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RESEARCH PAPER

Additive Ratio Assessment for Supplier Selection Using Compromise Weighting of Step Weight Assessment Ratio Analysis and The Method Based on Removal Effects of a Criteria: A Case Study in the Indonesian Leather Industry

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ABSTRACT
This paper proposes a decision-support model for supplier selection based on integrating the step weight assessment ratio analysis (SWARA), the method based on the removal effects of a criterion (MEREC), and Additive Ratio Assessment (ARAS) using a case study of the leather industry in Indonesia. The model starts by identifying the main criteria using the opinions of leather industry experts using Delphi. The second stage is to weigh them based on the main criteria, using compromising of objective and subjective weighting methods, namely MEREC and SWARA. The suppliers are selected and ranked based on the main criteria. Lastly, a sensitivity analysis will be performed to check the robustness. Delphi methodology adopted in this study gives managers in Indonesia's leather industries insights into the factors that must be considered when selecting suppliers for their organizations. The selected approach also aids them in prioritizing the criterion. Managers can utilize the supplier selection methodology suggested in this study to rank the suppliers based on various factors/criteria. This study makes three novel contributions to the supplier selection area. First, Delphi is applied to the Indonesian leather industry and integrates MEREC, SWARA, and ARAS into supplier selection. Second, sensitivity analysis allows the determination of the impact of modifications in the primary criteria on the ranking of suppliers and assists decision-makers in assessing the resilience of the process. Last, we find it essential to develop a simple methodology for managers of the Indonesian leather industry to select the best suppliers. Moreover, this method will help managers divide complex decision-making problems into more straightforward methodologies.

KEYWORDS: *Additive ratio assessment (ARAS);The method based on the removal effects of criterion (MEREC);*step weight assessment ratio analysis (SWARA); *Delphi;* Supplier selection.

1. Introduction

Raw materials are essential in manufacturing because the production system cannot work correctly without them [1]. However, the quality of suppliers, who play a vital part in a company's success by ensuring that things are manufactured according to the expectations and preferences of enterprises or consumers, must be given special consideration [2] [3][4]. As a result, selecting suppliers has become acknowledged as one of the significant challenges businesses must solve to preserve a strategic competitive advantage [5][6]. This makes the supplier selection process an essential part of operations.

PT. Adi Satria Abadi (ASA) is one of the largest leather industries in Indonesia. The company produces gloves from animal skin. This company manufactures its products utilizing a long-term, sustainable, make-to-order strategy that relies on the assistance of medium- to large-sized businesses [7]. According to the organization, each supplier has a unique personality when meeting raw material requirements. Because the vendors could not match the company's specifications, they repeatedly failed to deliver [7]. The company is dissatisfied with the price, delivery delays, and product quality that it has received.

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To compete in the industrial world, firms must establish effective supply chains, one of which is maintaining contact with suppliers [8]. Supply chain management substantially impacts healthy business performance and success [9]. As a result, it is critical to maintain a robust supply chain and create positive relationships with suppliers. The selection of suppliers is crucial for managing industry relationships [10]. To improve business performance and reduce PT ASA dissatisfaction, the company undertakes an assessment to identify priority suppliers. Every semester, a supplier assessment is conducted to evaluate the performance of each period's vendors. The company evaluates the procurement unit twice a year.

Research is required when selecting suppliers to reduce the probability of the organization being unsatisfied [11]. Multiple criterion decision-making (MCDM) approaches, notably Additive Ratio Assessment (ARAS), have been employed in supplier selection research to address the challenge of supplier selection. The ARAS method's computational technique offers more simple advantages than other established MCDM methods, such as Technique For Others Reference by Similarity to Ideal Solution (TOPSIS), Vlse kriterijumska optimizacijai compromise vengeance (VIKOR), Weight Aggregated Sum Product Assessment (WASPAS), Measurement of alternatives and ranking according to COmpromise solution (MARCOS), and Complex Proportional Assessment (COPRAS) [12].

The Analytical Hierarchy Process (AHP) is a weighing method often used to select suppliers [13]. Its benefits include universality, reduced subjectivity due to incorporating the human component, and verification of data inconsistencies [14]. As a result, the ARAS technique and AHP for supplier evaluation were incorporated into its design, such as Mavi [15], Tamošaitiene et al. [16], Liao et al. [17], Büyüközkan and Göçer [18], Fu [19], etc.

Nevertheless, the AHP still has certain constraints, such as a substantial base data requirement and a restricted range of scales [14]. The Stepwise Weight Assessment Ratio Analysis (SWARA) is a method that, although analogous to the AHP, is more efficient in evaluating the criteria [20]. The SWARA method is far less computationally demanding than the AHP strategy. It requires fewer pairwise comparisons [21], making this method more straightforward and not complicated than AHP [12]. Many criterion weighting approaches are inherently complex in their computations but need better precision [22]. Nevertheless, SWARA's complexity could be enhanced while maintaining a satisfactory level of accuracy [23]. SWARA is a direct approach that enables experts to articulate their expertise conveniently [24]. For instance, unlike the AHP and Best-Worst Method (BWM), SWARA allows experts to evaluate the criteria without considering any particular best or worst criterion. This facilitates experts' providing assessments and participating more freely [25]–[27].

