critical material class and often experiences problems with its quality. This study evaluates supplier performance using the Vendor Performance Indicator approach, with Quality, Cost, Delivery, Flexibility, Responsiveness, Health, Safety, and Environment criteria. The weighting analysis will be done using the Analytical Hierarchy Process method using Software Super Decision. The results of this study indicate that PT. BB is the best supplier of carbon steel plates, with weight for Quality of 24.5%, Cost of 17.8%, Delivery of 23.2%, Flexibility of 7.7%, Responsiveness of 7.9%, Health Safety and Environment of 18, 8%. The supplier with the highest weight is recommended based on the Vendor Performance Indicator and Analytical Hierarchy Process method and is prospecting to become a long-term partner of PT. X.

Keywords: Assessment, Hierarchy, Indicators, Performance, Vendor.

Introduction

The growing trend of supply chain globalization enables organizations to procure a diverse range of goods and services through outsourcing. Outsourcing represents a viable approach to attaining supply chain success, particularly in responsiveness and enhancing corporate competitiveness (Suraraksa & Shin, 2019). Vendors are essential in each stage of the product cycle in the supply chain, responsible for maintaining a company's supply of services and goods. Vendor performance evaluations are crucial in a supply chain; they must be completed to achieve satisfactory company performance from the customers' perspective. Choosing the most appropriate supply source can assist a company in acquiring a competitive advantage. According to (Išoraitė, 2018), the competitive advantages of a

business are derived from its possession and allocation of resources and capabilities, resulting in both positioning and performance advantages over its competitors.

According to the Supplier Performance Measurement Benchmarking Report of (Minahan & Vigoroso, 2022), vendor performance measurement is a systematic way of measuring employee performance based on the Key Performance Indicator that has been established. Implementing performance measurement systems aims to make it easier to measure the performance of each employee's work output to produce a more accurate analysis. Given the increased dependence on external supply partners, it is unsurprising that more than 70% of responding companies regarded supplier performance measurements as "very important" or "critical" for their operations. The other 17% considered vendor performance

measures "important", and 8% of respondents considered supplier measurement sufficiently important. More than half (56%) of companies today have formal procedures to measure supplier performance, but most companies (72%) measure performance as less than half of their total supply base. It is also reported that 54% of companies measure the performance of less than a quarter of their suppliers.

Completing vendor assessments can help the organization maintain or improve its service level in fulfilling the needs of its customers. The ability of the vendor to collaborate with the company should be used to evaluate vendor performance. Long-term relationship collaboration is required to establish mutual trust and reliability, which will benefit both parties, as stated by (Saunders, 1997) in (Hawkins et al., 2020). Aside from price, other factors to consider when considering a vendor include consistency in quality and delivery, reliability, responsiveness, flexibility, and service level. Vendor performance assessments are critical for them to evaluate their performance to improve their performance in carrying out the supply process to companies, mainly in the manufacturing industry.

The supplier evaluation must be tailored according to the items' positioning (Abel, Edward, 2020). Supply positioning materials are divided based on risk and profit (Saeed et al., 2016). The degree of difficulty connected with sourcing a product or service and the vulnerability imposed on the organization is called the risk impact. The cost impact measures the amount to which supply contributes to profitability. Profitability may be realized by lowering expenses, paying a lower price for goods or services, or implementing more efficient purchasing procedures. Determining the type of relationship by situating vendors based on risk and profit effect can assist procurement and supply chain experts in developing the appropriate type of supplier partnerships.

According to the widely acknowledged and practical framework known as The Kraljic Matrix, the process of categorizing supply positioning materials into four distinct groups is utilized to achieve accurate vendor segmentation. These categories are routine, leverage, bottleneck, dan

critical items (Perdana & Mulyono, 2021). Routine items refer to non-critical products with low and low supply risks due to their extensive variety and numerous alternative providers. This category includes basic office supplies, maintenance and repair materials, and operational necessities, commonly called M.R.O. (Maintenance, Repair, and Operations) items. Bottleneck items refer to goods or commodities with limited value and are susceptible to risks arising from abrupt price escalations and a restricted pool of alternative suppliers. This particular category can be characterized as a segment in which buyers hold a dominant position, engaging in competitive bidding processes that result in relatively low levels of risk. This phenomenon can be attributed to numerous alternative suppliers and substitutes, such as steel plates and sections. Critical items, also known as strategic items, belong to a category that entails significant risk due to their heavy reliance on a limited number of suppliers. However, these products also have the potential to generate substantial profits. The products encompassed within this particular category consist of assembly, engines, and optics. It is important to note that the dynamics of power equilibrium within the buyer-supplier relationship influence these products. The optimal approach for managing this particular set of products is achieving a harmonious equilibrium between procurement and supplier relationships by implementing performance-driven partnerships.

