



A Hybrid TOPSIS–PIV Method with Compromise Weighting of SWARA and MEREC for Supplier Selection in the Indonesian Leather Industry

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Abstract

Supplier selection constitutes a critical decision in the leather industry, as supplier performance directly influences material quality, production continuity, cost, and product competitiveness. Nevertheless, supplier evaluation in this sector involves multiple, often conflicting criteria, which complicates efforts to obtain reliable rankings through a single weighting or ranking method. Existing approaches tend to rely either on subjective expert judgments or objective data characteristics, neither of which fully captures the complexity inherent in supplier selection. This study addresses this gap by offering an integrated supplier selection framework that combines subjective and objective weighting with complementary ranking techniques. The proposed framework integrates the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Proximity Indexed Value (PIV) methods with a compromise weighting scheme derived from the Stepwise Weight Assessment Ratio Analysis (SWARA) and the Method based on the Removal Effects of Criteria (MEREC). The Delphi method identifies and validates the supplier evaluation criteria. A case study in an Indonesian leather manufacturing company demonstrates the framework's applicability. The findings indicate that the hybrid approach yields consistent supplier rankings and facilitates more robust decision-making by integrating expert judgments with objective data characteristics. The proposed framework thus offers a practical and reliable decision-support tool for supplier selection in the leather industry.

Keywords *Supplier selection, MEREC, SWARA, TOPSIS, PIV*

INTRODUCTION

Raw materials are a fundamental component of manufacturing systems, and supplier performance directly affects product quality, delivery reliability, and organizational competitiveness (Akhtar, 2023; Ristono et al., 2024b). Consequently, supplier selection has become one of the most critical strategic decisions in supply chain management (Gupta et al., 2019; Ristono, 2025). PT. Adi Satria Abadi (PT. ASA), one of Indonesia's largest leather glove manufacturers, faces persistent supplier-related problems, including inconsistent product quality, delivery delays, and price dissatisfaction (Ristono, 2024b; Ristono et al., 2024; Wahyuningsih et al., 2022). These issues highlight the need for a more effective supplier evaluation and selection system to improve supply chain performance.

Supplier selection is widely recognized as a multi-criteria decision-making (MCDM) problem (Ristono et al., 2018a, 2018b, 2021). Numerous studies have applied methods such as TOPSIS, PIV, and AHP because they effectively evaluate multiple alternatives (Ristono, 2024a). TOPSIS is appreciated for its simplicity and computational efficiency (Anam et al., 2022; Rahman et al., 2022; Sharma et al., 2022), whereas PIV has demonstrated greater stability and better resistance to rank reversal (Ristono, 2025; Ristono et al., 2026b). Similarly, AHP has been extensively used to determine criteria weights (Çelikkilek & Tüysüz, 2020), although it requires numerous pairwise comparisons and becomes less efficient as the number of criteria increases (Ali et al., 2023; Galik et

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al., 2022).

To overcome these limitations, recent studies have proposed alternative weighting approaches. SWARA provides a simpler subjective weighting process with fewer comparisons (Keshavarz-Ghorabae, 2021; Ristono et al., 2020; Ristono et al., 2024a), while MEREC is a promising objective weighting method that offers higher accuracy than several conventional objective weighting techniques (Ayan et al., 2023; Cheng et al., 2023). Nevertheless, relying solely on subjective or objective weighting may introduce bias (Mishra et al., 2022; Mukhametzyanov, 2021), making a compromise weighting strategy more appropriate for supplier evaluation (Debnath et al., 2023; Ecer & Aycin, 2023; Ristono et al., 2026a).

Another limitation of previous supplier selection studies is that they primarily focus on ranking suppliers while paying less attention to systematically identifying evaluation criteria (Behera & Beura, 2023; Bingol, 2022; Ecer & Pamucar, 2022; Goswami et al., 2022). Because selection criteria significantly influence the final decision (Koskey et al., 2023), this study first uses the Delphi method to identify and validate supplier evaluation criteria through expert consensus (Debnath et al., 2023; Hue & Oanh, 2023; Karamaşa et al., 2021). Subsequently, SWARA determines subjective weights, MEREC provides objective weights, and both are integrated into a compromise weighting scheme. The study then ranks suppliers using TOPSIS and PIV, and aggregates the results with the Borda count method to improve decision robustness (Drumm et al., 2022; Ecer & Pamucar, 2022; Laupichler et al., 2023).