A vital characteristic of the SWARA approach is its capacity to quantify experts' viewpoints on the statistical significance of variables while calculating their weights [23]. In SWARA, experts can utilize their implicit experiences, knowledge, and information [28]. Within this methodology, the criteria weight is determined by the preferences of the decision-maker [29]. Therefore, subjective weighting requires the consultation of competent experts with an extensive understanding of the pertinent theory and practical expertise [30]. Concurrently, the arrangement of the data, or the values of the criteria, can also be considered during the assessment procedure, and the objective weights of the criteria can be utilized to determine the appropriate level of effectiveness of each criterion [30]. An inherent limitation of these methods is their loss of effectiveness as the number of criteria increases. Decision-makers must employ cognitive processes to express their preferences, and including additional factors diminishes the accuracy of their choices [31]. Optimal selection of a weighting mechanism is essential in supplier selection as the criteria weights significantly impact the review results [32], which need to be adjusted accordingly [33].

Therefore, professionals may need help providing reliable information on the preferences for different solutions in specific practical scenarios, considering factors such as the objective environment, professional competency, and time constraints [34]. Consequently, at this point, our study has compromised both a subjective weight and an objective attribute weight determination method that assigns attribute weights straight from the evaluation data. The compromised weighing approach is anticipated to mitigate the possible bias resulting from a single subjective or objective weight or offset the subjective weight's insufficiency [35].

The Method based on the Removal Effects of Criterion (MEREC) is an objective weighing approach. Because MEREC is not subject to the opinions and judgments of decision-makers [36][37][38]. While determining the weight of a criterion, MEREC focuses on the change in the total criteria weight by deactivating that criterion [39]. To be more precise, the weight of a criterion is indicated by the shift in criterion weight [40]. The MEREC method is a newly developed technique for weight assessment [41]. The aim of the MEREC weighting method is more efficient than both CRiteria Importance Through Inter-criteria Correlation (CRITIC) and entropy methods [36]. This approach yields more accurate results than conventional objective weighting methods such as Entropy and CRITIC [36]. Hence, MEREC and comparable algorithms are better suited for determining the criteria' objective weights [42]. MEREC boasts substantial advantages over other objective weighting systems, such as a solid mathematical foundation, computation, and simplicity of comprehension [43]. Nevertheless, only a limited number of research papers have been undertaken using MEREC [44].

Research using ARAS with SWARA has been carried out in many areas, such as the selection of personnel [45], [46], rank of companies according to the indicators of corporate social responsibility [12], selection of the best information technology expert [47], calculate the optimal operational parameters for a spark ignition engine [48], rank the four renewable energy technologies [49], assessment of sites in Afghanistan for hydrogen production with geothermal energy [50], machine selection [51], rank the Internet of Things (IoT) risks [52], selection of an equipment maintenance strategy in the manufacturing industry [53], evaluation of the quality of health care services [54], risk assessment of firefighting jobs [55], identifying the problems resulting from the scarcity of empty containers and prioritizing suitable remedies [56], determination of best renewable energy sources in India [57], and supplier selection [58]. The use of Delphi in the integration of ARAS and SWARA was carried out in research to evaluate the performance of oil and gas projects [59], prioritization and value patents [60], prioritizing the areas of Internet of Things (IoT) application in the agriculture sector [61], selecting the most appropriate transportation type [62], evaluating the strategies to promote foreign direct investment [63], and supplier selection [64]. Meanwhile, MEREC integrated SWARA and ARAS in selecting digital marketing technology [65]. There has been no research on supplier selection that compromises SWARA with MEREC as weighting criteria for ARAS, with selection criteria using Delphi. This study introduces a novel methodology for merging Delphi, SWARA, MEREC, and ARAS. Figure 1 shows the stages of the proposed method.

2. Material Method

The study will commence by conducting a Delphi factor analysis to ascertain the company's criterion requirements. Furthermore, each choice criterion carries distinct weights when addressing MCDM challenges [39]. First, SWARA evaluates the subjective criterion, whereas MEREC evaluates the objective parameters. In computing subjective criteria weights from expert opinion, SWARA outperforms the Full Consistency Method (FUCOM) and MEREC [42]. Subsequently, both measures (MEREC and SWARA) are compromised. Other MCDM approach methods must be employed to ascertain alternative priority decisions, as the SWARA method was exclusively designed to determine the weight of each criterion employed [66]. So, the vendor is chosen to utilize the ARAS methodologies.

2.1. Delphi

Delphi is utilized in this study to select the criterion. The advantage of Delphi is that no precise sample size criterion has been given in the literature, as Delphi relies on group dynamics rather than statistical power to bring experts together [67]. Delphi's ability to combine quantitative and qualitative data is an additional advantage [68]. The second advantage is the opportunity to solicit expert comments via an open questionnaire [68]. Researchers gathered and assessed expert perspectives topically before presenting them to the same panel of experts to determine their agreement or disagreement with the synthesis findings [69]. After multiple rounds of discussion, a consensus was reached that represented the aggregate expert view [70].

Someone outside the panel, usually a researcher, aided in the procedure, and the comments went unnoticed by other experts. Figure 1 displays the Delphi phases used in this study; for further information, see Laupichler et al. [71].

2.2. SWARA

Keršuliene et al. [72] presented the SWARA for the subjective weighting method. The SWARA approach is applicable when two or more criteria have been established according to the specific situation [23]. The following stages can accurately demonstrate how the SWARA technique derives the relative weights of criteria [21]:

1. First step. The requirements for expected relevance are listed in descending order.
2. Second step. Beginning with the second criterion, the answer describes the relative relevance of criterion j concerning the

prior (j-1) criterion. This ratio is the Comparative Importance of Average Value, s_j, by Kersuliene et al. [20].

