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Research Article

Integration of Analytic Network Process and PROMETHEE in Supplier Performance Evaluation

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A B S T R A C T

Supplier performance evaluation is one of the important factors in the supply chain because it is one of the company's strategies for increasing customer satisfaction and also maintaining the company's services in meeting consumer demand. This study proposes the integration of the Analytic Network Process (ANP) and the Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) to evaluate supplier performance. The integration of the two methods is proposed to obtain more complex assessment results because the combination of the two methods considers various criteria derived from ANP and various preferences from PROMETHEE, so both methods are very good to use instead of using just ANP or PROMETHEE or other methods. ANP exhibit more complex relationships between criteria and levels in the decision hierarchy, while PROMETHEE provides decision-makers with flexible and straightforward outranking to analyze multi-criteria problems. In this study, ANP is used to weight the criteria, and PROMETHEE is used to rank suppliers in evaluating supplier performance. Integrating these two methods provides more objective and accurate results in multi-criteria decision-making. The proposed method is validated by solving an industrial case of supplier evaluation problem using the real data from the skewer industry. Finally, some useful implications for managerial decision-making are discussed.

INTRODUCTION

Supplier is one of the most essential chains for the profit and survival of most companies. The companies know that the quality of their products and services is directly related to the quality of the suppliers' products and services. According to Pujawan and Goyal [1], suppliers are companies or individuals who provide the resources needed by companies and competitors to produce certain goods and services. Improper supplier performance can cause losses to the company. For example, long supplier lead times cause the production process to be hampered, resulting in delays in meeting consumer demands [2]. Therefore, supplier performance evaluation is one of the crucial factors in the supply chain because it is one of its strategies for increasing customer satisfaction. According to Saunders [3], supplier evaluation should be based on the supplier's ability to cooperate with the company; a long-term relationship is needed because it will foster mutual trust and reliability.

Supplier performance evaluation is critical to identifying strengths and weaknesses [4]. The company can take a strategy for managing suppliers [5]. In general, the selection of supplier criteria is relative and depends on self-determined standards. Supplier performance evaluation can be assessed based on several methods such as Analytic Network Process (ANP), Analytic Hierarchy Process (AHP), Vendor Performance Indicator (VPI), and other decision-making methods [6].

ANP is one of the Multi-Criteria Decision Making (MCDM) methods developed by Saaty [7]. The Analytic Network Process is a mathematical theory that allows a person to make decisions in the face of interrelated and interconnected factors in a mathematical system. According to Tanjung and Devi [8], the simplicity of the ANP method makes it a more general method and easier to apply for various qualitative case studies, such as forecasting, evaluation, decision making, mapping, and others. ANP has advantages, such as a more objective view, accurate, stable results, and a more complex relationship between levels of decision attributes, without a rigid hierarchical structure [7].

Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) is an outranking method that provides an easy way to apply well to various problem structures [9]. The PROMETHEE method is also one of the methods used to determine the order (priority) in multi-criteria analysis. PROMETHEE is divided into two, namely PROMETHEE I and PROMETHEE II. PROMETHEE I is a partial ranking with the most considerable value for leaving flow, and the smallest value for entering flow as the best alternative. If the decision-maker

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wants a complete solution, they should use PROMETHEE II [10]. PROMETHEE II is generated in the form of net flow. With complete ranking, information for decision-makers is more realistic because it can make comparisons to all alternatives that appear [10].

Criteria in evaluating supplier performance are essential to finding out which supplier is the right one to maintain in supplying raw materials. The criteria are used to describe the strategy in the supply chain, so the decision to determine the criteria is challenging. The criteria in the ANP method have an interrelated relationship because ANP has a reciprocal concept [11]. The relationship between these interrelated criteria has been described in previous studies by [12], [13], and [14]. Some of these studies use the relationship criteria in selecting and evaluating suppliers. According to Ho, et al. [15] the criteria often used in manufacturing for supplier selection or evaluation are quality, followed by delivery, price or cost, production capability, service, management, technology, research and development, finance, flexibility, reputation, relationships, risk, and safety and environment. In addition, Luthra, et al. [16] frequently used criteria such as the price, delivery, quality, and quantity of goods.

