

PROXIMITY INDEX VALUE FOR SUPPLIER SELECTION USING COMPROMISE WEIGHTING OF ANALYTICAL HIERARCHY PROCESS (AHP) AND MEREC: A CASE STUDY IN INDONESIAN LEATHER INDUSTRY

VALOR DO ÍNDICE DE PROXIMIDADE PARA A SELEÇÃO DE FORNECEDORES UTILIZANDO A PONDERAÇÃO DE COMPROMISSO ENTRE O PROCESSO HIERÁRQUICO ANALÍTICO (AHP) E O MEREC: UM ESTUDO DE CASO NA INDÚSTRIA DE COURO DA INDONÉSIA

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Abstract

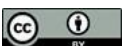
This study addresses supplier selection challenges by proposing a model that uses the Proximity Index Value (PIV) using compromise criteria weighting of the Analytical Hierarchy Process (AHP) and the Method Based on the Removal Effects of Criteria (MEREC). Delphi is applied in the proposed model on criteria selection, accommodating all objective and subjective criteria. The model was then tested practically at a leather company in Indonesia. Our model effectively captures the dynamics of decision-making groups in supplier ranking, emphasizing the importance of criteria selection in making better decisions. Notably, the robustness of our method is demonstrated by its insensitivity to parameter changes, ensuring efficient results.

Keywords: Supplier Selection. MEREC. AHP. PIV. Delphi.

Resumo

Este estudo aborda os desafios da seleção de fornecedores propondo um modelo que utiliza o Índice de Proximidade (PIV), com base na ponderação de critérios de compromisso do Processo Analítico Hierárquico (AHP) e do Método Baseado nos Efeitos de Remoção dos Critérios (MEREC). O método Delphi é aplicado no modelo proposto para a seleção de critérios, abrangendo todos os critérios objetivos e subjetivos. O modelo foi então testado na prática em uma empresa de couro na Indonésia. Nosso modelo captura efetivamente a dinâmica dos grupos de tomada de decisão na classificação de fornecedores, enfatizando a importância da seleção de critérios para a tomada de melhores decisões. Notavelmente, a robustez do nosso método é demonstrada por sua insensibilidade a mudanças de parâmetros, garantindo resultados eficientes.

Palavras-chave: Seleção de Fornecedores. MEREC. AHP. PIV. Delphi.



1 INTRODUCTION

In the manufacturing industry, raw materials are a crucial factor, and this needs to be considered because the goods production system will not be able to run correctly without these raw materials. To ensure that the products are created under the demands and preferences of businesses or consumers, extra attention must be paid to the quality of suppliers (Yadav & Sharma, 2016),(Douaioui *et al.*, 2024). As a result, choosing suppliers has been acknowledged as one of the key challenges businesses face in retaining a strategic competitive position (Gupta *et al.*, 2019),(Ahmad *et al.*, 2024). Suppliers are one of the company's success factors.

PT. Adi Satria Abadi (ASA) is a company that produces gloves from animal skins. This business uses a sustainable, long-term make-to-order production method that uses medium- to large-sized enterprises to generate the products (Wahyuningsih *et al.*, 2023). The character of each supplier is very different in terms of serving the needs of raw materials, according to the company. Suppliers occasionally let the company down because they couldn't live up to the standards set by the company (Wahyuningsih *et al.*, 2023). The price, delays in product delivery, and product quality received are all disappointments for the company.

Companies must develop effective supply chains to compete in the industrial world, one of which is maintaining ties with suppliers (Bag *et al.*, 2023). Supply chain management significantly influences enterprises' performance and success (Kabak & Oztek, 2022). Therefore, it is necessary to cultivate positive relationships with suppliers and maintain a good supply chain. An influential factor in managing industry relations is now the supplier selection process (Akbaş & Erbay Dalkiliç, 2018). So, the company assesses and establishes priority supplier selection to maximize company performance and reduce PT ASA dissatisfaction. A supplier assessment is conducted every semester to examine each period's supplier performance. The PT carries out the evaluation. ASA procurement department.

A study is required to choose providers or suppliers to reduce the possibility of the organization experiencing disappointment. The choice or selection of suppliers is one of the challenges in multi-criteria decision-making (MCDM). Hence, numerous MCDM techniques, such as the proximity indexed value (PIV), have been used in supplier

selection studies. According to the literature, the TOPSIS method is commonly used to solve MCDM problems (Bingol, 2022). However, PIV outperforms TOPSIS regarding rank reversal (Mufazzal & Muzakkir, 2018). Because it lacks rank reversal and is more stable and consistent (Goswami *et al.*, 2022),(Kumar Behera & Beura, 2023). PIV is a reliable MCDM tool that yields more exact and accurate findings than other methods (Goswami *et al.*, 2022),(Kumar Behera & Beura, 2023). Finally, the PIV approach is an efficient and freshly designed way of comparing alternatives (Bingol, 2022). Because of this advantage, it has been extensively recognized and fascinated by academics in many knowledge disciplines (Khan *et al.*, 2019; Yahya *et al.*, 2019). Many past researchers also proved that PIV produces superior, reliable, and rank reversal final outcomes than traditional tools such as AHP, COPRAS, TOPSIS, VIKOR, etc (Goswami *et al.*, 2022). Due to these significant advantages, the authors adopted PIV to execute this leather supplier selection in the Indonesian leather industry.