PT. X is one of the companies of the state-owned enterprise agency that is moving into the field of manufacturing. PT. X produces the Engineer to Order products, among them the Heat Exchanger requested by manufacturing industries, including PT. Badak L.N.G., Pressure Vessel requested from PT. Puspitindo, Membrane Skid for PT. Petrochina and Knockout Drum for the PT. Pertamina Plaju. Engineer To Order is a manufacturing system tailored to items based on customer requests (Hapsari, Rinci Kembang, 2018). During the manufacturing process, PT. X requires several materials that play a crucial role in constructing their products. One such material is a plate made of carbon steel. According to the supply positioning model, the carbon steel material plate

belongs within the critical materials category. The installation process frequently encounters difficulties related to the quality of the material plate provided by the vendor, leading to disruptions in the operational manufacturing process. One of the possible effects will be a production delay of the product due to the rejection of the off-specification materials. This occurrence poses significant economic and consumer confidence challenges for the organization. The analysis of proper vendor selection is necessary for carbon steel plate materials due to their significant role and frequent deviations from specifications. Considering the abovementioned concerns, the present study assessed vendor performance to identify the most optimal supply of carbon steel plates. This evaluation was carried out by employing a set of criteria and sub-criteria tailored to align with the organization's specific requirements.

Previous studies found that the Vendor Performance Indicators method can determine criteria and sub-criteria to assess vendors' performance using quality, Cost, Delivery, Flexibility, and responsiveness indicators. The research integrates the Vendor Performance Indicators with the Analytical Hierarchy Process method in the weighting analysis for each criterion, sub-criteria, and alternatives (Pramita & Wirawan, 2019) (Noviani et al., 2021).

The Super Decision software is used as a tool for the implementation of the Analytical Hierarchy Process method. This method is valuable for problem-solving and decision-making (Sooksaksun & Chanta, 2023). It involves organizing decision elements into hierarchical structures, assessing the importance of pairwise comparisons, and synthesizing the resulting relative outcomes. The Analytical Hierarchy Process is a mathematical theory that has been widely employed for decision-making purposes. This study added a criteria assessment aspect in the form of Health, Safety, and Environment aside from quality, cost, delivery, Flexibility, and Responsiveness criteria as a novelty and expansion of previous research, as this aspect is deemed to play a significant role in regulating and ensuring work safety issues related to the impact of material quality. Incorporating Health,

Safety, and Environment standards leads to the formulation of improved vendor assessment indicators, which in turn contribute to the effective management of business operations and the accomplishment of a zero-accident objective.