Several supplier performance evaluation studies have been conducted, including, Pujotomo, et al. [17] using ANP and TOPSIS methods, ANP is used for weighting criteria, and TOPSIS is used for supplier ranking. Garside and Saputro [12] used Fuzzy ANP and Goal Programming; Fuzzy ANP was used to determine suppliers based on criteria and Goal Programming for order allocation. Akbar, et al. [18] used the AHP method for the proposed evaluation indicators. Nugraha [19] uses AHP and TOPSIS, ANP uses weighting criteria, and TOPSIS evaluates supplier performance. Ekawati, et al. [20] used the ANP method to assess supplier performance. Wan, et al. [21] used the fuzzy PROMETHEE method for supplier selection. Giannakis, et al. [22] used the ANP method to evaluate supplier performance.

Research that has used a combination of ANP and PROMETHEE has been carried out by Peng, et al. [23] for material selection and Kilic, et al. [24] for ERP selection. However, to the best of our knowledge, the integration of the ANP and PROMETHEE methods has never been used for supplier evaluation. Therefore, the integration of the two methods is proposed to obtain more complex assessment results because the combination of the two methods considers various criteria derived from ANP and various preferences from PROMETHEE, so that both methods are very good to use instead of using just ANP or PROMETHEE or other methods. Furthermore, the proposed method is applied to the evaluation of raw material suppliers of skewers producing company located in Malang city, Indonesia.

METHOD

This study discusses the integration of ANP and PROMETHEE on supplier performance evaluation. The research framework in Figure 1 shows the stages of integration carried out. Stage 1 begins with determining the criteria. The criteria taken into consideration in evaluating supplier performance are determined by holding discussions with the head of the logistics department. At the discussion stage with the company, the researcher proposed several criteria based on references in previous studies and then adjusted them to the company's conditions so that these criteria did not deviate far from the research topic.

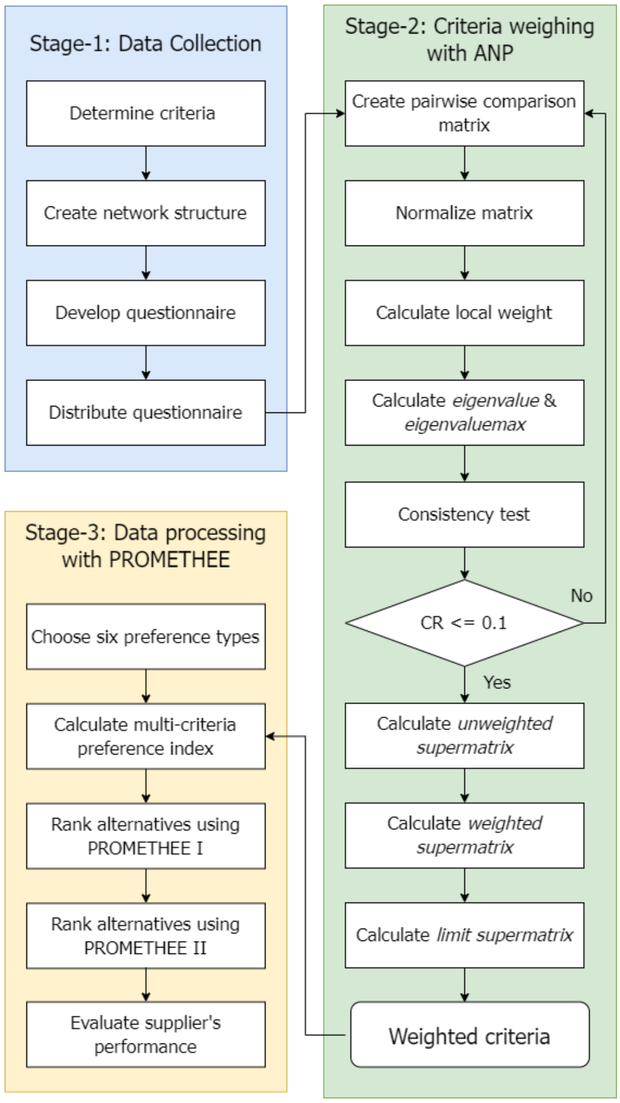


Figure 1. Integration of ANP and PROMETHEE on supplier performance evaluation

After determining the criteria, the next step is to create a network structure [7]. Networking consists of clusters of objectives, criteria, and alternatives. The form of the network created describes the influence between goals, criteria, and alternatives and vice versa. A questionnaire assessing the criteria's importance was compiled from the network structure created on a scale of 1-9. Then the questionnaire is distributed to the respondents.