However, criterion weights are crucial for the PIV methods. The Analytical Hierarchy Process (AHP) is a weighting process commonly used to choose suppliers (Ristono *et al.*, 2020). The advantages of AHP include universality, reduced subjectivity due to the inclusion of human components, and verification of data inconsistencies (Vladimirovna Kochkina *et al.*, 2017). So, during its development, the PIV method was integrated with AHP for supplier evaluation. Khanh *et al.* (2019) present two examples of solving website selection problems to reveal the applicability and efficacy of the combined AHP-PIV methods. In this research, the decision-maker's choices determine the weight of the supplier criteria (Keshavarz-Ghorabae *et al.*, 2021). As a result, subjective weighing demands the expertise of qualified professionals with an extensive understanding of relevant theory and hands-on experience (Zavadskas & Podvezko, 2016). The primary downside of the AHP is that it becomes inefficient as the number of criteria grows. In other words, decision-makers must convey their preferences through their thinking, and adding more criteria reduces their accuracy (Alfares & Duffuaa, 2016). Meanwhile, the data structure, or the requirements values, can be considered throughout the evaluation process, and the objective weights of the criteria can be used to define the suitable degree of each criterion's dominance (Zavadskas & Podvezko, 2016). The choice of weighting mechanism is critical in supplier selection (Ayan *et al.*, 2023) because the

weight of the requirements significantly influences the review results, which must be addressed (Ginevičius, 2011).

Thus, due to factors such as the objective environment, professional level, and time, experts may need assistance delivering credible information regarding alternative solutions in specific practical settings (Cheng *et al.*, 2023). As a result, this study has merged a subjective weight and an objective attribute weight determination approach, which derives attribute weights directly from evaluation data. The compromised weighing technique is meant to reduce the potential bias of a single subjective or objective weight or to compensate for the subjective weight's deficiencies (Mukhametzhanov, 2021). The Method Based on the Removal Effects of Criteria (MEREC) is an objective weighting approach. MEREC is a relatively new method for evaluating the criteria weights (Mishra *et al.*, 2022). MEREC is a more accurate, precise, and practical objective weighting method than entropy and CRITIC (Goswami *et al.*, 2022), (Goswami *et al.*, 2022). That is why MEREC and similar methods are better suited for determining the objective weights of the criteria under consideration (Debnath *et al.*, 2023). However, a few research studies have been conducted using MEREC (Ecer & Aycin, 2023).

The research will consider the company's significant aspects by first conducting a factor analysis utilizing the Delphi technique. The factors are weighted using compromised AHP and MEREC, followed by supplier selection using the Proximity Index Value (PIV). Sensitive data is one of the aspects examined, so it is vital to do a sensitivity test to give the company a clear picture of which suppliers to prioritize.

