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Decision Support System for Evaluating Textile Supplier Performance Based on Weights by Envelope and Slope and Mixed Aggregation by Comprehensive Normalization Technique for Multi-Criteria

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ABSTRACT

The textile industry is highly dependent on supplier performance in ensuring the quality of raw materials, timely delivery, price stability, and supply continuity. The complexity of supplier evaluation involving many criteria often leads to subjectivity and inconsistencies in decision-making when using conventional approaches. This study proposes a decision support system to evaluate textile supplier performance based on a combination of Weights by Envelope and Slope (WENSLO) and Mixed Aggregation by Comprehensive Normalization Technique for Multi-Criteria (MACONT). The WENSLO method is used to determine the weight of criteria objectively based on data distribution characteristics, while MACONT is applied to assess and rank supplier alternatives through a comprehensive normalization and aggregation process. The case study was conducted involving nine suppliers and five evaluation criteria, namely material quality, timeliness, price, supply capacity, and responsiveness. The results of the study indicate that the proposed model is capable of producing clear and stable supplier rankings, with Supplier A9, Supplier A7, and Supplier A2 occupying the top three positions. These findings demonstrate that the integration of WENSLO and MACONT can enhance the objectivity and consistency of decision-making, as well as provide a more reliable and relevant framework for evaluating textile suppliers to support data-driven supply chain management.

Keyword : Textile supplier evaluation; Decision Support System; WENSLO; MACONT; Multi-criteria decision making.

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1. INTRODUCTION

In the highly competitive and quality-sensitive textile industry, suppliers play a strategic role as the determinant of the sustainability of the production process and the company's competitiveness, particularly through consistent raw material quality, timely delivery, and price stability that can maintain cost efficiency(Alamoodi et al., 2024; Hashemi-Tabatabaei et al., 2025; Sundararaman et al., 2023). The quality of materials directly affects the final product quality and production defect rate, while timely delivery determines the smoothness of the production schedule and the company's ability to meet market demand. On the other hand, price stability is an important factor in controlling operational costs and reducing the risk of fluctuations that could disrupt long-term planning. However, evaluating suppliers in this context is not a simple task because it involves various interrelated criteria that are often conflicting, such as between competitive pricing and high-quality materials(Chakraborty et al., 2023; Sundararaman et al., 2023). This complexity requires an evaluation approach that can consider all criteria simultaneously and objectively, so that supplier selection decisions are not based solely on one dominant aspect, but reflect the supplier's overall performance within the framework of multi-criteria decision making.

Conventional approaches in evaluation and decision-making often face serious limitations due to high levels of subjectivity and the potential for inconsistent outcomes(Akbulut & Aydın, 2024; Barman et al., 2024; Y. Wang & Liu, 2025). Assessments that rely on intuition, personal experience, or the preferences of decision-makers tend to produce non-uniform criterion weights that are difficult to replicate, resulting in decisions that may vary even when the conditions and alternatives being evaluated are relatively the same. This subjectivity also opens the door to bias, whether conscious or unconscious, ultimately reducing the level of objectivity and fairness in the evaluation process(Mandal et al., 2025; Oprasto et al., 2025). Furthermore, without a structured analytical framework, conventional approaches often fail to maintain decision consistency when the number of criteria increases or when there are small changes in the data, making decisions unstable and less scientifically accountable.

This condition underscores the need for a multi-criteria decision making (MCDM) based decision support system (DSS) capable of providing evaluations that are objective and stable. An MCDM-based DSS is designed to process various criteria simultaneously using structured mathematical procedures, thereby reducing the dominance of subjectivity in determining weights and assessing alternatives(Katrancı et al., 2025; Otay et al., 2024). This approach enables more consistent decision-making because any changes in data or criteria weights can be analyzed systematically and transparently. Furthermore, an MCDM-based DSS supports decision stability by ensuring that ranking results do not change easily due to small fluctuations in input, making the decisions generated more reliable and relevant for application in complex and dynamic managerial contexts(Dua et al., 2024; Momena et al., 2024).