In stage 2, the data from the questionnaire results were processed using the ANP method. The questionnaire results are compiled into a pairwise comparison matrix, as shown in Table 1. The comparison is made by evaluating the relative importance of one

Table 1. Pairwise Comparison Matrix

A	B_1	B_2	B_3	…..	B_n
B_1	B_{11}	B_{12}	B_{13}		B_{1n}
B2	B_{21}	B_{22}	B_{23}	…..	B_{2n}
B3	B_{31}	B_{32}	B_{33}	…..	B_{3n}
…..	…..	…..	…..	…..	…..
Bn	B_{n1}	B_{n2}	B_{n3}	…..	B_{nn}

criterion with another is a scale of 1 to 9 [7]. The following steps summarize the ANP procedures

1. Normalize the pairwise comparison matrix (Equation 1).

$$[a_i, a_j] = \frac{a_{ij}}{\sum nk} \quad (1)$$

where $[a_i, a_j]$ denotes matrix values in columns *i* and j, and $\sum nk$ is the sum of values in each column.

2. Compute weight of the local criteria (Equation 2)

$$\text{Local criteria weight} = \frac{\sum nb}{N} \quad (2)$$

where $\sum nb$ denotes the number of matrix values in each row and *N* is the number of matrix element.

3. Compute the eigen values (EV) by multiplying the local criteria weights with the initial comparison matrix (Equation 3).

$$\text{EV} = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \times \text{local criteria weight} \quad (3)$$

4. Compute maximum Eigen value (λ_{max})

$$\lambda_{max} = \frac{EV}{\text{local criteria weight}} \quad (4)$$

5. Compute CI and CR (Equation 5-6)

$$CI = \frac{\lambda_{max} - n}{\text{n} - 1} \quad (5)$$

$$CR = \frac{\text{CI}}{\text{RI}} \quad (6)$$

where:
CR = Consistency Ratio
CI = Consistency Index
RI = Random Index
λ_{max} = Maximum Eigen value
n = Number of elements compared

The consistency ratio has to be less than or equal to 10%, meaning that the comparison process between the two criteria is carried out consistently [7]. If the value is more than 10%, there is an inconsistency in setting the value of pairwise comparisons between criteria. If this happens, the solution generated from the ANP method will be meaningless to the researcher, so data collection needs to be conducted again.

6. Develop super-matrix to obtain the final weight of criteria and alternatives, as follow:
   a. Unweighted Super-matrix Step
   This step is based on pairwise comparisons between clusters, criteria, and alternatives by entering the column priority vector into the appropriate cell matrix.
   b. Weighted Super-matrix Step
   This step is generated by multiplying all the elements in the unweighted super-matrix by the values in the corresponding cluster matrix so that each column has a sum of one.
   c. Limit Super-matrix Step
   In this step, the weighted super-matrix is increased in weight by multiplying the super-matrix by itself several times; when the weight value is in each column, the limit super-matrix is obtained.

In stage 3, the criteria weight of the ANP method is used for ranking suppliers using the PROMETHEE. The following steps explain PROMETHEE procedures.

1. Select the type of preference from each criterion [25]. There are six types of preferences as follows [26]:

   a. Usual Type
   Usual preference is a general type of preference with no threshold; there is no significant difference between alternative *a* and alternative *b*. If *a* = *b* or *f(a)* = *f(b)*, then the *p*-value is zero (Equation 7). The P(*d*) function for this preference is presented in Figure 2a.