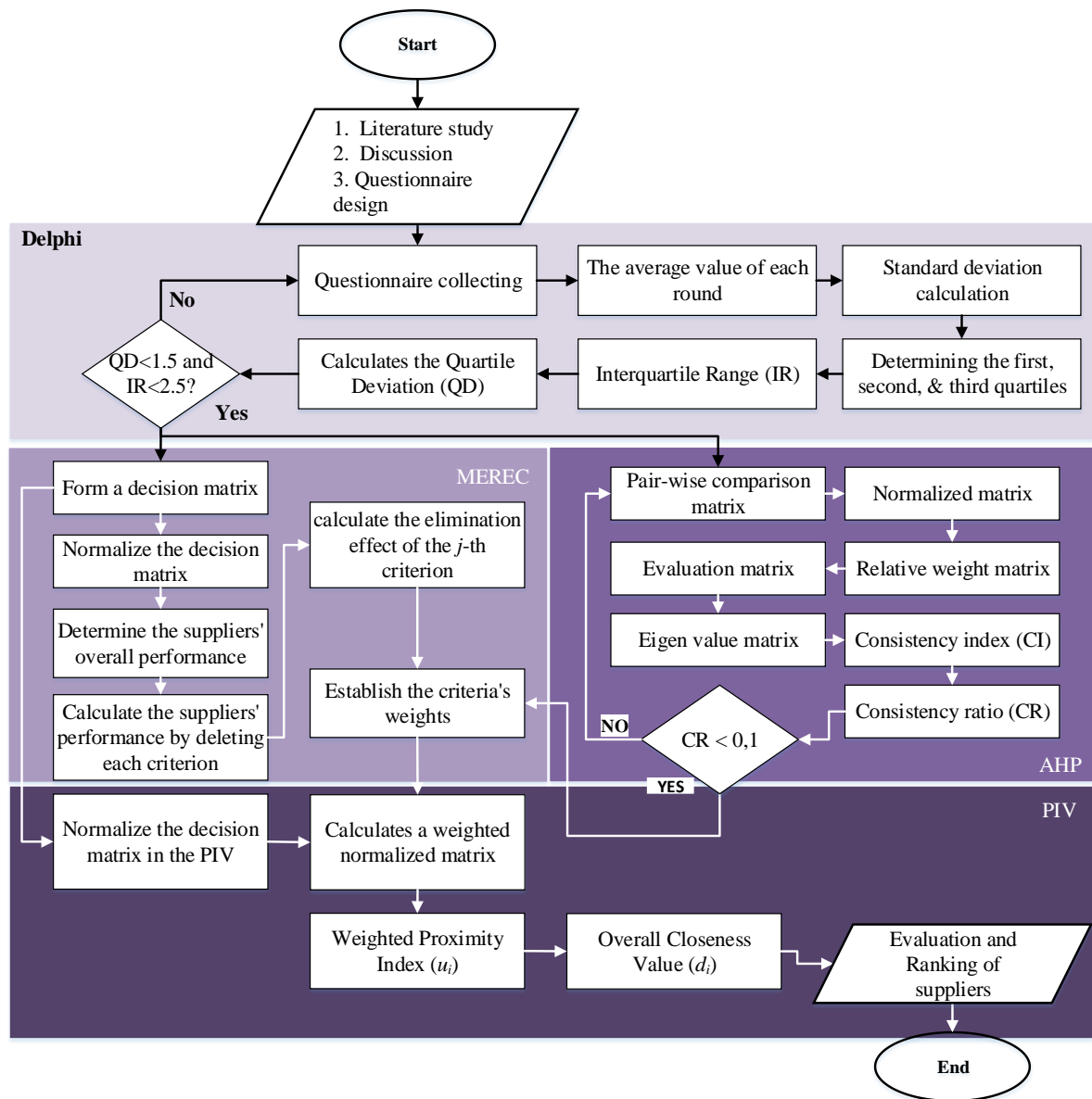
2 MATERIAL METHOD

The company's decision-makers provided the criteria in earlier research (Ristono *et al.*, 2018b). Most supplier selection research has not examined selection criteria further, and those studies concentrate on methods for choosing alternative suppliers (Ristono *et al.*, 2018a). In actuality, selecting the requirements is a crucial step in the supplier selection procedure (Ali *et al.*, 2023). There are numerous techniques for choosing criteria; for more details, see Ristono *et al.* (Ristono *et al.*, 2018a).

2.1 Delphi

Delphi is used in this study to choose the criterion. The benefit of using Delphi is that no precise sample size criterion has been specified in the literature because Delphi depends on group dynamics rather than statistical power to bring experts to consensus (Cafiso *et al.*, 2013). Delphi's capability to mix quantitative and qualitative data provides an additional benefit (Brady, 2015). The second benefit is getting expert opinions using an open questionnaire (Koskey *et al.*, 2023). Researchers collected and examined expert perspectives topically before presenting them to the same panel of experts for their agreement or disagreement with the synthesis findings (Koskey *et al.*, 2023). A consensus representing the aggregate expert opinion was obtained after several rounds of discussion (Hue & Oanh, 2023). In each round, experts can change their responses. Following exposure to the viewpoints of other specialists or to clarify perspectives, modifications may take place (Drumm *et al.*, 2022). The process was assisted by someone outside the panel, frequently a researcher, and the comments went unreported by other experts. Figure 1 depicts the Delphi phases used in this investigation; for more details, see Laupichler *et al.* (Laupichler *et al.*, 2023).

Figure 1
Structure of the proposed method



2.2 AHP

After choosing the criteria, weigh them using AHP and evaluate suppliers using TOPSIS. The most popular MCDM technique after the AHP is TOPSIS, which has a selection rate of 63.14% and does not necessitate paired comparisons (Chai *et al.*, 2013). Additionally, it is demonstrated that TOPSIS outperforms AHP, which requires many paired comparisons for many options (Nazim *et al.*, 2022). However, the mathematical

method is relatively simple, and the reasoning of the AHP approach is reasonable and understandable (Dožić *et al.*, 2023). As a result, AHP is mainly used to weight the criterion. In this study, TOPSIS is used for supplier selection, while AHP is used for criteria weighting. So, AHP can be applied to this problem to provide systematically appropriate weighting criteria and confirm the decision-making process.