Although various objective weighting methods have been widely used in MCDM studies, exploration of the Weights by Envelope and Slope (WENSLO) method is still relatively limited, both in terms of theoretical development and empirical application(Kara et al., 2025; J. Wang et al., 2026). Most research tends to focus on more popular weighting methods such as Entropy, CRITIC, or ITARA, so the potential of WENSLO in capturing data characteristics through the envelope approach and the slope of changes in criterion values has not been extensively studied. The limited number of comparative studies involving WENSLO also results in a lack of understanding regarding the advantages, sensitivity, and stability of the weights generated when applied in various decision-making contexts. Consequently, WENSLO's contribution as an alternative objective weighting method that has the potential to improve the accuracy and consistency of decisions in MCDM-based decision support systems has not been fully explored, leaving significant opportunities for further research. The WENSLO method has several advantages that make it attractive as an objective weighting approach within the MCDM framework. WENSLO can capture variations and patterns of changes in criterion data more informatively through envelope value analysis and change slope, so the resulting weights not only reflect data distribution but also the sensitivity of each criterion to changes in alternative values(Subramanian et al., 2025; Yalçın et al., 2025). This approach helps to reduce the dominance of subjectivity since the weights are determined entirely based on the actual data characteristics, while also enhancing the consistency of results when applied to datasets with different levels of variability. Moreover, WENSLO is relatively flexible to be combined with various MCDM ranking methods, thereby contributing to more stable, transparent, and analytically accountable decision-making.

Mixed Aggregation by Comprehensive Normalization Technique for Multi-Criteria (MACONT) is a multi-criteria decision-making method designed to integrate the advantages of both additive and multiplicative aggregation approaches into a comprehensive evaluation framework. This method emphasizes a thorough normalization process of criterion data so that differences in scale and characteristics between criteria can be managed consistently before aggregation is carried out. By combining several forms of aggregation, MACONT is able to provide a more balanced assessment because it not only considers the absolute contribution of each criterion but also the proportional relationship between criteria in determining the performance of alternatives. This approach helps reduce result distortions that often occur when only one type of aggregation is used, as well as improve the stability and reliability of alternative rankings. Therefore, MACONT is widely regarded as a flexible and adaptive method in supporting decision support systems, especially in problems involving multiple criteria with varying levels of importance and data characteristics.

Most of the existing research on supplier performance evaluation still tends to rely on a single weighting approach, whether subjective or objective, so the ranking of alternatives often does not fully reflect the actual complexity of the various interacting criteria. Dependence on a single weighting method also makes evaluation results vulnerable to bias or data fluctuations, limiting the stability and consistency of supplier rankings. Furthermore, until now, there has been no integrated model that combines the WENSLO method with MACONT for supplier evaluation in the textile industry, even though this combination has great potential to leverage the strengths of each method: WENSLO in generating objective weights that are sensitive to data patterns, and MACONT in providing an ideal benchmark for comparing alternatives. This gap indicates a significant research gap, as the integrated model can provide a more comprehensive, stable, and objective evaluation framework, while also enabling more accurate and accountable decision-making in the context of complex supplier management.

This study makes a significant contribution by proposing a Decision Support System model that combines the WENSLO and MACONT methods, thereby providing a more comprehensive and data-driven evaluation framework in the context of selecting textile suppliers. By integrating WENSLO, the model can generate objective criteria weights based on data characteristics and change patterns, while MACONT is able to provide a more balanced assessment because it not only considers the absolute contribution of each criterion, but also the proportional relationship between criteria in determining the performance of alternatives. The combination of these two methods not only enhances the accuracy and consistency of evaluations but also reduces the subjectivity commonly encountered in conventional approaches, making the evaluation results more stable and accountable. Furthermore, this model provides a systematic framework for managers to make strategic decisions regarding supplier selection, allowing for a comprehensive identification of superior suppliers in terms of material quality, timeliness, and price stability, while also enhancing the effectiveness of supply chain management in the complex and dynamic textile industry.