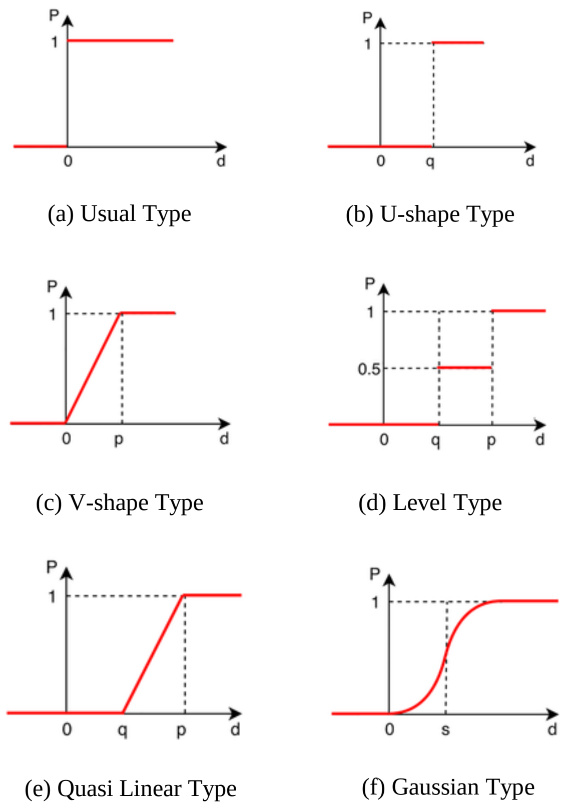
$$P(d) = \begin{cases} 1 & d > 0 \\ 0 & d \leq 0 \end{cases} \quad (7)$$

   b. U-shape Type
   The U-shape preference, also known as the Quasi preference, is used for data in terms of quality. It involves one threshold called indifference, denoted as *q*. The value of indifference is required to be above 0 (Equation 8). The P(*d*) function for this preference is presented in Figure 2b.

$$P(d) = \begin{cases} 1 & d > q \\ 0 & d \leq q \end{cases} \quad (8)$$

   c. V-shape Type
   This type of preference is used for quantitative data and uses one threshold, denoted as *p*, with a value above 0 (Equation 9). The P(*d*) function of this type is presented in Figure 2c.

$$P(d) = \begin{cases} 1 & d > q \\ 0 & d \leq q \end{cases} \quad (9)$$



(a) Usual Type
(b) U-shape Type
(c) V-shape Type
(d) Level Type
(e) Quasi Linear Type
(f) Gaussian Type

Figure 2. Preference Type

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d. Level Type
This preference type is similar to the U-shape type, which processes quality data or only adds one threshold. The P(*d*) function (Equation 10) for this preference is presented in Figure 2d.

$$P(d) = \begin{cases} 1 & d > p \\ 0.5 & p \geq d > q \\ 0 & q \geq d \end{cases} \quad (10)$$

e. Quasi linear Type
This type is almost similar to the linear type, which processes quantitative data by adding a threshold (*m*). The P(*d*) function (Equation 11) for this preference is presented in Figure 2e.

$$P(d) = \begin{cases} 1 & d > p \\ \frac{d-q}{p-q} & p \geq d > q \\ 0 & q \geq d \end{cases} \quad (11)$$

f. Gaussian Type
This type is often used to process data that is continuous. The P(*d*) function (Equation 12) for this preference is presented in Figure 2f.

$$P(d) = 1 - e^{-d^2/_{2s^2}} \quad (12)$$

The preference function data and its parameters are entered directly into the visual PROMETHEE software, which is used to perform calculations using the PROMETHEE or similar to the formula calculation in Equations 7-12.

2. Compute the preference index
According to Brans and De Smet [10], the preference index is the intensity of the preference of decision-makers who state that the alternative is more than others. Once having the type of preference that fits each criterion, this index is determined using Equation (13).

$$\varphi(a,b) = \sum_{i=1}^{n} \pi P_i(a,b); \forall a,b \in A \quad (13)$$

where P_i, π and φ denote preference function, weigh and preference index, respectively.

3. Obtain partial ranking of alternatives.
The partial ranking is obtained using PROMETHEE 1 by computing "entering flow" and "leaving flow" [10]:

a. Entering flow
Entering flow is the number of those that have an approaching direction from node *a*, and this is an outranking measurement character (Equation 14).

$$\phi + a_i = \sum_{i=1}^{I} \pi\ (a_1, a_i) \quad (14)$$

where (a_1, a_i) is positive direction preference index.

b. Leaving flow
Leaving flow is the sum of those with a direction away from node *a* instead of *b*.

$$\phi - a_i = \sum_{i=1}^{I} \pi\ (a_1, a_i) \quad (15)$$

where (a_1, a_i) is negative direction preference index.