3. Third step. The coefficient k_j should be calculated as follows:

$$K_j = \begin{cases} 1 & , j = 1 \\ S_j + 1 , & j > 1 \end{cases} \quad (1)$$

4. Fourth step. Calculate the revised weight q_j as

$$q_j = \begin{cases} 1 & , j = 1 \\ \frac{q_{j-1}}{Kj}, & j > 1n \end{cases} \quad (2)$$

5. Fifth step. The respective weights of the evaluation criteria are established as follows:

$$W_j = \frac{q_j}{\sum_{k=1}^{n} q_k} \quad (3)$$

Where w_j represents the relative weight of criterion j.

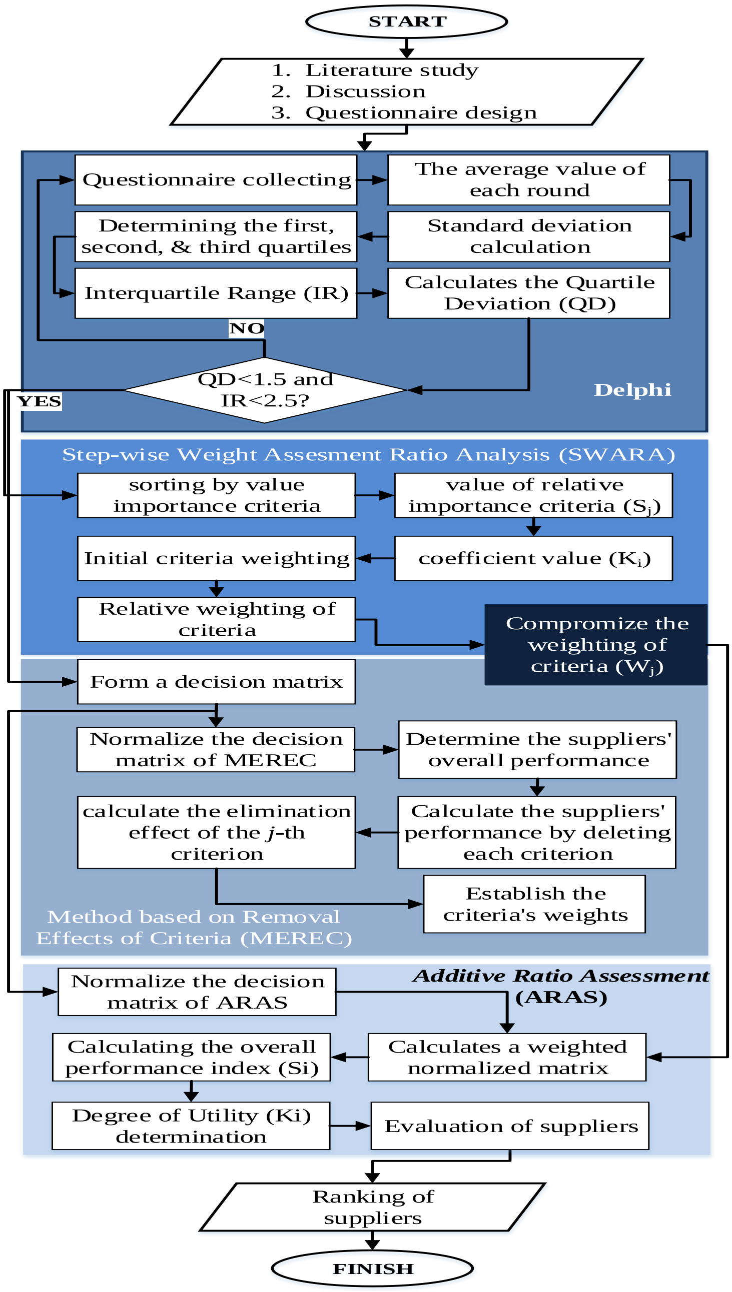

Fig. 1. The proposed method

2.3. MEREC

The MEREC approach uses correct data or a decision matrix to objectively balance the criteria and establish their relative importance [29]. The MEREC technique uses the removal impact on alternatives to calculate attribute weights [34].

When deleting a criterion significantly affects the performance of the alternative, that criterion is given greater weight [29]. This characteristic distinguishes MEREC from other objective weighting systems (such as CILOS, Shannon's entropy, and CRITIC) [44]. The stages in weighting criteria using MEREC are as follows [29]:

1. First step. This stage involves creating a decision matrix that displays the ratings or values for each alternative about each criterion. As shown by the symbol x_{ij}, the elements of this matrix must be more than zero ($x_{ij} > 0$). If the decision matrix has any negative values, they should be converted into positive values using the proper method. Assume that the decision matrix has the following shape: *n* choices and *m* criteria.

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nm} \end{bmatrix} \tag{4}$$

2. Second step. Make the choice matrix (N) normal. In this stage, the decision matrix's components are scaled using a straightforward linear normalization. The letters n^{x}_{ij} stand for the elements of the normalized matrix. If *j* is beneficial criteria use Eq.(5), and if *j* is non-beneficial criteria use Eq. (6).

$$n_{ij}^{x} = \frac{\min\limits_{k} (x_{kj})}{x_{ij}} \tag{5}$$

$$n_{ij}^{x} = \frac{x_{ij}}{\max\limits_{k} (x_{kj})} \tag{6}$$

3. Third step. Determine the suppliers' overall performance.

$$S_i = ln\left[1 + \left[\frac{1}{m}\sum_j \left|ln\langle n_{ij}^{x}\rangle\right|\right]\right] \tag{7}$$

4. Fourth step. Calculate the suppliers' performance by deleting each criterion.

$$S_i^{*} = ln\left[1 + \left[\frac{1}{m}\sum_{k,k\neq j} \left|ln\langle n_{jk}^{x}\rangle\right|\right]\right] \tag{8}$$