AHP is often separated into three stages (Secundo *et al.*, 2017). The first step is defining the issue and creating a list of related problems (Dožić & Kalić, 2015). This is the benefit of AHP, as the issue can now be exposed and thoroughly dissected during the construction of the hierarchical structure (Deretarla *et al.*, 2023). The next step is to rank the elements in order of importance, working up from pairwise comparisons to the relative weighting of the criterion (Deretarla *et al.*, 2023). Synthesis, or measuring the consistency ratio index, is the third stage. This seeks to determine the validity of the relative weighting outcomes of these criteria (Saaty & Ozdemir, 2003). Figure 1 displays the AHP stages employed in this investigation; for more details, see Ristono *et al.* (Ristono, 2019).

2.3 MEREC

Keshavarz-Ghorabae *et al.* (2021) proposed the MEREC as an objective weighting method. Using accurate data or a decision matrix, the MEREC approach weighs the criteria objectively to determine their relative importance (Keshavarz-Ghorabae *et al.*, 2021). The MEREC approach employs the removal impact on alternatives to determine attribute weights (Cheng *et al.*, 2023). When removing a criterion has an enormous overall effect on the performance of the alternative, that criterion is given more weight (Keshavarz-Ghorabae *et al.*, 2021). So, MEREC focuses on the change in overall criterion weight by turning off a criterion while determining the weight of another (Ecer & Pamucar, 2022). More specifically, a movement in criterion weight demonstrates the importance of a criterion (Kaya *et al.*, 2023). This property differentiates MEREC from other objective weighting methods (CRITIC, CILOS, Shannon's entropy, etc.) (Ecer & Aycin, 2023). MEREC provides significant advantages over other objective weighing systems, such as ease of comprehension, computation, and a solid mathematical foundation (Ecer & Hashemkhani Zolfani, 2022); neutral and free from inconsistencies, ambiguity, and uncertainty (Mishra *et al.*, 2022); and free of

decision makers' opinions and judgments (Goswami *et al.*, 2022)(Keleş, 2023)(Das & Chakraborty, 2023).

The stages in weighting criteria using MEREC are as follows (Keshavarz-Ghorabae *et al.*, 2021)(Shanmugasundar *et al.*, 2022):

1. First step. This step entails constructing a decision matrix that shows the ratings or values for each possibility regarding each criterion. As indicated by the notation x_{ij} , the elements of this matrix must be greater than zero ($x_{ij} > 0$). If the decision matrix has any negative values, they should be changed to positive ones using the appropriate procedure. Assume the decision matrix has the following structure: n choices and m criteria.

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nm} \end{bmatrix} \quad (1)$$

2. Second step. Make the choice matrix (N) normal. The decision matrix's components are scaled using a simple linear normalization during this step. The letters n_{ij}^x represent the elements of the normalized matrix. If j is beneficial criteria, use Eq. (2); if j is cost criteria, use Eq. (3).

$$n_{ij}^x = \frac{\min_k(x_{kj})}{x_{ij}} \quad (2)$$

$$n_{ij}^x = \frac{x_{ij}}{\max_k(x_{kj})} \quad (3)$$

3. Third step. Eq. (4) can determine the suppliers' overall performance. For this reason, a logarithmic metric with equal criteria weights is used (Das & Chakraborty, 2023). Smaller normalized values are considered to result in better supplier performance.

$$S_i = \ln \left[1 + \left| \frac{1}{m} \sum_j |\ln(n_{ij}^x)| \right| \right] \quad (4)$$

4. Fourth step. The suppliers' performance after deleting each criterion can be determined using Eq. (5). The same logarithmic scale is used here to assess the performance of the alternatives after deleting each criterion individually (Das & Chakraborty, 2023). This measure indicates the difference between the total alternative's performance and its performance when omitting a criterion. A primary logarithmic metric is typically used with equal weights to evaluate the requirements' performance (Das & Chakraborty, 2023). On the other hand, the absolute deviation measure is used to determine the effects of deleting each criterion in the decision-making problem.

$$S_i^* = \ln \left[1 + \left| \frac{1}{m} \sum_{k, k \neq j} |\ln(n_{jk}^x)| \right| \right] \quad (5)$$

5. Fifth step. Using the values from Steps 3 and 4, compute the elimination effect of the j^{th} criterion in this step. Let E_j denote the result of deleting the j^{th} condition. To determine the values of E_j , apply the Eq. (6).

$$E_j = \sum_i |S_i^* - S_i| \quad (6)$$

6. Sixth step. Determine the criteria's final weights. This step uses the elimination effects (E_j) from Step 5 to calculate the objective weight of each criterion. The weight of the j^{th} criterion is given by w_j^m in the sentences below. The equation used to calculate w_j^m is used in Eq. (7).

$$w_j^m = \frac{E_j}{\sum_k k} \quad (7)$$

This study provides a compromise method that weighs the advantages of both objective and subjective weighing systems (Moradian *et al.*, 2019). In other words, this technique weights the criterion with a combination of MEREC and SWARA. The combined weights for each criterion are more reasonable than (Çalışkan *et al.*, 2013; Moradian *et al.*, 2019). The synthesis weight for the j^{th} criterion is (Chu & Su, 2012).

$$W_j = \frac{w_j^m \times w_j^s}{\sum_{j=1}^n [w_j^m \times w_j^s]}; j=1 \dots n \quad (8)$$

where

w_j^m is the weight of the j^{th} criterion obtained using the MEREC approach, and w_j^s is the weight of the j^{th} criterion obtained using the SWARA method.