From the results of PROMETHEE I, the smaller the value of Entering Flow and the greater the Leaving Flow, the higher the alternative's probability of being chosen.

4. Determine the net flow of each alternative.

Since the results of PROMETHEE I are partial, the ranking continues to PROMETHEE II to get the best ranking. PROMETHEE II includes a complex ranking because it is based on the Net Flow value for each alternative, namely the alternative with the higher Net Flow value is considered the best alternative [10]. Equation 10 determine the net flow of each alternative, as follow:

$$\phi(a_1) = \phi + (a_i) - \phi - (a_i) \quad (16)$$

where $\phi + (a_i)$ and $\phi - (a_i)$ denote entering flow and leaving flow, respectively.

RESULT AND DISCUSSION

To examine the applicability of the proposed ANP and PROMETHEE methods in supplier evaluation problem, this research was conducted in skewers producing company (namely UD. X) whose raw material (i.e., bamboo) are supplied from five suppliers. While qualitative approach is used in determining supplier evaluation criteria, a quantitative approach is used in analyzing supplier data based on several evaluation criteria.

The evaluation criteria are derived from previous studies followed by a discussion with the company to ensure the selected criteria suit the company's conditions. After completing this process, 13 criteria are finalized, as shown in Table 2. Each criterion is defined as follow:

1. The quality of the bamboo supplied must be consistently meet the specification, so that the skewer products produced can maintain consumer confidence.
2. The low level of product defects can be seen from the percentage of bamboo defects in each order so that there are not many losses due to defective bamboo.
3. Timeliness of delivery is assessed from the raw materials that arrive in accordance with the specified time.
4. The suitability of the number of shipments is assessed from the amount of material that arrives in accordance with the agreed order.
5. The location of the supplier can be assessed from how far it takes for the supplier to supply raw materials.
6. Discounts are seen from the number of discounts given by suppliers so that they can give a good reputation to the company.

Table 2. Supplier Performance Evaluation Criteria

No	Criteria	Code
1	Ability to provide consistent quality [4]	KK
2	Low defect rate [20]	KC
3	On-time delivery [17]	WP
4	The suitability of the number of shipments [17]	JP
5	Supplier Locations [17]	LS
6	Discounts [4]	PH
7	Rate of price increase [4]	KH
8	Raw material prices [17]	HB
9	Shipping cost [17]	BK
10	Warranty [4]	G
11	Responsive [4]	R
12	Flexibility in bidding [20]	FH
13	Flexibility in changing order quantity [20]	FP