5. Fifth step. Using the numbers from Steps 3 and 4, calculate the elimination effect of the *j*-th criterion in this step. Let E_j represent the outcome of eliminating the jth criterion. The formula below can be used to determine the values of E_j.

$$E_j = \sum_j |S_i^{*} - S_i| \tag{9}$$

6. Sixth step. Establish the criteria's final weights. The elimination effects (E_j) from Step 5 are used to compute each criterion's objective weight in this step. The weight of the *j*-th criterion is denoted by wj in the following sentences. The calculation of w_j is performed using the following equation.

$$w_j^{m} = \frac{E_j}{\sum_k k} \tag{10}$$

This paper proposes a compromise method that considers the benefits of both objective and subjective weighting methods [73]. In other words, this strategy weights the criterion using a mix of MEREC and SWARA. The compromised weight for each criterion is more reasonable [73], [74]. The synthesis weight for the *j*-th criteria is [75]:

$$W_j = \frac{w_j^{m}\ x\ w_j^{s}}{\sum_{j=1}^{n}\left[w_j^{m}\ x\ w_j^{s}\right]};\ j=1\ldots n \tag{11}$$

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. ARAS

Zavadskas and Turskis were the first to introduce ARAS [76]. Zavadkas and Turskis developed the ARAS provider selection approach for the solid waste disposal enterprise [77]. The utility value function, a benefit of the ARAS technique, determines the relative efficacy of workable alternatives in direct proportion to the priority and weight of the criteria considered [76]. Figure 1 shows the ARAS steps employed in this research. For further information, see Zavadskas et al. [76] and Zavadskas et al. [78].

Evaluating every provider for every criterion makes up the information requested by ARAS. The first phase of ARAS is to create the decision matrix using Eq. (4) [76]. The following step is to normalize the decision matrix using Eq. (12) for the benefit criteria and Eq. (13) for the non-benefit criteria and then multiply by the weight for each criterion (output from SWARA) using Eq. (14) [78]. The optimality function (S_i) value will be calculated by summing the values for each criterion (refer to Eq. (15)). The degree of utility is the foundation for supplier evaluation. The utility level is determined by dividing its value by the ideal optimality function for each provider [76] [78].

$$\bar{x}_{ij} = \frac{x_{ij}}{\sum_{i=0}^{m} x_{ij}} \quad (12)$$

$$x_{ij}^{*} = \frac{1}{x_{ij}}; \bar{x}_{ij} = \frac{x_{ij}^{*}}{\sum_{i=0}^{m} x_{ij}} \quad (13)$$

$$\hat{x}_{ij} = \bar{x}_{ij}.w_j; i=1\ldots m; j=1\ldots n \quad (14)$$

$$S_i = \sum_{j=1}^{n} \hat{x}_{ij}; i=1\ldots m \quad (15)$$

3. Research Findings and Discussion

3.1. Criteria selection

Delphi is implemented to identify critical criteria. A questionnaire is administered to expert groups, and consensus significance values are computed to verify essential criteria. The influence of the criteria is the determining factor in determining their significance. This stage seeks to acquire parameters that the company deems necessary. At this point, competent specialists had submitted the questionnaires.

The number of specialists might range from 5 to 20 individuals depending on their specific areas of specialization [79]. Based on the findings of Yusoff et al. [80], a minimum of seven experts is necessary for expert selection. This conclusion is corroborated by Mustapha et al. [81], who stated that seven samples are sufficient in the Delphi procedure when the experts exhibit high homogeneity. Previous studies suggest that when analyzing data using decision-making (DM), a minimum of 10 experts are necessary to achieve a significant consensus among them [82]. Based on all of the previous research, this study included ten specialists. Given these conditions, a quorum of ten experts is adequate to gather information and achieve expert consensus for evaluating and validating the model in this study. Table 1 presents further details about the experts.

Tab. 1. Summary of the details among the experts.

Number of experts	Position	Area of expertise	Years of leather industry experience
1	Manager	Leather industry	25 years
1	Purchasing supervisor	Purchasing	10 years
2	Warehouse Supervisor	Warehouse	15 and 20 years
4	Warehouse staff	Inventory	10-25 years
2	Purchasing staff	Purchasing	10 and 15 years

Sources: PT.ASA

The specialists were required to possess at least five years of experience or more, ensuring precision in their specialization and ongoing experience [83]. Then this paper includes the production manager, raw material procurement supervisor and team, and the warehouse supervisor and team. These managers and teams have been with similar firms for over 15 years. So, the answers they provided are regarded as legitimate. Tables 2 and 3 show the input and output from the Delphi stages and the criteria's convergence evaluation. If the standard deviation is less than 1.5 and the interquartile range is less than 2.5, the instrument is said to converge. Table 4 shows seven supplier selection parameters: reject, delivery, price, communication, complaint procedure, service, and flexibility.

3.2. Criteria weighting

The next stage is to acquire expert preferences. Finally, the average expert assessments are calculated. Sort the criteria in ascending order of significance. Because the preference indicator for the first criterion is 0, it is clear what the decision-makers desire for the second most important criterion. The technique is repeated until the least significant condition is met. These preferences are based on a pairwise comparison of this specific criterion and the first criterion, with the ratio of this comparison derived and designated as S_i. Use Eq. (1) to generate pairwise efficiency standards K_i. Pairwise comparisons show how significant each element is to the central and most crucial component. Eq. (2) yields relative weights (q_i) depending on the pairwise efficiency of the significance criterion ranking. Eq. (3) is used to calculate final weights (W_i). The SWARA results are reported in Table 4.

The initial stage in MEREC is to generate a decision matrix using Eq. (4); the results are shown in Table 5. The factors in Table 5 are separated into two categories: advantageous criteria and non-beneficial criteria. Non-beneficial criteria include delivery, pricing, and rejection.