2.4 PIV

Mufazzal and Muzakkir (2018) proposed PIV for MCDM problem. This PIV compares suppliers based on a proximity value representing the deviation from the best supplier (Bingol, 2022). The method computation step is as follows (Mufazzal & Muzakkir, 2018):

1. Decision problem formulation. At this step, the goal of the problem is found by determining decision criteria, $C_j (j = 1, 2, 3, \dots, n)$ and suppliers, $(A_i (i = 1, 2, 3, \dots, m))$. The value of X_{ij} is measured or unmeasured for each set of feasible suppliers. This step determines the final results of the calculation, so decision-makers must be thorough and careful in assigning values to qualitative attributes that cannot be measured. Additionally, rank reversal increases for non-uniform distributions between suppliers with adjacent scores.
2. Decision matrix construction. The existing values will be tabulated into a decision matrix. Each row of the matrix is allocated to one supplier, and each column is assigned one criterion.
3. Data normalization. Because X_{ij} values can be spread over different scales at different j values, they must be scaled to be combined for comparison in the same dimension. Data normalization can be formulated in Equation (9).

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}} \quad (9)$$

4. Determination of the weighted normalized decision matrix. In this research, a compromise weight between MEREC and SWARA is used for the weight value of supplier i , which is related to criterion j , formulated in Equation (10).

$$v_i = w_j * r_i \quad (10)$$

5. Evaluation of the Weighted Proximity Index (WPI). The weighted closeness index (u_i) is used to find the closest available supplier within the range of decision criteria. It measures the deviation of each supplier towards the best value, determined by selecting the maximum value for positive criteria and the minimum value for negative criteria. WPI is then calculated by taking the difference from the weighted normalized value for the best value in the range, formulated in equations (11) and (12). Eq. (11) is used by benefit criteria, and Eq. (12) is used by non-benefit criteria.

$$u_i = v_{max} - v_i \quad (11)$$

$$u_i = v_i - v_{min} \quad (12)$$

6. Determination of the overall closeness value. Each supplier's overall closeness value (d_i) is determined by combining the weighted closeness values (u_i) associated with each criterion. This value shows the overall closeness of a supplier to the best supplier, which is feasible for the problem being faced. The overall closeness value is needed to form a consistent ranking hierarchy and can minimize the phenomenon of ranking reversals. Determination of the overall closeness value is formulated in equation (13).

$$d_i = \sum_{j=1}^n u_j \quad (13)$$

7. Rating. The supplier with the smallest overall closeness value (d_i) will have the highest closeness to the best feasible supplier. The smaller the value, the more

worthy the supplier is considered. Thus, the supplier with the smallest d_i value will be ranked first, followed by the supplier with a more significant d_i value.

3 THE RESEARCH FINDINGS AND DISCUSSION

Delphi is the initial phase. The objective of this stage is to collect crucial criteria for the business. Competent experts handled the submission of questionnaires at this point. Tables 1 and 2 provide the input and outcomes from the Delphi stages. Assessment of the criterion using convergence. The instrument is said to converge if the standard deviation is less than 1.5 and the interquartile range is less than 2.5. Based on Table 2, it can be concluded that seven criteria are considered in supplier selection: reject, delivery, price, communication, complaint procedure, service, and flexibility. The next step is to make pairwise comparisons between the four criteria. Tables of pairwise comparisons between criteria are carried out by decision-makers from the company whom we regard as experts. This can be seen in Table 3. Based on a pairwise comparison calculated using AHP, the weight of the criteria is obtained, as shown in the column on the rightmost right in Table 3. The relative weight of these criteria is validated by calculating the consistency ratio (CR). From the results of these calculations, the consistency ratio is below 0.1, so it is declared valid.

Table 1

Assessment of criteria.