2. RELATED WORK

Research related to supplier selection and supplier performance evaluation in the context of the textile and manufacturing industries using the MCDM approach has developed rapidly in recent years. These studies show various integrations of weighting methods and ranking strategies to support decision-making that is more robust and relevant to modern industry practices. One of the latest studies in the context of the textile industry is the selection of sustainable suppliers in the textile dyeing industry, which combines the SWARA method for weight determination and WASPAS for ranking alternatives. The results of this study show that the quality of chemicals is the dominant criterion in supplier evaluation, as well as sensitivity analysis that strengthens the validity of the proposed MCDM model results(Rahman et al., 2022).

Furthermore, the latest research published in 2025 builds a sustainable supplier evaluation framework by integrating the Triple Bottom Line (TBL) principle with the SWARA–TOPSIS approach. The study found that in addition to economic aspects such as quality and price, environmental and social sustainability indicators — such as environmental management systems and occupational health — are now increasingly important evaluation factors in the selection of textile suppliers(Sithi et al., 2025). In the context of local research, a strategic model for evaluating and selecting suppliers in the SME-scale textile industry was designed using AHP to determine the weighting of criteria such as product quality, cost, flexibility, and market demand responsiveness. The results indicate that MCDM-based decision-making can enhance the operational performance of SMEs in choosing suppliers that meet their core business needs(Putri et al., 2025).

Another relevant study combined DEMATEL to measure the relationships between criteria with ANP in the context of textile supplier selection in Indonesia, showing the importance of understanding the impact between criteria. For example, product price has the highest weight in decision-making, followed by specification suitability and quality consistency, which then affect the final supplier ranking based on the determined weights(Utama et al., 2021). In addition to empirical case studies, bibliometric studies also show an increasing research trend in the application of MCDM in sustainable supplier selection, covering aspects of quality, cost, delivery, and service. This confirms that supplier purchasing decisions are increasingly taking into account environmental and social dimensions, alongside traditional operational criteria(Khulud et al., 2023).

Overall, recent literature indicates a shift in the focus of MCDM research in supplier evaluation from merely quantitative considerations to the integration of sustainability characteristics and the relationships between criteria. This highlights the need for a more adaptive and comprehensive evaluation model, as proposed in this study, which integrates WENSLO weighting with MACONT for supplier performance in the textile industry.

3. MATERIAL AND METHOD

A. Framework of the Proposed DSS

The framework of the proposed DSS is designed as a conceptual foundation to integrate the supplier evaluation process systematically, objectively, and structurally within a complex decision-making environment. This framework illustrates the workflow starting from determining relevant evaluation criteria, processing supplier performance data, to applying analytical methods that support consistent assessment and ranking of alternatives. Through this framework, each stage of decision-making is designed to be interconnected and transparent, making it easier to trace the logic of evaluation and reduce the potential for subjective bias. With a clear DSS framework, the supplier evaluation process not only becomes more directed and replicable, but also capable of producing more stable and reliable decisions as a basis for determining supplier selection strategies in the textile industry. Figure 1 is the framework of the proposed DSS implemented in this study.