Communication, service, adaptability, and a complaint system are all valuable characteristics. The advantageous criteria are normalized using Eq. (5), while the remaining criteria are normalized with Eq. (6). The results are shown in Table 6. The next step is calculating the alternatives' overall performance by removing each criterion from Eq. (7) and (8). The results may be seen in Table 7. The elimination effect of each criterion is calculated with Eq. (9), and the results are shown in Table 8. The weight of the MEREC criterion (Eq. (10)) is balanced against the weight of the SWARA criteria (Eq. (3)) using Eq. (11). Table 9 and Fig. 2 provides a summary of the criteria weights.

The numbers in Figure 2 show the criteria weights. The greater the value of weight, the higher its priority. The difference in criteria weights obtained through various weighing procedures highlights the importance of these strategies. The highest criteria weights from MEREC are flexibility and service, followed by reject and delivery criteria. The highest weights from SWARA are rejected and delivered with values of 0.182 and 0.166, respectively. After a compromise, the highest weights were rejected and delivered. The weighing findings obtained utilizing the compromise technique are consistent with the company's (PT. ASA) conditions, prioritizing the reject and delivery criteria with values of 0.432 and 0.262, respectively. This has a considerable impact on the order of the options.

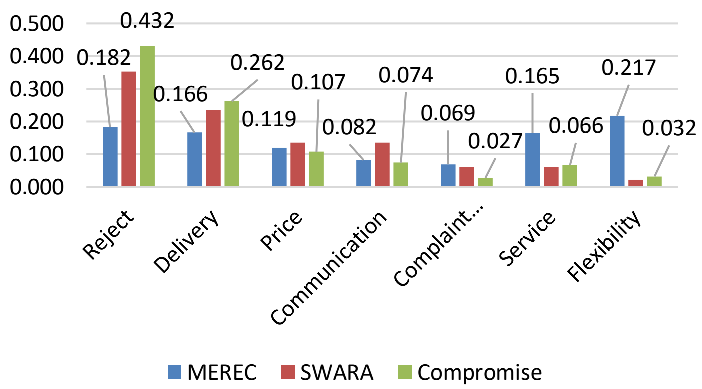

Fig. 2. Comparison of the weighting method

The results demonstrated that the specialized rejection factor is the most critical in evaluating the material supplier, weighing 46.9%, followed by delivery, price, service, complaint procedure, flexibility, and communication. Proven experience in the company is the most critical criterion, with a weight of almost 50%, followed by delivery, with a weight of 28.3%. As the company specializes in leather, it produces sensitive products. Rembang and Kediri should be selected as the best option according to the results of Table 11. Both suppliers have the highest weight due to proven experience and knowing the company's requirements, with utility indexes of 0.88153 and 0.88032, respectively. Their reject material is the lowest, with 0.06 and 0.07, respectively (See Table 4). The company focuses on a specialized rejection factor when selecting its material supplier, even though its objective is to reduce the supply chain cost to ensure that its customers are satisfied and get the best service.

3.3. Suppliers evaluation

This level involves evaluating suppliers using ARAS. In this procedure, the decision matrix is created using Eq. (4) and then normalized with Eq. (12) for the benefit criterion and Eq. (13) for the non-benefit requirements. The normalized matrix is multiplied by the weighting criterion matrix derived from the SWARA and MEREC compromise, as shown in Eq. 14. The optimality function (S_i) value is calculated using Eq. (15). Tables 10, 11, and 12 show the outcomes for each stage of the ARAS process. Table 12 shows the final results.

On analyzing the Head-to-Head data, it is observed that Rembang's higher weightage (Table 12) is mainly due to its performance in the reject criterion, while Kediri performed better in other criteria (Table 5). These factors are significant in reality. Hence, management focuses on rejecting material. So, Rembang is considered the better choice. Supplier ranking is determined by utility index. So, based on Table 12, the supplier rankings are Rembang, Kediri, Jombang, Cirebon, Wonogiri, Cianjur, Lumajang, and Sidoarjo.

3.4. Sensitivity analysis

A sensitivity analysis confirmed that the proposed model's conclusions were correct. Due to the possibility of changes, a sensitivity analysis was conducted. Human judgment directly impacts results; hence, they are subject to change. External considerations, such as politics, economy, social, natural disasters, etc, can influence the weights of the criterion. This part does a sensitivity analysis to determine the robustness of the ranking technique.

In this study, the total weightage of the supplier was determined by adjusting the weightage of each criterion individually. In contrast, the weights of all other criteria were allowed to fluctuate relative to each other. This is done to determine the critical points, which are the points at which the aggregate weightage of the suppliers varies for each criterion. The identification of critical points determines the robustness of the initial decision.

Sensitivity analysis concerning reject: Nine circumstances are chosen to do this, and the ranking is completed while considering the additional weights. Scenario 1 represents the currently researched scenario with the current weights. Scenario 2: The reject criteria weight increases by 2.5% from the initial weight while the other weights adjust. Scenario 3: The reject criteria weight increases by 5% from the initial weight while the other weights adjust. Scenario 4: The reject criteria weight increases by 7.5% from the initial weight while the other weights adjust. Scenario 5: The reject criteria weight increases by 10% from the initial weight while the other weights adjust. Scenario 6: The reject criteria weight increases by 12.5% from the initial weight while the other weights adjust. Scenario 7: The reject criteria weight increases by 15% from the initial weight while the other weights adjust. Scenario 8: The reject criteria weight increases by 17.5% from the initial weight while the other weights adjust. Scenario 9: The reject criteria weight increases by 20% from the initial weight while the other weights adjust. Scenario 10: The reject criteria weight increases by 22.5% from the initial weight while the other weights adjust. The result is mentioned in Fig.3. The ranking of suppliers will not change when the reject is 52.9%, increases by 22.5% from 43.18%, delivery is 24.589%, price is 9.09%, communication is 5.77%, complaint procedure is 1.13%, service is 4.99%, and flexibility is 1.55%. In conclusion, the sensitivity analysis regarding reject criteria reaffirms the reliability and robustness of our results. Regardless of the reject value, the ranked supplier remains unchanged, providing a reliable and stable basis for supplier evaluation.