Therefore, this study proposes an integrated supplier selection framework that combines Delphi, SWARA, MEREC, TOPSIS, PIV, and the Borda count method. Using the Indonesian leather industry as a case study, the proposed framework aims to provide a more comprehensive, reliable, and robust decision-making approach for supplier evaluation and selection.

LITERATURE REVIEW

Research is essential to lower the organization's likelihood of disappointment while selecting suppliers (Israel et al., 2023). Supplier selection is one of the problems in multi-criteria decision-making (MCDM); as a result, a number of MCDM techniques have been applied in supplier selection research, including the Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) (Ristono et al., 2021) and Proximity Indexed Value (PIV) (Ristono, 2025). TOPSIS has the following advantages: the computational procedure is straightforward (Kahraman et al., 2009; Shih et al., 2001), relatively simple (García-Cascales & Lamata, 2012; Ginting et al., 2017), quick and applicable (García-Cascales & Lamata, 2012; Vladimirovna-Kochkina et al., 2017), easy to understand (Komlan, 2016; Safari et al., 2014), comprehensible and rational (Başdar & Alper, 2017), and efficient in high computational (Olson, 2004; Yeh, 2002). The comparison TOPSIS incorporates weights (García-Cascales & Lamata, 2012), simplicity (Wang et al., 2017), comprehensibility (Yeh, 2002), practicality for ranking and selection (Eraslan, 2015), and conciseness and systematization (Wang, 2018). Because of its advantages, TOPSIS reduces current limitations (Galik et al., 2022); nonetheless, it is frequently used in MCDM situations (Çelikkbilek & Tüysüz, 2020). The literature states that MCDM problems are frequently solved using the TOPSIS method (Bingol, 2022).

However, when it comes to rank reversal, PIV performs better than TOPSIS (Mufazzal & Muzakkir, 2018) because of its greater stability and consistency and lack of rank reversal (Behera & Beura, 2023; Goswami et al., 2022). Compared to other approaches, PIV is a dependable MCDM tool that produces more precise and accurate results (Behera & Beura, 2023; Goswami et al., 2022). Lastly, PIV is a new and effective method for comparing options (Bingol, 2022). This benefit has led to widespread recognition and interest among scholars across numerous fields (Khan et al., 2019; Yahya et al., 2019). Additionally, numerous previous studies have shown that PIV yields better,

more dependable, and rank-reversal final results than conventional techniques such as AHP, VIKOR, TOPSIS, and COPRAS ([Goswami et al., 2022](#)). The authors used TOPSIS and PIV to select leather suppliers in the Indonesian leather sector for these reasons. For detailed TOPSIS steps, please see [Azimifard et al. \(2018\)](#) and [Jain et al. \(2018\)](#). For detailed PIV steps, please see [Ristono et al. \(2026b\)](#) and [Mufazzal and Muzakir \(2018\)](#).

However, the TOPSIS and PIV approaches depend on criterion weights ([Ristono et al., 2024a](#)). A popular weighting method for selecting suppliers is the Analytical Hierarchy Process (AHP) ([Ristono et al., 2020](#)). AHP benefits include checking for inconsistency, universality, and reduced subjectivity when human input is included ([Vladimirovna-Kochkina et al., 2017](#)). Consequently, it was designed using the TOPSIS technique and AHP for supplier evaluation. [Azimifard et al. \(2018\)](#) employ TOPSIS to identify sustainable suppliers after considering AHP throughout the selection process. [Cinnirella et al. \(2022\)](#) use a combination of AHP and TOPSIS to assess environmentally responsible waste management organizations. [Menon and Ravi \(2022\)](#) employed AHP and TOPSIS to evaluate supplier sustainability in an electronics supply chain. [Marzouk and Sabbah \(2021\)](#) used AHP and TOPSIS to evaluate suppliers in the building business. [Jain et al. \(2018\)](#) used AHP and TOPSIS to identify leading providers that meet Indian automotive norms. [Singh et al. \(2018\)](#) used AHP and TOPSIS to assess supplier performance for Indian start-ups.