No	Criteria	Respondent										Mean	Standard deviation
		1	2	3	4	5	6	7	8	9	10		
1	Reject	5	5	4	5	5	4	5	5	5	5	4.782	0.343
2	Delivery	5	5	5	4	4	5	4	4	5	5	4.573	0.302
3	Price	5	4	5	4	5	4	5	4	3	3	4.129	0.506
4	Communication	5	4	5	4	5	3	5	4	5	4	4.345	0.403
5	Complaint procedure	3	4	5	4	3	4	3	3	3	5	3.622	1.013
6	Service	4	5	4	3	4	5	4	5	4	4	4.156	0.777
7	Flexibility	2	3	2	5	4	3	4	4	5	5	3.515	1.440

Table 2

Results of the Delphi stage

first quartile	second quartile	third quartile	Interval of Range (IR)	Quartile Deviation
4.129	4.249	4.573	0.444	0.222

Table 3

Pair-wise comparison and criteria weight.

Criteria		Criteria							Weight
		Quality	Delivery	Price	Communi- cation	Complaint procedure	Service	Flexi- bility	
1	Quality	1.00	1.05	1.16	1.10	1.32	1.15	1.36	0.164
2	Delivery	0.96	1.00	1.11	1.05	1.26	1.10	1.30	0.157
3	Price	0.86	0.90	1.00	0.95	1.14	0.99	1.17	0.142
4	Communication	0.91	0.95	1.05	1.00	1.20	1.05	1.24	0.149
5	Complaint procedure	0.76	0.79	0.88	0.83	1.00	0.87	1.03	0.124
6	Service	0.87	0.91	1.01	0.96	1.15	1.00	1.18	0.143
7	Flexibility	0.74	0.77	0.85	0.81	0.97	0.85	1.00	0.121

The First step in the MEREC method is decision matrix formulation. A decision matrix is an arrangement of suppliers and their criteria values in rows and columns, as shown in Table 4 by using Eq. (1). It can be observed from Table 4 that the supplier values are defined on a different scale and have a different range. Therefore, the decision matrix is normalized to convert these values into a similar scale using equations (2) for beneficial and (3) for non-beneficial criteria. After obtaining the normalized decision matrix via Eq. (2) and (3), we find the overall performances of suppliers and suppliers' performance after deleting each criterion in the Third step and the Fourth step through Eq. (7) and Eq. (8), respectively. These results can be seen in Tables 5 and 6. Finally, the weight values of the requirements (w_j^m) are extracted by Eq. (10). Then, they are compromised with SWARA weighing (w_j^s), which is demonstrated in Table 7 and Figure 2.

Table 4

Decision matrix.

No	Supplier	Criteria						
		Quality	Delivery	Price	Communi- cation	Complaint procedure	Service	Flexibility
1	Cianjur	0.090	4.4	80	70	86	80	95
2	Kediri	0.070	4.2	70	70	90	70	80
3	Lumajang	0.085	5.2	80	80	78	80	90
4	Cirebon	0.080	4.0	60	75	82	70	65
5	Jombang	0.060	5.6	70	70	92	60	55
6	Wonogiri	0.065	5.8	80	70	86	90	70
7	Sidoarjo	0.090	5.0	85	70	80	70	60
8	Rembang	0.060	4.8	75	65	80	60	55

Table 5

Normalization of the decision matrix (MEREC).

		Quality	Delivery	Price	Communi- cation	Complaint procedure	Service	Flexibility
1	Cianjur	1.000	0.759	1.000	1.000	0.935	0.750	0.579
2	Kediri	0.778	0.724	0.875	1.000	0.978	0.857	0.688
3	Lumajang	0.944	0.897	1.000	0.875	0.848	0.750	0.611
4	Cirebon	0.889	0.690	0.750	0.933	0.891	0.857	0.846
5	Jombang	0.667	0.966	0.875	1.000	1.000	1.000	1.000
6	Wonogiri	0.722	1.000	1.000	1.000	0.935	0.667	0.786
7	Sidoarjo	1.000	0.862	1.063	1.000	0.870	0.857	0.917
8	Rembang	0.667	0.828	0.938	1.077	0.870	1.000	1.000

Table 6

The suppliers' overall performance by deleting each criterion

		Quality	Delivery	Price	Communi- cation	Complaint procedure	Service	Flexibility
1	Cianjur	0.156	0.121	0.156	0.156	0.147	0.120	0.086
2	Kediri	0.134	0.125	0.149	0.165	0.163	0.146	0.119
3	Lumajang	0.157	0.150	0.164	0.147	0.143	0.128	0.102
4	Cirebon	0.154	0.122	0.133	0.160	0.154	0.149	0.148
5	Jombang	0.024	0.074	0.061	0.079	0.079	0.079	0.079
6	Wonogiri	0.097	0.138	0.138	0.138	0.130	0.087	0.108
7	Sidoarjo	0.081	0.061	0.073	0.081	0.062	0.060	0.069
8	Rembang	0.065	0.093	0.109	0.108	0.100	0.118	0.118

The AHP-weighted results demonstrate that the communication criterion outweighs the price criterion multiple. Meanwhile, under compromise weighting, the weight of the price criterion is increased. This aligns with the company's reality. Despite the shortcomings of the subjective technique (including AHP), such as the need for greater transparency throughout the decision-making process, the method has proven helpful in weighing various resources based on subjective evaluations. A comparison of the multiple criteria revealed that flexibility, the most crucial component of the MEREC approach, was ranked last in the AHP method and sixth in the compromised technique.