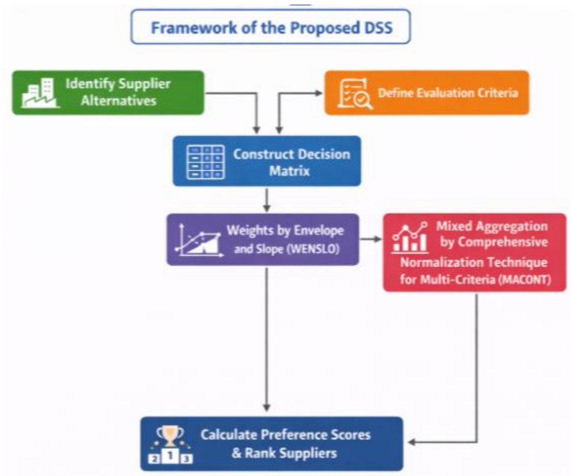

Figure 1. The framework of the proposed DSS

The framework of the proposed DSS is designed as an integrated, data-based evaluation flow to support the objective and stable selection of textile suppliers. The process begins with the identification of supplier alternatives and the establishment of relevant evaluation criteria, such as material quality, on-time delivery, and price stability. Next, supplier performance data is organized into a decision matrix and processed using the weights by envelope and slope (WENSLO) method to generate objective criteria weights based on data patterns and variations. The weights obtained are then used in the alternative evaluation stage with the Mixed Aggregation by Comprehensive Normalization Technique for Multi-Criteria (MACONT), where each supplier is providing a more balanced assessment because it does not only consider the absolute contribution of each criterion. The final stage produces preference values and supplier rankings as DSS outputs ready to be used by decision-makers. This framework ensures that each stage is carried out systematically, transparently, and consistently, thereby supporting more reliable decision-making in textile industry supplier management.

B. Weights by Envelope and Slope Method (WENSLO)

Weights by Envelope and Slope (WENSLO) is an objective weighting method used in this study to determine the importance level of each criterion based on the characteristics of the data being analyzed. This method works by utilizing the concept of value envelopes and the slope of changes between alternatives to capture variations and sensitivities of criteria more accurately. Through this analysis, WENSLO is able to identify criteria that have a more significant influence on performance differences among alternatives without involving subjective judgment from decision-makers. The application of WENSLO allows the weighting process to be conducted systematically and data-driven, resulting in weights that are more consistent and can be justified as a basis for calculations in the subsequent evaluation and ranking stages.

The steps of the WENSLO method begin with the formation of a decision matrix as shown in (1) to represent the performance of each alternative against all criteria. The next step is data normalization for each criterion based on (2) so that the values used are on a comparable scale. After that, the degree of data dispersion for each criterion is determined with reference to (3), which serves to capture the variation of values among alternatives. The next step is to determine the balancing parameters of the criteria based on (4) to reflect the characteristics of the data distribution. Furthermore, the intensity of changes in the values of each criterion is analyzed through the stages referred to in (5). The results from these stages are used to obtain the initial importance values of the criteria according to (6). In the final stage, the criteria weights are determined by normalizing these importance values as referred to in (7), resulting in the final weights ready to be used in the evaluation and decision-making process.

$$X = [x_{ij}]_{mxn} \quad (1)$$

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

$$\Delta Z_j = \frac{\max_j z_{ij} - \min_j z_{ij}}{1+3.322*\log(m)} \quad (3)$$

$$\varphi_j = \frac{\sum_{i=1}^{m} z_{ij}}{(m-1)*\Delta Z_j} \quad (4)$$

$$E_j = \sum_{i=1}^{m-1} \sqrt{\left(z_{i+1j} - z_{ij}\right)^2 + \Delta Z_j^{\,2}} \quad (5)$$

$$q_j = \frac{E_j}{\varphi_j} \quad (6)$$

$$w_j = \frac{q_j}{\sum_{j=1}^{n} q_j} \quad (7)$$

The $X = [x_{ij}]_{mxn}$ decision matrix serves as a representation of initial data containing the performance values of each alternative against each criterion. The symbol x_{ij} indicates the performance of the ith alternative on the jth criterion, while m and n represent the number of alternatives and the number of criteria used in the evaluation. The normalized value z_{ij} is used to express the proportion of each alternative's contribution to a criterion on a comparable scale. The parameter ΔZ_j serves as an indicator of the degree of value dispersion for the jth criterion. The symbol φ_j functions as a balancing factor that links the accumulation of criterion values with their dispersion level. The value E_j serves to describe the intensity of changes or the dynamics of values for the jth criterion. The parameter q_j serves as a measure of the initial relative importance of the jth criterion. The final weight w_j serves as the official level of importance for each criterion in the decision support system.

C. Mixed Aggregation by Comprehensive Normalization Technique for Multi-Criteria (MACONT)

Mixed Aggregation by Comprehensive Normalization Technique for Multi-Criteria (MACONT) is a multi-criteria decision-making method that combines additive and multiplicative aggregation approaches within a single integrated evaluation framework. This method is designed to assess the performance of alternatives more balancedly by considering both the absolute contribution and the proportional relationship between criteria, thereby representing complex evaluation conditions more accurately. The main advantage of MACONT lies in its ability to reduce biases that often arise when only one type of aggregation is used, improve the stability and consistency of ranking results, and provide flexibility in handling criteria with varying nature and levels of importance. With these characteristics, MACONT becomes a reliable and adaptive method to support data-driven decision support systems in multi-criteria problems.