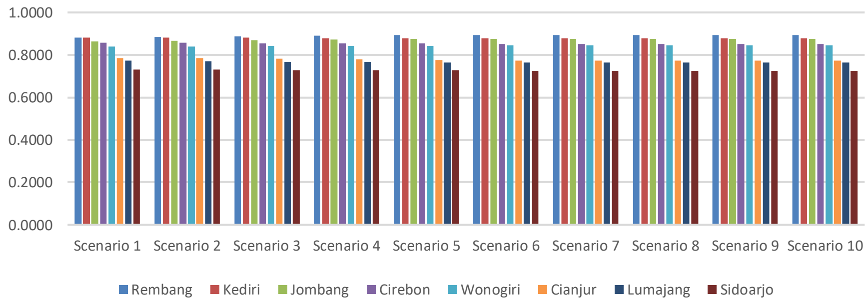

Fig. 3. Suppliers evaluation based on changes in reject criteria

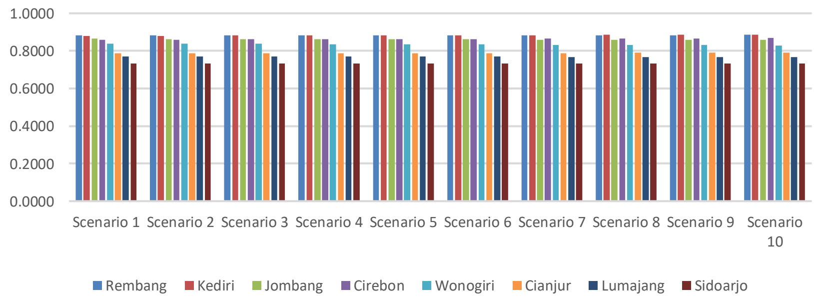

Fig. 4. Suppliers evaluation based on changes in delivery criteria

Sensitivity analysis concerning delivery, price, communication, complaint procedure, service, and flexibility criteria: The scenario constructed is the same as the sensitivity analysis concerning rejection criteria. The results are shown in Figures 4 to 9. Based on those figures, the sensitivity analysis regarding all criteria reaffirms the reliability and robustness of our results. Regardless of all criteria values, the ranked supplier remains unchanged, providing a reliable and stable basis for supplier evaluation.