Nonetheless, AHP still has several disadvantages, including the need for extensive baseline data and a narrow scale range ([Vladimirovna-Kochkina et al., 2017](#)). Compared with AHP, the Stepwise Weight Assessment Ratio Analysis (SWARA) approach is more effective for evaluating criteria ([Keršulienė et al., 2010](#)). SWARA requires fewer pairwise comparisons and significantly fewer computing resources than AHP ([Stanujkic et al., 2015](#)). It also simplifies the method ([Karabasevic et al., 2016](#)). Many criterion weighting methods require greater accuracy but are unduly complicated to calculate ([Aghdaie et al., 2014](#)). However, SWARA can be more sophisticated while maintaining high accuracy ([Zolfani & Saparauskas, 2013](#)). The SWARA method's most notable characteristic is its capacity to measure experts' judgments on the significance ratio of qualities while estimating their weights ([Zolfani & Saparauskas, 2013](#)). Experts can use their information, experiences, and implicit knowledge in SWARA ([Mardani et al., 2017](#)). For the SWARA calculation steps, please see [Keršulienė et al. \(2010\)](#).

In subjective methods such as SWARA, the decision-maker sets the criteria weights ([Keshavarz-Ghorabae et al., 2021](#)). Because of this, subjective weighting requires skilled experts with a thorough grasp of relevant theory and practical experience ([Zavadskas & Podvezko, 2016](#)). Meanwhile, objective criterion weights can define each criterion's degree of dominance, and the data structure, or the criteria values, can be considered throughout the evaluation process ([Zavadskas & Podvezko, 2016](#)). These methods' primary drawback is that they become ineffective as the number of criteria rises ([Ristono et al., 2025](#)). In other words, decision-makers must convey their preferences through their thinking, and adding more criteria reduces the accuracy of those choices ([Alfares & Duffuaa, 2016](#)). Selecting a weighting system is crucial when choosing a provider ([Ayan et al., 2023](#)) because criterion weights strongly affect the review results and must be considered ([Ginevičius, 2011](#)).

Therefore, professionals may need assistance in delivering reliable information on alternative solution choices in certain practical circumstances because factors such as the objective environment, professional level, and time influence the results ([Cheng et al., 2023](#)). Consequently, this study combined an objective attribute-weight determination method, which derives attribute weights directly from evaluation data, with a subjective weight ([Ristono et al., 2026b](#)). The compromised weighing method aims to compensate for the shortcomings of subjective weights or reduce the potential bias of a single subjective or objective weight ([Mukhametzyanov, 2021](#)). An

objective weighting method is based on the Removal Effects of Criteria (MERECE). MERECE is a relatively recent method of weight evaluation (Mishra et al., 2022). Compared to entropy and CRITIC, MERECE is a more accurate, exact, and useful objective weighting technique (Goswami et al., 2022). For this reason, MERECE and related techniques are more appropriate for figuring out the objective weights of the relevant criteria (Debnath et al., 2023; Ristono et al., 2026a). Nonetheless, MERECE has been used in a few investigations (Ecer & Aycin, 2023).

RESEARCH METHOD

This study used an integrated multi-criteria decision-making (MCDM) framework to evaluate and select suppliers for an Indonesian leather manufacturing company. The research consisted of five sequential stages.