The stages of MACONT begin with the preparation of a decision matrix that contains the performance values of each alternative against all criteria as the basis for evaluation using (1). The next stage is the normalization process using three different normalization techniques to ensure that data from various criteria are on a comparable scale and represent the data characteristics more comprehensively using (8)-(10). The results from these three processes are then combined to obtain the final normalization values that reflect the performance conditions of the alternatives comprehensively using (11). Next, the normalized values are processed through two aggregation mechanisms, namely comprehensive normalized aggregation using (7) and mixed max–min deviation aggregation using (8), to capture the total contribution of criteria as well as the variation in alternative performance. The final stage of MACONT produces a final comprehensive score using (9), which is used as the basis for determining preference values and ranking alternatives in the decision support system.

$$x_{ij}^{1} = \begin{cases} \dfrac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}; benefit\ criteria \\ \dfrac{\frac{1}{x_{ij}}}{\sum_{i=1}^{m} \frac{1}{x_{ij}}}; cost\ criteria \end{cases} \quad (8)$$

$$x_{ij}^2 = \begin{cases} \frac{x_{ij}}{\max x_{ij}}; benefit\ criteria \\ \frac{\min x_{ij}}{x_{ij}}; cost\ criteria \end{cases} \tag{9}$$

$$x_{ij}^3 = \begin{cases} \frac{x_{ij}-\min x_{ij}}{\max x_{ij}-\min x_{ij}}; benefit\ criteria \\ \frac{x_{ij}-\max x_{ij}}{\min x_{ij}-\max x_{ij}}; cost\ criteria \end{cases} \tag{10}$$

$$x_{ij}^* = (\lambda * x_{ij}^1) + (\mu * x_{ij}^2) + ((1-\lambda-\mu) * x_{ij}^3) \tag{11}$$

$$s_i^a = \delta \frac{\sum_{j=1}^{n} w_j (x_{ij}^* - \overline{x_j})}{\sqrt{\left(\sum_{j=1}^{n} w_j (x_{ij}^* - \overline{x_j})\right)^2}} + (1-\delta) \frac{\frac{\prod_{j=1}^{n} (\overline{x_j} - x_{ij}^*)^{w_j}}{\prod_{j=1}^{n} (x_{ij}^* - \overline{x_j})^{w_j}}}{\sqrt{\left(\frac{\prod_{j=1}^{n} (\overline{x_j} - x_{ij}^*)^{w_j}}{\prod_{j=1}^{n} (x_{ij}^* - \overline{x_j})^{w_j}}\right)^2}} \tag{12}$$

$$s_i^b = \delta \max_j (w_j (x_{ij}^* - \overline{x}_j)) + (1-\delta) \min_j (w_j (x_{ij}^* - \overline{x}_j)) \tag{13}$$

$$s_i^* = \frac{1}{2} \left(s_i^a + \frac{s_i^b}{\sqrt{\sum_{i=1}^{m} (s_i^a)^2}} \right) \tag{14}$$

The symbol x_{ij} indicates the performance of the ith alternative on the jth criterion, while m and n represent the number of alternatives and the number of criteria used in the evaluation. The symbol x_{ij}^1 functions as the result of the first normalization, representing the performance value of an alternative against a criterion by considering the relative proportion of the data, thus being able to show the contribution of the alternative in a balanced way for both benefit and cost-type criteria. This normalization emphasizes relative comparisons between alternatives within a single criterion. The symbol x_{ij}^2 functions as the result of the second normalization, reflecting the position of the alternative's value relative to the extreme values for each criterion. This representation illustrates the closeness of an alternative's performance to the best or worst conditions, making it useful for capturing the relative dominance of an alternative within a criterion. The symbol x_{ij}^3 serves as the third normalization result, depicting the position of the alternative's value within the range of minimum and maximum criterion values. This normalization functions to show the distribution and relative distance of alternative values across the entire criterion domain, for both benefit and cost criteria. The symbol $\max x_{ij}$ is used to represent the highest performance value achieved by all alternatives for the jth criterion. Conversely, the symbol $\min x_{ij}$ is used to indicate the lowest performance value of all alternatives for the jth criterion.