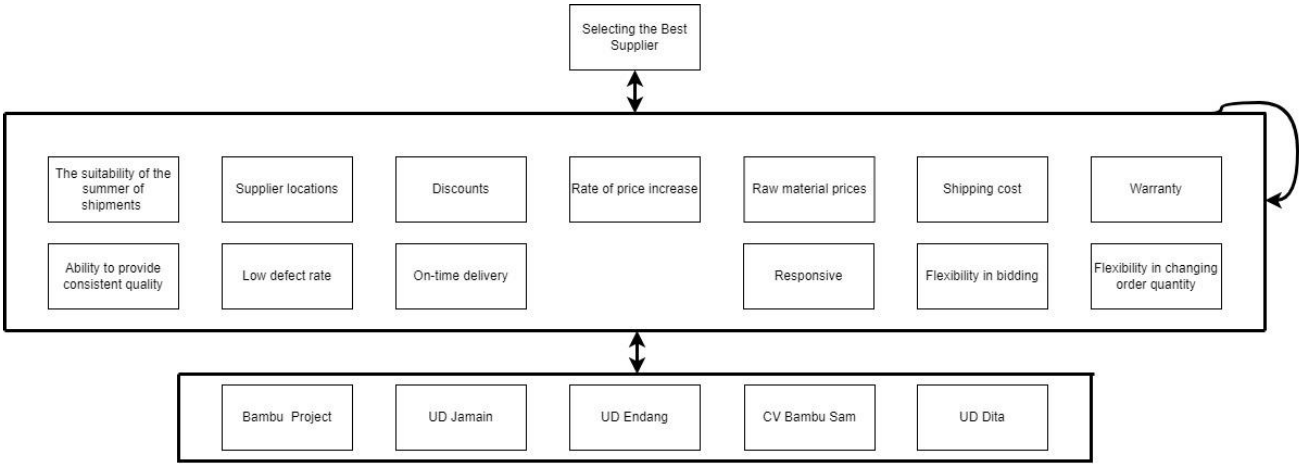

Figure 3. Network Structure of ANP

7. The rate of increase in the price of raw materials is judged by the level of how often and how high the prices are issued by suppliers in accordance with market conditions.
8. The price of raw materials assessed is in the form of conformity with the price provided by the supplier with the price in the market, for bamboo the price is around Rp. 15,000-Rp. 20,000.
9. Shipping costs are taken into account, namely the cheaper the fees charged, the better for the company.
10. The warranty is a very important criterion for the company because if the ordered item is defective or damaged, it can be replaced by the supplier, whether it is a replacement of goods or a price cut.
11. Responsiveness here is how responsive the supplier is in solving problems that occur, both problems with raw materials, delivery, and problems with the company.
12. Flexibility in price quotes, which is intended to provide flexibility for suppliers and companies to offer prices to each other until the point of agreement.
13. Flexibility in changing the number of orders, namely providing flexibility between the company and suppliers in making order transactions so that if at any time number of orders changes (still within reasonable limits) due to certain conditions, the supplier can handle it without having to discuss again.

The network structure is then developed to describe the relationship of goals with criteria and alternatives and vice versa so that a two-way relationship occurs. For example, the goal relationship is connected to the KK criterion (consistent quality), then the KK criterion is connected to Supplier 1 (alternative). Furthermore, there is a relationship between the criteria that influence each other. For example, the KK criteria affect all criteria except the LS (supplier location) and BK (shipping costs) criteria. Connectors between nodes are made based on the color of the nodes to make it easier to see the relationship between networks so that the colors on the network have no special meaning. The network structure can be seen in Figure 3.

The weighting of the criteria is computed from the results of the questionnaires that have been distributed. The questionnaire results were then converted into a pairwise comparison matrix, as shown in Table 3. The Consistency Ratio (CR) was obtained around 5%-8%, (less than 10%) which means the comparison is consistent. The unweighted super-matrix is created by making pairwise comparisons between the goal clusters, criteria, and alternatives by entering the column priority vectors into the appropriate matrix cells. All elements in the unweighted super-matrix are multiplied with the values in the appropriate cluster matrix so that each column has a sum of one. Finally, the limit super-matrix, namely weighted super-matrix, is increased by

Table 3. Pairwise Comparison Matrix

Criteria	KK	KC	WP	JP	LS	PH	KH	HB	BK	G	R	FH	FP
KK	1	2	3	3	6	6	5	1/3	1/2	5	3	6	7
KC	1/2	1	4	4	4	3	3	1/2	1/2	3	5	5	5
WP	1/3	1/4	1	2	3	4	2	1/3	1/2	2	3	3	5
JP	1/3	1/4	1/2	1	3	2	2	1/4	1/2	4	3	4	4
LS	1/6	1/4	1/3	1/3	1	3	3	1/4	1/3	2	2	2	3
PH	1/6	1/3	1/4	1/2	1/3	1	1/3	1/6	1/4	1/3	1/3	2	2
KH	1/5	1/3	1/2	1/2	1/3	3	1	1/6	1/3	1/2	1/2	5	2
HB	3	2	3	4	4	6	6	1	2	4	4	5	7
BK	2	2	2	2	3	4	3	1/2	1	3	3	4	4
G	1/5	1/3	1/2	1/4	1/2	3	2	1/4	1/3	1	1/2	1/3	2
R	1/3	1/5	1/3	1/3	1/2	3	2	1/4	1/3	2	1	2	3
FH	1/6	1/5	1/3	1/4	1/2	1/2	1/5	1/5	1/4	3	1/2	1	3
FP	1/7	1/5	1/5	1/4	1/3	1/2	1/2	1/7	1/4	1/2	1/3	1/3	1