Materials and Methods

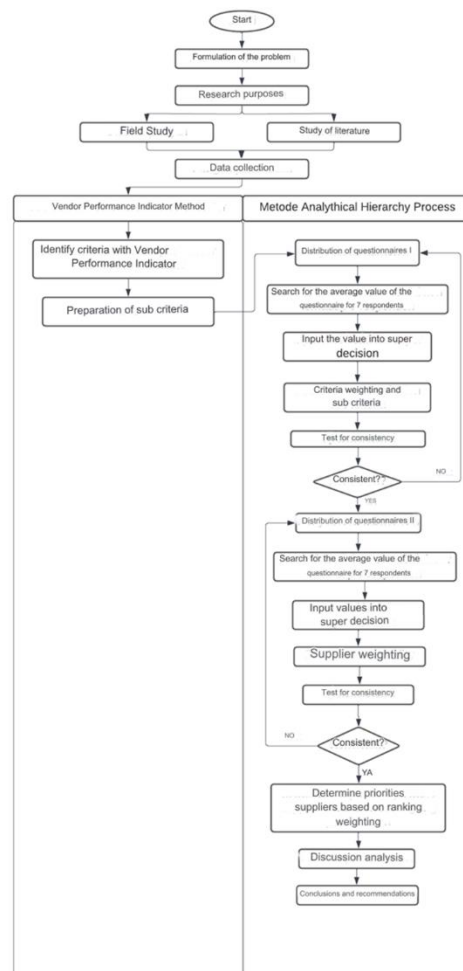
In an integrated methods study, quantitative and qualitative approaches must be evaluated in a way that does not result in conflicts, as both methods should collaborate and complement each other to pursue a similar goal. The feasibility of this scenario is contingent upon adopting an open and innovative approach while refraining from embracing polarizing viewpoints. Ultimately, these factors can deduce that the amalgamation of methodologies within the realm of research represents a manifestation of innovation (Tonon, 2019). The present study used an integrated methods approach incorporating qualitative and quantitative methodologies. Qualitative research is constructed through interpretation, drawing upon diverse perspectives and empirical data from interviews and observations. (Fiantika, 2022). Quantitative research is a study that processes data numerically to obtain structured data (Sinambela & Sinambela, 2021). The qualitative component of this study involves gathering data on supplier selection criteria and sub-criteria through interviews conducted with key stakeholders, including the Procurement Department, the Quality Control Department, and the Health Safety and Environment Department. The quantitative method is employed to conduct analyses that involve numerical data. Data collection is accomplished through the utilization of questionnaires. Purposive sampling is a non-random sample technique that involves determining and collecting samples based on specific criteria related to the objective of the research, in this case the selection of the best vendor. Purposive sampling is used to better match the sample to the goals and objectives of the study, enhancing the validity of the research and the reliability of the data and findings (Campbell et al., 2020). The implementation of the questionnaire

involves the execution of two queries. The first query is conducted to determine the weighting of criterion and sub-criteria, while the second query is used to determine the weighting of suppliers.

Vendor selection is a critical decision component in supply chain management (Taherdoost & Brard, 2019). The process of supplier selection plays a crucial part in enhancing the competitive advantage of a company. Supplier selection is critical in Supply Chain Management since it is a multiple-criteria decision-making that incorporates qualitative and quantitative factors. Multiple Criteria Decision Making is a process used to evaluate and select the most suitable option based on many criteria or factors.

Effective vendor selection has the potential to yield several advantageous outcomes, including the reduction of purchasing costs, the augmentation of profits, the mitigation of product lead times, the enhancement of customer happiness, and the intensification of firm competition (Mangka et al., 2021). Several distinct stages are undertaken in the process of vendor selection. The first stage in selecting a supplier is identifying the requirements often employed: quality, delivery performance, Cost, capability, and price. The next stage is conducting a survey utilizing a structured questionnaire to conduct a weighting analysis of both the main criteria and sub-criteria that involves the consideration of various factors, such as Cost and time. After careful consideration, a selection should be made by picking the most suitable provider based on the implementation of the chosen methodology.

The data source refers to the entity or system from which the data was acquired. Primary data for this study includes information on the weighting of criteria and sub-criteria and data on alternative carbon steel plate suppliers. These data were collected through the distribution of questionnaires to experts in the field. The secondary data utilized in this study consists of criteria and sub-criteria data derived from the analysis results gained through applying the Vendor Performance Indicator and Analytical Hierarchy Process methods. Following is the research flow:



Picture 1. Research Flow.

Based on the research flow shown in Picture 1 above, the research flow begins with formulating the issue based on the existing situation in PT. X to find out the problems that are currently occurring in the company. Identifying the problems that occur, the next stage is to determine the study purpose. In this case, the goal is to evaluate vendor performance and determine the weighting of criteria and sub-criteria. Literature and field studies are conducted to gain theoretical insight and knowledge related to problem identification. Literature studied from scientific journals, theses, and official publications regarding Vendor Performance Evaluation, Vendor Performance Indicators, and Analytical Hierarchy Process.

In data analysis, the Vendor Performance Indicator Method is implemented, where criteria are identified using vendor performance indicators by interviewing respondents, namely the Head of the Procurement Division, Procurement Staff, Health,

Safety, and Environment personnel, Head of Quality Control Division, and Internal Users. Vendor performance evaluation activities will be arranged into three hierarchical levels. Level 0 is intended for goals or objectives that must be achieved in the research, level 1 and level 2 are intended for predetermined criteria and sub-criteria, and level 3 is intended for alternatives, namely each supplier

sampled in the research. The aim of distributing Questionnaire 1 is to weigh the selected criteria and sub-criteria. Then, Questionnaire 2 aims to determine the ranking of the vendors used as research samples. The assumption used to carry out weighting is a scale ranging from 1-9 (Saaty, Thomas L. Vargas, 2012), as follows:

Table 1. Pairwise Comparison Table.