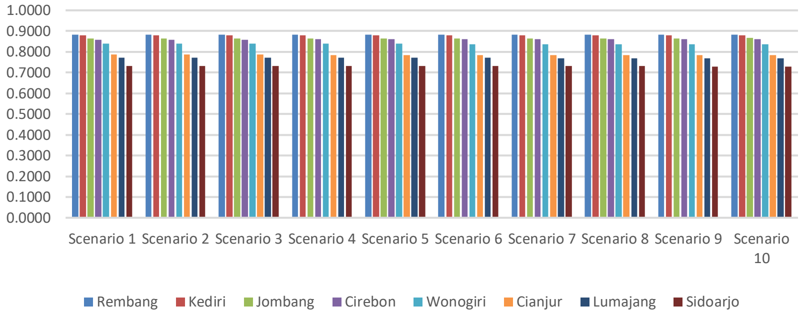

Fig. 5. Suppliers evaluation based on changes in price criteria

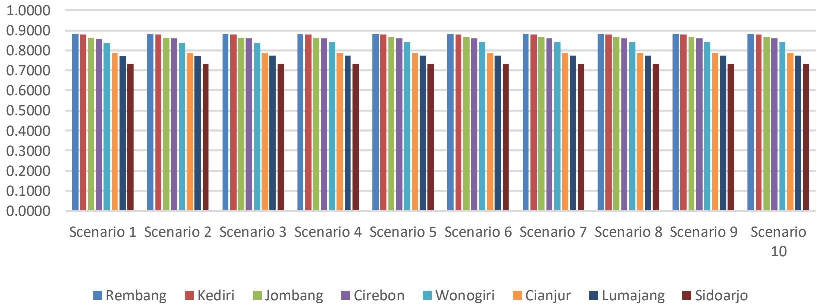

Fig. 6. Suppliers evaluation based on changes in communication criteria

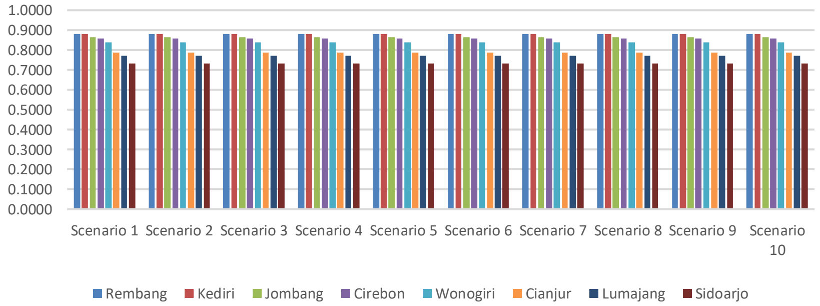

Fig. 7. Suppliers evaluation based on changes in complaint procedure criteria

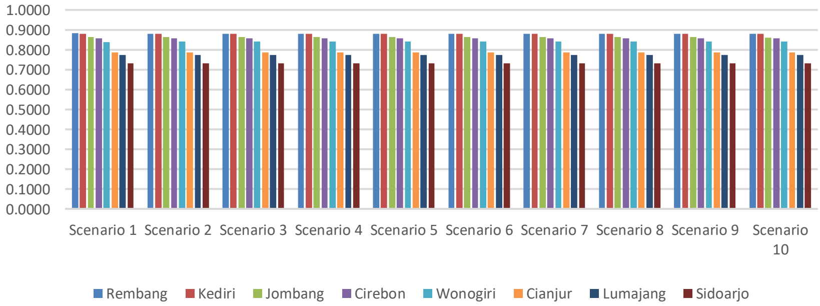

Fig. 8. Suppliers evaluation based on changes in service criteria

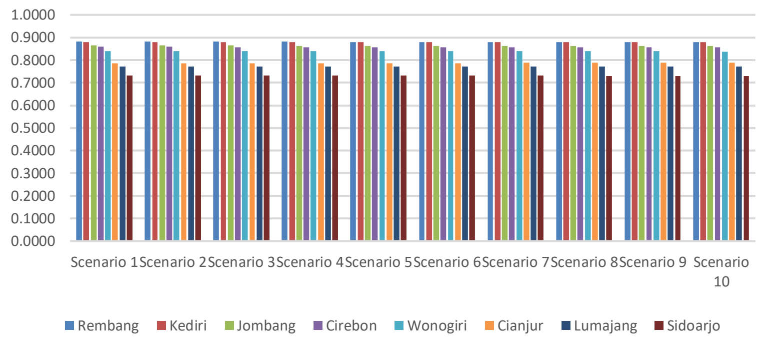

Fig. 9. Suppliers evaluation based on changes in flexibility criteria

3.5. Managerial implications.

The managerial implications of the case examined in this paper are substantial. This study employs the Delphi methodology to provide managers in Indonesia's leather industry with a comprehensive understanding of the factors that must be considered when selecting suppliers. The chosen approach also prioritizes the criterion. Managers can employ the hierarchical structure of the supplier selection methodology proposed in this study to rank the suppliers according to various factors and criteria. The sensitivity analysis conducted in this study also examines the impact of modifying the weights of requirements on the ranking of suppliers, which will assist managers in making informed decisions.

The managerial decision to choose Rembang as the optimal supplier is both robust and appropriate. In conventional times, the cost is regarded as a substantial factor, necessitating minimal consideration for rejection, whereas other factors are assigned a specific degree of significance. Nevertheless, as in Indonesia, leather products are indispensable during the tropical season, and the manager must guarantee that their production is operational. Additionally, the manager should not be concerned with the cost and other factors, as they have been relegated to the background due to the high demand and the product's importance to the organization's survival. The reject criterion must be prioritized to guarantee the smooth operation of the production process. Accordingly, the supplier with a superior rejection rate should be prioritized and regarded as the primary option, regardless of their performance in other areas.

This method will also help managers divide intricate issues into more manageable hierarchies. After several months of implementation, the case company observed a 5% decrease in incoming rejections, a clear indication of the effectiveness of the proposed methodology. The management of the case companies is fully committed to implementing the supplier ranking identified in this paper and distributing orders under their ranking. This commitment is a testament to their confidence in the methodology's efficacy, reassuring other industry managers. Underfeed needs to be made aware of their ranking.

4. Conclusion

The organization's supply chain efficacy is contingent upon selecting an appropriate supplier. It facilitates the timely and cost-effective fulfillment of customer demands, ensuring customer satisfaction. Using Indonesia as an illustration, this paper suggests a model for evaluating Indonesia's suppliers in the leather industry. The multi-criteria decision-making instrument was implemented due to the problem's complexity. It was chosen and ranked during this procedure. Lastly, sensitivity analysis is implemented to investigate the impact of altering the weights of the primary criteria on the ranking of suppliers. This method offers the advantages of dividing the intricate problem into a more uncomplicated hierarchy and reducing the inconsistency of the decision-making judgments. The main criterion weights' range of change was identified through sensitivity analysis, while the ranking of suppliers remained stable.

The authors need to be made aware of the extant literature on supplier selection and concentrate on issues related to suppliers in a developing country. Indonesia's leather industry has experienced significant development over the past five years and is experiencing a boom. This investigation assisted a case company in decreasing its rejection rate during incoming inspections. The management of this organization is firmly persuaded of the efficacy of our proposed methodology, which is both straightforward to execute and compelling. They verified the efficacy and complexity of our proposed approach. Supplier selection may be contingent upon qualitative or quantitative variables. The evaluation of the factors that are essential for the choice of a supplier involves numerous qualitative concerns. Communication and service were among the factors that were challenging to quantify in our study.

Various hybrid techniques can address this disparity, including fuzzy Delphi, fuzzy SWARA, and fuzzy ARAS. In the future, it is possible to examine a variety of supply chain sectors and conduct a comprehensive comparison, emphasizing the obstacles associated with selecting suppliers for these distinct sectors. Additionally, supplier selection may be related to order-splitting strategies.

Tab. 2. Assessment of criteria.

No	Criteria	Respondent										Mean	Deviation standard
		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

Tab. 3. Results of the delphi.

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

Tab. 4. Results of the SWARA.