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Figure 4. Criteria Weight

multiplying the super-matrix several times until the column has the same value. Based on the normalization on the final limit super-matrix, the weigh of criteria is obtained as: the criteria that have the highest weight are the price of raw materials (0.162), followed by the ability to provide consistent quality 0.136, the low defect rate (0.107), and the lowest is flexibility in changing the number of orders (0.029). The overall weight can be seen in Figure 4.

The price of raw materials is a very influential criterion, slightly different from the weighting results obtained from previous studies [27], which also used bamboo suppliers as research objects. The results of the weighting of the research are the quality criteria being the most influencing criteria, followed by the price of materials. The results obtained could be different due to the different research locations used.

According to Mareschal and De Smet [28], the preference type is determined by the decision maker. The preference type used for qualitative data is the usual type. This is because the qualitative data uses a Likert scale (5 points) and slightly different the value of alternative preferences from one another. For quantitative data, use a V-shape type. The V-shape type requires a threshold, namely the difference threshold (p). Selection of the type of preference from each criterion is shown in Table 4.

The multi-criteria preference index or $\varphi(a,b)$ is the intensity of preference which means that alternative ***a*** is better than alternative ***b*** with simultaneous consideration of all criteria. This can be expressed as a value between 0 and 1, with the following conditions:

- $(a,b) \approx 0$, indicates a weak preference for alternative ***a*** over ***b*** based on all criteria.
- $(a,b) \approx 1$, indicating a strong preference for alternative ***a*** over ***b*** based on all criteria.

The criteria weight that has been obtained from ANP is multiplied by the preference type for each criterion to get the value of the multi-criteria preference index and then added up as in equation (13) which can be seen in Table 5. After obtaining a multi-criteria preference index, the partial ranking is obtained using PROMETHEE I (Table 6).

From the results of the net flow using PROMETHEE 2, the first rank is Supplier 3 with a net flow value of 0.1742, followed by Supplier 5 as the second rank with a value of 0.0406, and Supplier 4 with a net flow value of -0.1219. Supplier 3 is ranked first or the best alternative because it has the highest net flow, which means it has a balance of value between leaving flow and entering flow [10].

Table 4. Preference Type

Historical Data	**Supplier**					**Objective**	**Preference Type**	**Unit**
	S1	**S2**	**S3**	**S4**	**S5**			
(WP)	4	3	3	2	4	Min	V-Shape	Days
(LS)	45	40	30	25	32	Min	V-Shape	Km
(PH)	10	5	0	2	5	Max	V-Shape	%
(HB)	18.000	17.000	20.000	18.000	15.000	Min	V-Shape	IDR
(BK)	22.000	20.000	18.000	15.000	18.000	Min	V-Shape	IDR
(KK)	5	4	5	3	4	Max	Usual	
(KC)	4	3	4	3	3	Max	Usual	
(JP)	1	2	3	2	2	Max	Usual	
(KH)	4	4	3	2	3	Max	Usual	
(G)	3	3	4	5	3	Max	Usual	
(R)	4	4	5	5	4	Max	Usual	
(FH)	4	3	3	2	3	Max	Usual	
(FP)	3	3	4	3	4	Max	Usual	