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two Elements Contribute Equally To The Objective
3	Moderate Importance	Experience and Judgement Slightly Favor One Element Over Another
5	Strong Importance	Experience and Judgement Strongly Favor One Element Over Another
7	Very Strong Importance	One Element is Favored Very Strongly Over Another
9	Absolute Importance	One Element is Absolute Over Another
2,4,6,8	Slight Importance	Importance Between Two Elements

Super Decision Software is running for Analytical Hierarchy Process processing. The criteria, sub-criteria, and vendors are then weighted based on the results obtained from the Super Decision Software. The consistency of questionnaire results is tested by calculating the consistency ratio. In this case, the Super Decision Software displays the consistency ratio value. So, it can be determined whether the questionnaire is valid or not.

Results and Discussion

Result

Vendor Performance Indicator

The vendor performance indicator approach is used to evaluate vendors' performance that has been completed in PT. X to develop the criteria to be utilized for evaluating the performance of vendor plates in PT. X. Following the compilation of the criteria, determine the sub-criteria employed in the vendor performance assessment by conducting interviews with personnel involved in quality control, procurement, health safety, and environment. A series of interviews were conducted utilizing the Vendor Performance Indicator as a guiding framework to determine the

criterion and sub-criteria for selection with individuals listed below:

Table 2. Interviewed Respondents.

Code	Department	Respondent	Experience
E1	Chief of Procurement Department	1	5 years
E2	Staff of Procurement Department	1	10 years
E3	Chief of Quality Control Department	1	25 years
E4, E5	Chief of HSE Department	2	20 years, 12 years
E6, E7	User	2	20 years, 32 years
Total Respondents		7	

The interview outcome was obtained based on the findings of publicly conducted interviews with all respondents, which contained the criteria and sub-criteria that would indicate the supplier performance assessment. Based on (C.C. LI & HUNG, 1997), a framework for compiling vendor performance indicators is Q.F.C.D.R., where Quality (Q) is the supplier's ability to meet quality that has been adjusted to established standards;

Cost (C) is related to the price level of raw materials offered by the supplier, Delivery (D) is the ability to fulfill the quantity and delivery time; Flexibility (F) is the ability to fulfill requests if there are changes to the quantity and delivery time; and

Responsiveness (R) is the supplier's ability to respond to problems related to changes in demand and delivery schedules. The criteria and sub-criteria are as follows:

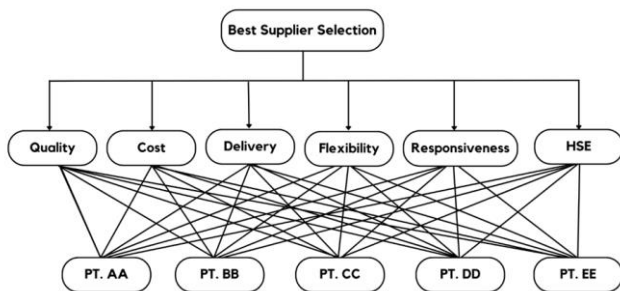
Table 3. Criteria and Sub-Criteria to Respondents.

No	Criteria	Sub Criteria	Respondent
1	Quality	Material that meets certification	E3
		Material that meets purchase order specifications	
2	Cost	Price matching with quality and specification	E1, E2
		Assisting in the payment scheme	
		Price matching with project requirements	
3	Delivery	Material shipment quantity following the Purchase Order	E6, E7
		Timeliness of material delivery complying with the Purchase Order	
4	Flexibility	Fulfill requests for changes in material quantities	E1, E2
		Fulfill requests for changes to material delivery times.	
		Perform achievements following the Purchase Order.	
5	Responsiveness	Responsive to changes in material quantities	E1, E2
		Responsive to changes in material delivery times	
		Responsive to complaints	
6	HSE (Health Safety and Environment)	Competent drivers	E4, E5
		Drivers use complete personal safety equipment.	
		Delivery meets Health, Safety, and Environment aspects.	
		Material Handling	
		Materials Packaging	
	Fleets Condition		

Analytical Hierarchy Process

1. Hierarchy Arrangement

Several vendors supply plate material to PT. X in 2022. However, this study uses a sample of five suppliers with supplier criteria with the most considerable purchase order value during 2022, namely PT. AA, PT. BB, PT. CC, PT. DD, PT. EE.