No	Criteria	Code	Mean	Rating	Relative value of interest level (S_j)	Coefficient of criteria (K_j)	Initial weighting (q_j)	Final weighting of criteria (W_j)
1	Reject	A1	4.782	1		1.000	1.000	0.354
2	Delivery	A2	4.573	2	0.500	1.500	0.667	0.236
3	Price	A3	4.345	3	0.750	1.750	0.381	0.135
4	Communication	A4	4.156	4	1.000	2.000	0.381	0.135
5	Complaint procedure	A5	4.129	5	1.250	2.250	0.169	0.060
6	Service	A6	3.622	6	1.500	2.500	0.169	0.060
7	Flexibility	A7	3.515	7	1.75	2.75	0.062	0.022
	Mean			4	Sum		2.829	1

Tab. 5. Decision matrix.

No	Supplier	Criteria						
		Reject*	Delivery^	Price^	Communi Cation**	Complaint procedure**	Service**	Flexibility**
1	Cianjur	0.090	4.40	80	70	86	80	95
2	Kediri	0.070	4.20	70	70	90	70	80
3	Lumajang	0.085	5.20	80	80	78	80	90
4	Cirebon	0.080	4.00	60	75	82	70	65
5	Jombang	0.060	5.60	70	70	92	60	55
6	Wonogiri	0.065	5.80	80	70	86	90	70
7	Sidoarjo	0.090	5.00	85	70	80	70	60
8	Rembang	0.060	4.80	75	65	80	60	55

*Data sources: PT. ASA

**Data sources: processed questionnaire data

Tab. 6. Decision matrix normalized of the MEREC.

No	Supplier	Criteria						
		Reject	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

Tab. 7. Suppliers' performance by deleting each criterion.

No	Supplier	Criteria						
		Reject	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

Tab. 8. The elimination effect of each criterion.

No	Supplier	Criteria						
		Reject	Delivery	Price	Communi cation	Complaint procedure	Service	Flexibility
1	Cianjur	0.000	0.034	0.000	0.000	0.008	0.036	0.069
2	Kediri	0.031	0.040	0.016	0.000	0.003	0.019	0.046
3	Lumajang	0.007	0.013	0.000	0.016	0.020	0.036	0.062
4	Cirebon	0.014	0.046	0.035	0.008	0.014	0.019	0.020
5	Jombang	0.055	0.005	0.018	0.000	0.000	0.000	0.000
6	Wonogiri	0.041	0.000	0.000	0.000	0.008	0.052	0.030
7	Sidoarjo	0.000	0.020	0.008	0.000	0.019	0.021	0.012
8	Rembang	0.053	0.024	0.008	0.009	0.018	0.000	0.000

Tab. 9. The summary of the criteria weight.

No	Method	Criteria weight						
		Reject	Delivery	Price	Communi cation	Complaint procedure	Service	Flexibility
1	MEREC	0.199	0.180	0.084	0.034	0.089	0.179	0.236
2	SWARA	0.354	0.236	0.135	0.135	0.060	0.060	0.022
3	Compromise	0.469	0.283	0.076	0.030	0.036	0.071	0.034

Tab. 10. Decision matrix normalized of the ARAS.

No	Supplier	Criteria						
		Reject	Delivery	Price	Communi cation	Complaint procedure	Service	Flexibility
1	Cianjur	0.1321	0.1304	0.1339	0.1231	0.1201	0.1343	0.1429
2	Kediri	0.0881	0.1186	0.1004	0.1077	0.1123	0.1194	0.1429
3	Lumajang	0.1132	0.1242	0.1147	0.1077	0.1175	0.1045	0.1203
4	Cirebon	0.0933	0.1003	0.1004	0.1231	0.1018	0.1194	0.1353
5	Jombang	0.0991	0.1304	0.1339	0.1154	0.1070	0.1045	0.0977
6	Wonogiri	0.1321	0.0932	0.1147	0.1077	0.1201	0.0896	0.0827
7	Sidoarjo	0.1219	0.0899	0.1004	0.1077	0.1123	0.1343	0.1053
8	Rembang	0.0881	0.1043	0.0945	0.1077	0.1044	0.1045	0.0902

Tab. 11. Decision matrix weighted of the ARAS.

No	Supplier	Criteria						
		Reject	Delivery	Price	Communi cation	Complaint procedure	Service	Flexibility
1	Cianjur	0.05705	0.03417	0.01433	0.00909	0.00330	0.00887	0.00453
2	Kediri	0.03803	0.03106	0.01075	0.00795	0.00309	0.00789	0.00453

3	Lumajang	0.04890	0.03254	0.01229	0.00795	0.00323	0.00690	0.00381
4	Cirebon	0.04027	0.02628	0.01075	0.00909	0.00280	0.00789	0.00429
5	Jombang	0.04279	0.03417	0.01433	0.00852	0.00294	0.00690	0.00310
6	Wonogiri	0.05705	0.02441	0.01229	0.00795	0.00330	0.00592	0.00262
7	Sidoarjo	0.05266	0.02356	0.01075	0.00795	0.00309	0.00887	0.00334
8	Rembang	0.03803	0.02733	0.01012	0.00795	0.00287	0.00690	0.00286

Tab. 12. Overall performance index, utility index, and ranking of suppliers.

No	Supplier	Overall performance index	Utility index	Ranking suppliers
1	Cianjur	0.10330	0.78649	6
2	Kediri	0.11562	0.88032	2
3	Lumajang	0.10137	0.77179	7
4	Cirebon	0.11275	0.85846	4
5	Jombang	0.11353	0.86440	3
6	Wonogiri	0.11022	0.83921	5
7	Sidoarjo	0.09607	0.73145	8
8	Rembang	0.11578	0.88153	1

5. Conflict of Interest

The authors declare no conflict of interest.

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