Table 5. Results of the Multicriteria Preference Index

Alternatives	KK	KC	WP	JP	LS	PH	KH	HB	BK	G	R	FH	FP	IPM
Weight	0.0997	0.0328	0.0295	0.0448	0.1629	0.0634	0.1079	0.0623	0.1368	0.0749	0.0644	0.0558	0.0649	
S1S2	1	1	0.25	0	0.12	0.71	0	0.05	0.09	0	0	1	0	0.276
S2S1	0	0	0	1	0	0	0	0	0	0	0	0	0	0.045
S1S3	0	0	0.25	0	0.36	1	1	0	0.19	0	0	1	0	0.319
S3S1	0	0	0	1	0	0	0	0.1	0	1	1	0	1	0.255
S1S4	1	1	0.5	0	0.48	1	1	0	0.33	0	0	1	0	0.498
S4S1	0	0	0	1	0	0	0	0	0	1	1	0	0	0.184
S1S5	1	1	0	0	0.31	0.71	1	0.15	0.19	0	0	1	0	0.427
S5S1	0	0	0	1	0	0	0	0	0	0	0	0	1	0.110
S2S3	0	0	0	0	0.24	0.71	1	0	0.09	0	0	0	0	0.204
S3S2	1	1	0	1	0	0	0	0.15	0	1	1	0	1	0.391
S2S4	1	0	0.25	0	0.36	0.42	1	0	0.23	0	0	1	0	0.387
S4S2	0	0	0	0	0	0	0	0.05	0	1	1	0	0	0.142
S2S5	0	0	0	0	0.19	0	1	0.1	0.09	0	0	0	0	0.157
S5S2	0	0	0.25	0	0	0	0	0	0	0	0	0	1	0.072
S3S4	1	1	0.25	1	0.12	0	1	0.1	0.14	0	0	1	1	0.458
S4S3	0	0	0	0	0	0.28	0	0	0	1	0	0	0	0.093
S3S5	1	1	0	1	0	0	0	0.26	0	1	1	0	0	0.333
S5S3	0	0	0.25	0	0.04	0.71	0	0	0	0	0	0	0	0.059
S4S5	0	0	0	0	0	0	0	0.15	0	1	1	0	0	0.149
S5S4	1	0	0.5	0	0.17	0.42	1	0	0.14	0	0	1	1	0.416

Table 6. PROMETHEE I Ranking Results

Alternatives	Leaving Flow	Entering Flow
S3	0.5058	0.3316
S5	0.3908	0.3502
S4	0.4341	0.4904
S2	0.3161	0.4336
S1	0.3417	0.4636

Table 7. PROMETHEE II Ranking Results

Alternatives	Net Flow	Ranking
S3	0.1742	1
S5	0.0406	2
S4	0.0247	3
S2	-0.1175	4
S1	-0.1219	5

From the results of supplier ranking with PROMETHEE II:

a. Supplier 3 is the supplier with the best performance. This can be seen from the quality of the suppliers, who are very good and responsive to the company. The drawback that needs to be considered from this supplier is the price of raw materials, which is expensive but not too different from other suppliers.
b. Supplier 5 have good performance. This can be seen in the lowest raw material prices from other suppliers and good quality. This supplier needs to pay attention to the number of orders that sometimes do not match.
c. Suppliers 4 has reasonably good performance. This is due to low shipping costs due to the location of the supplier being close to the company. The drawback with this supplier is the number of orders that sometimes do not match the order.
d. Supplier 2 has lower performance. This is because orders are often not according to order, and there are no main criteria. Almost all criteria are average, but the price increase is quite good, and the price of raw materials is low.
e. The supplier 5 has a poor performance. This is due to the high shipping costs and the number of orders that are often not as ordered, but a high discount is one of the advantages, and the quality is quite good.

CONCLUSION

This research proposed the integration of ANP and PROMETHEE to solve supplier performance evaluation problems. Furthermore, the proposed method was applied in the skewer industry. We found both methods helpful in solving such a problem, mainly when research simultaneously uses quantitative and qualitative data. The advantage of ANP is that it can handle problems in terms of the many alternatives and criteria to remain objective in conducting the assessment. Moreover, PROMETHEE can solve problems regarding the number of attributes of each variable, so it is precise in producing the level of importance in each attribute. The combination of ANP and PROMETHEE has proven to produce a very good alternative ranking.

The ANP method itself produces weights based on various criteria with the results of the influential criteria being the price of raw materials (0.162), and the criterion with a low weight is flexibility in changing the number of orders (0.029). While the PROMETHEE method itself produces a more subjective ranking because it is based on various preferences. The supplier with the worst performance is the first supplier because of expensive shipping costs and the number of orders that often do not match the order, but it has the advantage that the discount is relatively high and the quality is quite good. For further research, we suggest Fuzzy ANP to reduce the subjectivity of judgments by decision makers and add the DEMATEL method to find out which criteria have a big influence.

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