Picture 2. Hierarchy Arrangement.

2. The weighting of Criteria and Sub-Criteria

Criteria and sub-criteria weighting is used to determine the level of assessment for each criterion

and sub-criteria. The weighting of these criteria and sub-criteria is carried out using the Analytical Hierarchy Process method, with the software that will be used Super Decision Software. The data that will be used in assessing these criteria and sub-criteria comes from questionnaires filled in by parties who are experts in their fields. The following are experts who are tasked with filling in the criteria and sub-criteria questionnaires, as shown in the previous Table 2

3. The weighting of the main criteria

After completing the questionnaire with experts, the data from these experts was collected and then analyzed using software, namely Super Decision. Weighting is done by calculating the geometric means of all experts who have filled in the respondents, then the geometric means values will be input into the super decision software according

to the comparison used. The following are the results of the questionnaire:

Table 4. Data Analysis of Questionnaire

Criteria A	Criteria B	E1	E2	E3	E4	E5	E6	E7
Quality	Cost	1	1	2	5	5	1/5	1
Quality	Delivery	1	1	4	5	4	1/3	1/3
Quality	Flexibility	3	3	3	6	5	2	7
Quality	Responsiveness	3	3	2	6	5	1/2	7
Quality	HSE	3	3	1	1/7	1/6	2	1
Cost	Delivery	1	1	1	1/3	0.5	1	1/3
Cost	Flexibility	5	3	1	1	1	7	5
Cost	Responsiveness	5	3	1	1	1	7	5
Cost	HSE	1	3	1	1/7	1/6	7	3
Delivery	Flexibility	5	3	1	3	2	9	7
Delivery	Responsiveness	5	3	2	3	2	9	7
Delivery	HSE	1	3	1	1/7	1/6	9	1
Flexibility	Responsiveness	1/3	1	1	1	1	5	1
Flexibility	HSE	1/4	1	1	1/7	1/6	1/2	5
Responsiveness	HSE	1/4	1	2	1/7	1/6	1/2	5

Based on the results of the comparison of the main criteria, the following weight values were obtained:

Table 5. The Weighting Of Main Criteria.

No	Main Criteria	Weighting	Percentage
1.	Quality	0.24543	24.5%
2.	Cost	0.17811	17.8%
3.	Delivery	0.23247	23.2%
4.	Flexibility	0.07686	7.7%
5.	Responsiveness	0.07880	7.9%
6.	HSE	0.18832	18.8%
Total			100%

Based on the percentage value obtained, it can be seen that the criterion that has the most significant weight is the quality criterion with a weight of 0.24543, followed by the delivery criterion with a weight of 0.23247, after that the cost criterion with a weight of 0.17811, then the Health Safety and Environment criterion with a weight of 0.18832, then the responsiveness criterion with a weight of 0.07880, and finally the flexibility criterion with a weight of 0.07686.

4. Sub-Criteria Weighting

Besides weighting the criteria in selecting suppliers, weighting is also carried out for sub-criteria. This weighting is carried out on each sub-criterion contained in the criteria. This weighting comes from geometric means values from the experts. Steps The steps for weighting sub-criteria are the same as weighting for each sub-criteria, as follows:

Table 6. Weighting of Quality Sub-Criteria.

No	Sub Criteria	Weighting
1	Material that meets certification	0.44891
2	Material that meets purchase order specifications	0.55109

Table 7. Weighting of Cost Sub-Criteria.

No	Sub Criteria	Weighting
1	Price matching with quality and specification	0.45235
2	Assisting in the payment scheme	0.28151
3	Price matching with project requirements	0.26614

Table 8. Weighting of Delivery Sub-Criteria.

No.	Sub Criteria	Weighting
1	Material shipment quantity following Purchase Order	0.44006
2	Timeliness of material delivery complying with the Purchase Order	0.55994

Table 9. Weighting of Flexibility Sub-Criteria

No.	Sub Criteria	Weighting
1	Fulfill requests for changes in material quantities	0.20299
2	Fulfill requests for changes to material delivery times	0.40601
3	Perform achievements following the Purchase Order	0.39100

Table 10. Weighting of Responsiveness Sub-Criteria.

No.	Sub Criteria	Weighting
1	Responsive to changes in material quantities	0.20947
2	Responsive to changes in material delivery times	0.30213
3	Responsive to complaints	0.48840

Table 11. The Weighting of Health, Safety, and Environment Sub-Criteria.