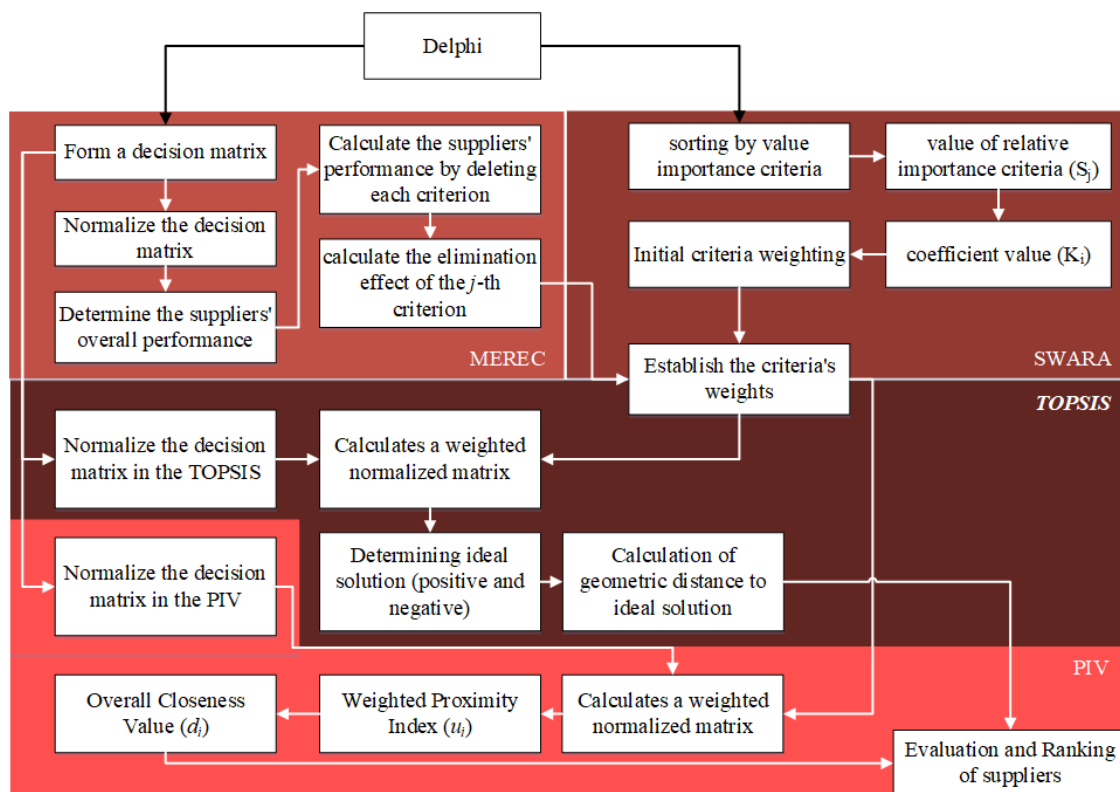


Figure 1. Structure of the proposed method

First, the study identified supplier evaluation criteria from relevant literature and validated them through the Delphi method based on expert judgments. The validated criteria were then weighted using two complementary approaches: the Stepwise Weight Assessment Ratio Analysis (SWARA) to obtain subjective weights and the Method based on the Removal Effects of Criteria (MERECE) to determine objective weights from supplier performance data. The SWARA and MERECE weights were then integrated using a compromise weighting approach to combine expert preferences and the information in the decision matrix. In the third stage, the compromise weights and supplier performance data were used to rank eight supplier alternatives using two complementary MCDM methods: Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Proximity Indexed Value (PIV). TOPSIS determines supplier preference based on relative closeness to the positive and negative ideal solutions, whereas PIV evaluates each supplier's proximity to the best-performing condition. Finally, the TOPSIS and PIV rankings were

aggregated using the Borda count method to produce a consensus final ranking. Figure 1 illustrates the overall methodological framework.

FINDINGS AND DISCUSSION

The Delphi method identified six supplier evaluation criteria: Reject, Price, Communication, Service, Complaint Procedure, and Flexibility (Table 1). These criteria represent both operational and relational aspects of supplier performance (Table 2), which are important in multi-criteria supplier selection decisions (Galik et al., 2022). The experts subsequently evaluated the relative importance of the criteria using SWARA. SWARA systematically transforms expert judgments into criterion weights (Debnath et al., 2023; Ristono et al., 2026a). However, because subjective weighting may be influenced by expert perceptions, MEREC was incorporated to determine objective criterion importance (Tables 3 and 4) based on the effect of removing each criterion from the overall evaluation (Ecer & Aycin, 2023). The compromise weighting scheme obtained from SWARA and MEREC therefore combines managerial preferences with information contained in the supplier performance data. Table 5 presents the resulting weights.

The compromise weights were subsequently applied in TOPSIS and PIV to obtain complementary supplier rankings. TOPSIS evaluates alternatives based on their relative closeness to the positive and negative ideal solutions and is widely used for decision-making problems involving multiple, conflicting criteria (Çelikkilek & Tüysüz, 2020). The normalized decision matrix was weighted using the compromise weights, followed by determining the positive and negative ideal solutions, separation distances, and relative closeness coefficients. As shown in Tables 6–9, the TOPSIS results ranked Rembang first, followed by Kediri and Jombang. This result indicates that Rembang provides the most favorable overall performance when all evaluation criteria are considered simultaneously rather than based on a single criterion.