Table 7

The weighting comparison of three methods.

No	Weighting method	Criteria						
		Quality	Delivery	Price	Communi- cation	Complaint procedure	Service	Flexibility
1	MEREC	0.182	0.166	0.119	0.082	0.069	0.165	0.217
2	AHP	0.164	0.157	0.142	0.149	0.124	0.143	0.121

3	Compro-mise	0.209	0.182	0.117	0.085	0.060	0.164	0.183
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Figure 2

Comparison of the weighting criteria method

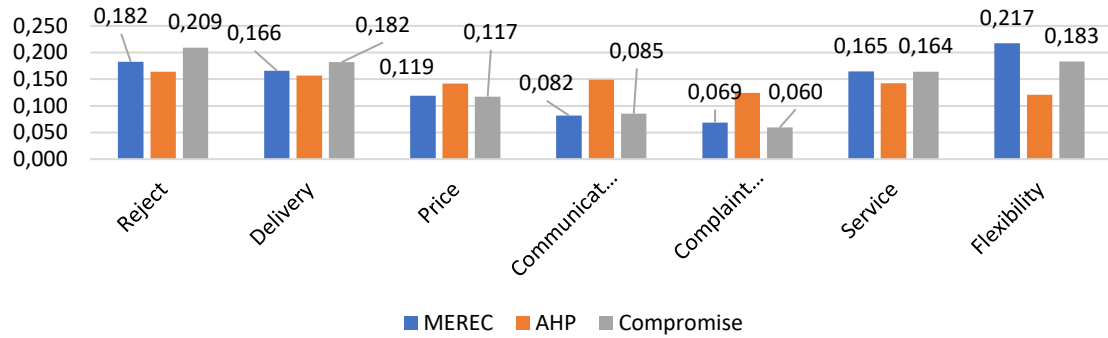


Table 8

WPI, overall closeness value, and rank.

No	Supplier	Criteria							d_i	Rank
		Quality	Delivery	Price	Communi cation	Complaint procedure	Service	Flexi bility		
1	Cianjur	0.0292	0.0052	0.0110	0.0042	0.0015	0.0079	0.0000	0.0591	2
2	Kediri	0.0097	0.0026	0.0055	0.0042	0.0005	0.0159	0.0134	0.0518	1
3	Lumajang	0.0243	0.0157	0.0110	0.0000	0.0035	0.0079	0.0045	0.0669	4
4	Cirebon	0.0194	0.0000	0.0000	0.0021	0.0025	0.0159	0.0267	0.0666	3
5	Jombang	0.0000	0.0209	0.0055	0.0042	0.0000	0.0238	0.0356	0.0901	7
6	Wonogiri	0.0049	0.0236	0.0110	0.0042	0.0015	0.0000	0.0223	0.0674	5
7	Sidoarjo	0.0292	0.0131	0.0138	0.0042	0.0030	0.0159	0.0312	0.1103	8
8	Rembang	0.0000	0.0105	0.0083	0.0063	0.0030	0.0238	0.0356	0.0874	6

In supplier evaluation, the data required by PIV is the assessment of each supplier for each criterion. This step is the initial step of PIV. The decision matrix can be created using Eq. (1). The data details are in Table 4. The data is divided into two types according to the type of criteria. The two types are benefit criteria (quality) and non-benefit criteria (price, delivery, communication, service, flexibility, and complaint procedure). The next step is to normalize the decision matrix using Eq. (9) and then multiply by the weight for each criterion (output from compromise AHP and MEREC) using Eq. (10). The third step is determining the weighted Proximity Index (WPI) using Eq. (11) and Eq. (12), for beneficial criteria and non-beneficial criteria, respectively. The fourth step is measuring

the overall closeness value using Eq. (14). The results of the second, third, and fourth steps can be seen in Table 8.