No.	Sub Criteria	Weighting
1	Competent drivers	0.07050
2	Drivers use complete personal safety equipment	0.10189
3	Delivery meets Health, Safety and Environment aspects	0.12084
4	Material Handling	0.27073
5	Materials Packaging	0.31182
6	Fleets Condition	0.12422

5. Supplier Weighting






In meeting the need for plates. PT. X has several plate suppliers, both local suppliers and overseas suppliers. In this research, we will assess 5 suppliers based on the supplier with the highest purchase order value, namely PT. AA, PT. BB, PT. CC, PT. DD, PT. EE. The data that will be used to weigh suppliers is contained in the second questionnaire. Respondents involved in supplier weighting as shown in Table 2 above. After the

data from all respondents is collected, the data is input into the super decision software. The following are the results of the weight of each alternative against the sub-criteria in supplier selection. After knowing the weighting of each alternative, the super decision will display the supplier ranking based on the weighting values as follows:

Report for toplevel

This is a report for how alternatives fed up through the system to give us our synthesized values. [Return to main menu.](#)

Alternative Rankings

Graphic	Alternatives	Total	Normal	Ideal	Ranking
	1. PT. AA	0.0706	0.1766	0.6499	3
	2. PT. BB	0.1087	0.2717	1.0000	1
	3. PT. CC	0.0600	0.1499	0.5518	4
	4. PT. DD	0.0572	0.1430	0.5266	5
	5. PT. EE	0.1035	0.2588	0.9529	2

Picture 3. Alternative Rankings of Vendors.

After assessing each supplier, calculations are carried out using the Analytical Hierarchy Process. The criteria influencing the supplier evaluation process are quality, with a weight of 0.24543, followed by Delivery criteria, with a weight of 0.23247. Then, the cost criteria with a weight of 0.17811 are the Health Safety and Environment criteria with a weight of 0.18832, the responsiveness criteria with a weight of 0.0788, and finally, the flexibility criteria with a weight of 0.07686.

Based on the results of the criteria and sub-criteria that have been selected using the Vendor Performance Indicator approach to evaluate supplier performance at PT. X. The supplier with the highest weight is PT. BB with a total of 0.2717, followed by PT. EE with a weight of 0.2588, and after that, continued with PT. AA with a weight of 0.1776, PT. CC with a weight of 0.1499, and the last one is PT. DD with a weight of 0.1430. From the following percentage, it can be stated that PT. BB occupies the highest position, and it can be stated that the relationship established by PT. X with PT. BB has been running well, so PT. BB can be used as a business partner for an extended period.

Conclusions

Based on the problem formulation and research results, it can be concluded that the criteria and sub-criteria that have been formed using the Vendor Performance Indicator approach and interviews and weighting using the Analytical Hierarchy Process obtained Quality (24.5%) which consists of two sub-criteria, namely material that meets certification (0.44891) and material that meets purchase order specifications (0.55109), Cost (17.8%) which consists of three sub-criteria, namely price matching with quality and specification (0.45235), assisting in the payment scheme (0.28151), and price matching with project requirements (0.26614), Delivery (23.2%) which consists of 2 sub-criteria, namely the material shipment quantity following the purchase order (0.44006) and timeliness of material delivery complying with the purchase order (0.55994). Flexibility (7.7%), which consists of 3 sub-criteria for fulfilling requests for changes in material quantities (0.20299), fulfilling requests for changes to material delivery times (0.40601), and performing achievements following the purchase order. (0.39100), Responsiveness (7.9%) which consists of 3 sub-criteria for responsive to changes in material quantities (0.20947), responsive to changes in material delivery times (0.30213), and responsive to complaints (0.48840), and Health Safety and Environment (18.8%) consisting of 6 sub-criteria for competent drivers (0.07050), drivers use complete personal safety equipment (0.10189), delivery meets Health, Safety, and Environment aspects. (0.12084), material handling (0.27073), materials packaging (0.31182), and fleet condition (0.12422). Based on the weight of the criteria and sub-criteria, as well as the supplier, the first-ranking supplier was obtained by PT. BB with an overall value weight of 0.2717. So, researchers recommend PT. BB to become a long-term partner of PT. X

Conflict of Interest: The authors declare that there are no conflicts of interest concerning the publication of this article.

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