PIV was then applied using the same supplier evaluation data and compromise weights. Unlike TOPSIS, PIV evaluates alternatives based on their proximity to, or deviation from, the best-performing condition (Ristono et al., 2026b). A lower proximity value therefore indicates better supplier performance. The PIV results show that Kediri ranked first, followed by Rembang, Cirebon, and Jombang. The presence of Rembang and Kediri in the two highest positions in both TOPSIS and PIV provides evidence of consistency between the two complementary ranking approaches. Such consistency can strengthen the robustness of supplier evaluation by reducing dependence on a single MCDM technique (Cheng et al., 2023).

Because different MCDM methods may generate different rankings, the TOPSIS and PIV results were aggregated using the Borda count method. Researchers have applied ranking aggregation in MCDM to obtain a consensus ranking from multiple decision-making approaches (Mukhametzhanov, 2021). The TOPSIS ranking was Rembang, Kediri, Jombang, Wonogiri, Cirebon, Cianjur, Lumajang, and Sidoarjo, while the PIV ranking was Kediri, Rembang, Cirebon, Jombang, Wonogiri, Cianjur, Lumajang, and Sidoarjo. The Borda count produced the final ranking of Rembang, Kediri, Jombang, Wonogiri, Cirebon, Cianjur, Lumajang, and Sidoarjo. Rembang achieved the highest final position, while Kediri ranked second. Although the two suppliers obtained the same Borda score, the tie was resolved using their aggregated performance from TOPSIS and PIV. Overall, the results demonstrate that integrating SWARA–MEREC weighting with TOPSIS–PIV ranking provides a more comprehensive and robust framework for supplier selection in the leather industry.

Table 1. SWARA results

No	Criteria	Code	Mean	S_j	K_j	q_j	w_j
1	Delivery	A2	4.573	2	0.500	0.667	0.236
2	Reject	A1	4.782	1		1.000	0.354

No	Criteria	Code	Mean	S_j	K_j	q_j	w_j
3	Price	A3	4.345	3	0.750	0.381	0.135
4	Complaint procedure	A5	4.129	5	1.250	0.169	0.060
5	Communication	A4	4.156	4	1.000	0.381	0.135
6	Flexibility	A7	3.515	7	1.75	0.062	0.022
7	Service	A6	3.622	6	1.500	0.169	0.060

Table 2. Decision matrix

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

Table 3. Normalization of the decision matrix (MEREC)

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

Table 4. The suppliers' overall performance by deleting each criterion

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

Table 5. The weighting comparison of three methods

No	Weighting method	Criteria						
		Delivery	Quality	Price	Complaint procedure	Communication	Flexibility	Service
1	MEREC	0.180	0.199	0.084	0.089	0.034	0.236	0.179
2	SWARA	0.236	0.354	0.135	0.060	0.135	0.022	0.060
3	Compro-mise	0.283	0.469	0.076	0.036	0.030	0.034	0.071

Table 6. Positive and negative ideal solution

No	Ideal solution	Criteria						
		Delivery	Quality	Price	Complaint procedure	Communication	Flexibility	Service
1	Y ⁺	0.075	0.121	0.030	0.011	0.029	0.015	0.029
2	Y ⁻	0.109	0.181	0.030	0.011	0.024	0.008	0.019

Table 7. Geometric distance to the positive ideal solution

No	Supplier	Criteria							D_i^+
		Delivery	Quality	Price	Complaint procedure	Communication	Flexibility	Service	
1	Rembang	0.0002	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000
2	Sidoarjo	0.0004	0.0036	0.0002	0.0000	0.0000	0.0000	0.0000	0.0036
3	Wonogiri	0.0012	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
4	Jombang	0.0009	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000
5	Cirebon	0.0000	0.0016	0.0000	0.0000	0.0000	0.0000	0.0000	0.0016
6	Lumajang	0.0005	0.0025	0.0001	0.0000	0.0000	0.0000	0.0000	0.0025
7	Kediri	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004
8	Cianjur	0.0001	0.0036	0.0001	0.0000	0.0000	0.0000	0.0000	0.0036