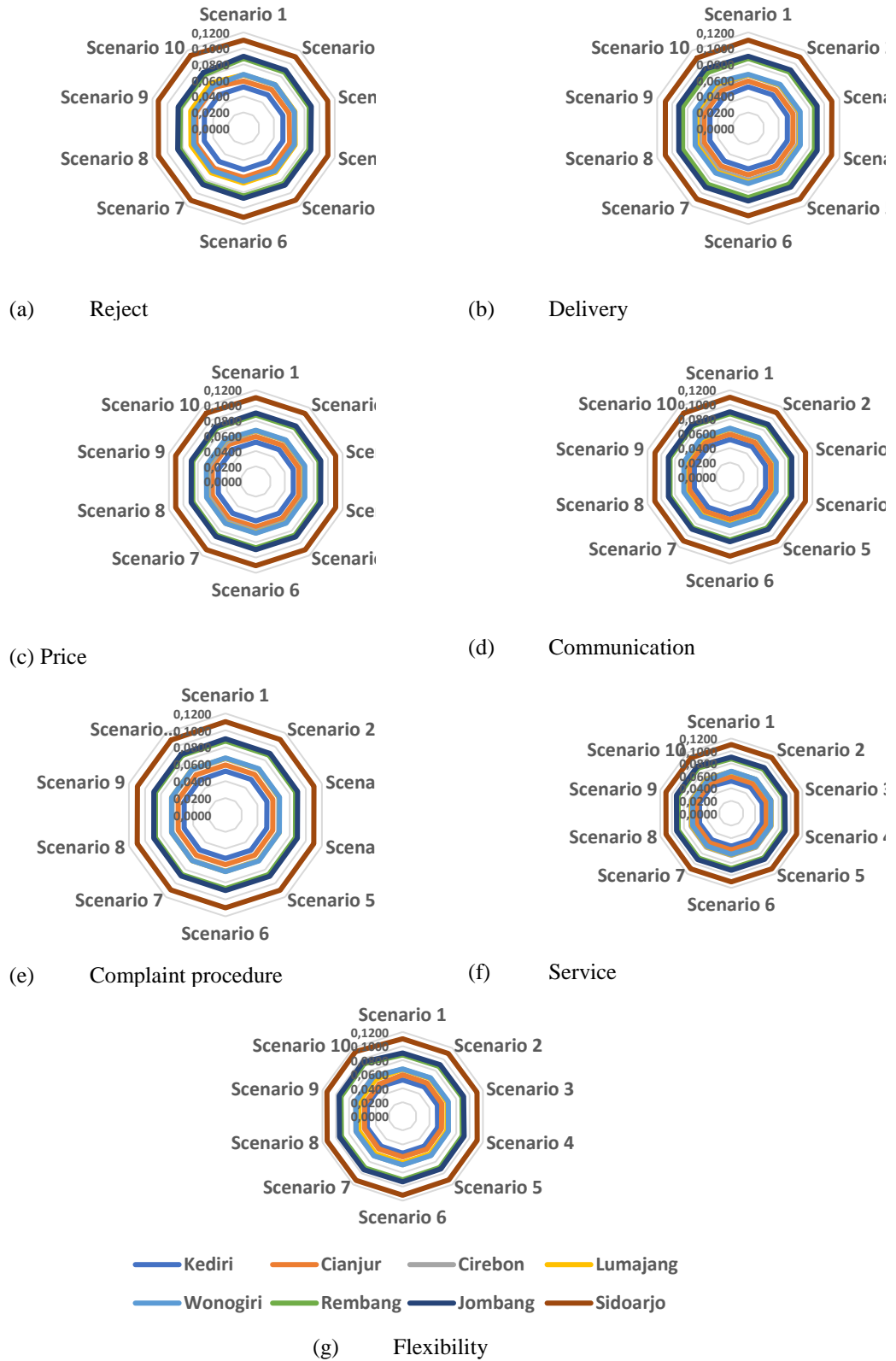
A sensitivity analysis was conducted to validate the suggested model's results because potential alterations directly influence this section's sensitivity analysis to change. External variables can affect the criterion weights. As a result, this section conducts a sensitivity analysis to determine how resilient the ranking system is. Four scenarios are developed to do this, and the ranking is carried out with the new weights in mind.

In each scenario, the criterion weight increases by 2.5%. Figures 2 depict the results. There are no figures that exhibit a distinct pattern. Figure 2 shows that Kediri and Jombang rank higher as the rejection weight increases. As the figures illustrate, the ranks of solutions are consistent across all situations. As a result, the suggested model process's outputs are reliable enough to be applied in a real-world problem, as 20% differences in the weight of all criteria have no discernible effect on the method's output.

4 CONCLUSION

The study developed a new framework that enables consumers to select vendors based on various characteristics. This hybrid method also allows users to integrate their datasets. This study investigated the subject of supplier evaluation in an actual case from Indonesia's leather industry. The decision-making unit used the proposed model's outputs as input data. Delphi was utilized to categorize the critical elements in supplier selection based on the changing opinions of leather industry specialists. To appropriately address the multi-objective problem, an integration of Delphi-AHP-MEREC-PIV was proposed. After weighting the criteria in the previous stage, PIV was used to rank the potential options. The top responses were then ranked in this step to allow managers and decision-makers to remain flexible. A sensitivity analysis was performed to examine the impact of potential changes to the criteria weights on the rankings of the best solutions. The results demonstrated that the proposed model is reliable and that the rankings resist changes in the criterion weights.

Figure 3
Current scenario



CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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