Table 8. Geometric distance to negative ideal solution

No	Supplier	Criteria							D_i^-
		Delivery	Quality	Price	Complaint procedure	Communication	Flexibility	Service	
1	Rembang	0.0004	0.0036	0.0001	0.0000	0.0000	0.0000	0.0000	0.0036
2	Sidoarjo	0.0002	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
3	Wonogiri	0.0000	0.0025	0.0001	0.0000	0.0000	0.0000	0.0001	0.0025
4	Jombang	0.0000	0.0036	0.0000	0.0000	0.0000	0.0000	0.0000	0.0036
5	Cirebon	0.0012	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004
6	Lumajang	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
7	Kediri	0.0009	0.0016	0.0000	0.0000	0.0000	0.0000	0.0000	0.0016
8	Cianjur	0.0007	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000

Table 9. Preference for each supplier

	Supplier	D_i^+	D_i^-	$D_i^+ + D_i^-$	V_i	Rank
1	Rembang	0.02112	0.06365	0.08477	0.75084	1
2	Sidoarjo	0.06508	0.02003	0.08511	0.23536	8
3	Wonogiri	0.03718	0.05222	0.08940	0.58412	4
4	Jombang	0.03284	0.06066	0.09350	0.64876	3
5	Cirebon	0.04102	0.03979	0.08081	0.49236	5
6	Lumajang	0.05614	0.02080	0.07694	0.27031	7
7	Kediri	0.02243	0.05079	0.07322	0.69369	2
8	Cianjur	0.06179	0.02967	0.09146	0.32439	6

Table 10. WPI, overall closeness value, and rank

No	Supplier	Criteria							d_i	Rank
		Delivery	Quality	Price	Complaint procedur e	Communi cation	Flexib ility	Service		
1	Rembang	0.015	0.000	0.008	0.001	0.005	0.006	0.010	0.045	2
2	Sidoarjo	0.019	0.060	0.013	0.001	0.004	0.005	0.006	0.109	8
3	Wonogiri	0.034	0.010	0.010	0.001	0.004	0.004	0.000	0.062	5
4	Jombang	0.030	0.000	0.005	0.000	0.004	0.006	0.010	0.055	4
5	Cirebon	0.000	0.040	0.000	0.001	0.002	0.005	0.006	0.054	3
6	Lumajang	0.023	0.050	0.010	0.002	0.000	0.001	0.003	0.088	7
7	Kediri	0.004	0.020	0.005	0.000	0.004	0.002	0.006	0.041	1
8	Cianjur	0.008	0.060	0.010	0.001	0.004	0.000	0.003	0.085	6

Table 11. Borda count for each supplier

No	Supplier	Supplier weight			Rank		Borda count			
		TOPSIS	PIV	Total	TOPSIS	PIV	Borda	TOPSIS	PIV	Total
1	Rembang	0.751	0.882	1.632	1	1	1	7	7	14
2	Sidoarjo	0.235	0.731	0.967	8	8	8	0	0	0
3	Wonogiri	0.584	0.839	1.423	4	5	4	4	3	7
4	Jombang	0.649	0.864	1.513	3	3	3	5	5	10
5	Cirebon	0.492	0.858	1.351	5	4	5	3	4	7
6	Lumajang	0.270	0.772	1.042	7	7	7	1	1	2
7	Kediri	0.694	0.880	1.574	2	2	2	6	6	12
8	Cianjur	0.324	0.786	1.111	6	6	6	2	2	4

CONCLUSIONS

This study developed an integrated framework for supplier evaluation and selection in the Indonesian leather industry. The framework combines Delphi for criteria identification, SWARA and MEREC for subjective and objective weighting, and TOPSIS and PIV for supplier ranking. The Borda count method was then used to obtain a consensus ranking. The results identified Rembang as the best supplier, followed by Kediri and Jombang, demonstrating the proposed framework's applicability in supporting supplier selection decisions.

LIMITATIONS & FURTHER RESEARCH

This study is limited to a single leather manufacturing company and a specific set of supplier evaluation criteria, which may limit the generalizability of the findings. Future research should validate the framework across multiple companies and incorporate sustainability, risk, and dynamic or fuzzy criteria.

Future research can extend the proposed framework by incorporating additional supplier evaluation criteria, such as sustainability, environmental performance, delivery reliability, and risk-related factors, to provide a more comprehensive assessment. Future studies may also validate the framework using data from multiple leather manufacturing companies or other manufacturing industries to examine its generalizability and robustness. In addition, fuzzy or dynamic MCDM approaches could be integrated to address uncertainty and changes in expert judgments and supplier performance over time.

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