The symbol x_{ij}^* serves as a comprehensive normalization value that integrates the three previous normalization results. The symbol s_i^a serves as the first aggregation score that reflects the evaluation of alternative performance through a comprehensive aggregation approach. This value combines additive and multiplicative information by considering the criteria weights as well as the degree of deviation of alternatives from the average value, thereby representing the overall performance of alternatives comprehensively. The symbol s_i^b functions as a second aggregation score that emphasizes the extreme variation in alternative performance. This value represents a combination of the maximum and minimum deviations of alternatives from the reference value, thus capturing the influence of both the most dominant and weakest criteria simultaneously. The symbol w_j serves as the weight of the jth criterion, representing the relative importance of each criterion in the decision-making process. This weight indicates the extent of a criterion's influence on the overall assessment of alternatives. The symbol s_i^* functions as the final comprehensive score that integrates the aggregation results of sia and sib. This value is used as the final preference index to evaluate and rank alternatives, as it reflects a balance between overall performance and extreme variation within the MACONT framework.

4. RESULTS AND DISCUSSION

Decision support system for evaluating textile supplier performance based on WENSLO and MACONT was developed in response to the need for textile supplier evaluation involving multiple criteria and requiring a high level of objectivity and consistency. This system is designed to manage the complexity of supplier performance assessment by combining objective weighting methods and multi-criteria aggregation techniques within a structured analytical framework. WENSLO is used to determine the weight of criteria based on data characteristics and variations objectively, while MACONT plays a role in integrating the performance values of alternatives through a comprehensive normalization and aggregation process. Through this approach, the proposed DSS is capable of producing more stable, transparent, and accountable supplier performance evaluations, thereby supporting more accurate decision-making in textile industry supply chain management.

A. Identifying Evaluation Criteria

Identifying evaluation criteria is a very important initial stage in a decision support system because the chosen criteria will determine the direction and quality of the assessment results. At this stage, aspects relevant to the evaluation objectives are carefully analyzed so that they can comprehensively represent the performance of the evaluated object. In the context of evaluating textile suppliers, the selection of criteria must consider key factors that affect the smoothness of the production process and the company's competitiveness. Well-identified criteria will help reduce assessment bias, improve evaluation consistency, and ensure that each alternative is evaluated based on clear and measurable parameters. The stage of identifying evaluation criteria becomes the main foundation for building an objective, systematic, and accountable decision-making process. The criteria used in this study are presented in Table 1.

Table 1. Data of the criteria used

Criteria Code	Criteria Name	Criteria Type	Description
C1	Material Quality	Benefit	Describes the quality level of the raw materials supplied, including consistency, durability, and compliance with textile production standards. Good material quality directly affects the quality of the final product.
C2	Delivery Time	Cost	Shows the supplier's ability to meet delivery schedules as agreed. Timeliness is crucial to ensure smooth production processes and avoid operational delays.
C3	Price	Cost	Represents the level of costs that a company must incur to obtain raw materials from suppliers. A lower price value indicates better supplier performance as long as they continue to meet quality standards.
C4	Capacity and Supply Continuity	Benefit	Demonstrates the supplier's ability to provide raw materials sustainably according to production volume needs. This criterion is important to ensure the continuity of the production process.
C5	Responsiveness and Service	Benefit	Describes the speed and quality of the supplier's response to requests, complaints, or changes in needs. Good service supports long-term collaborative relationships.

Based on the established criteria data, the evaluation of textile suppliers' performance can be carried out more systematically and comprehensively because each criterion represents an important aspect that affects the success of the procurement process. Grouping the criteria into benefit and cost types also provides clarity in the analysis process, allowing each performance value to be interpreted accurately according to its characteristics. With clearly and measurably defined criteria, the next evaluation stage can be conducted objectively and consistently, serving as a strong foundation for applying the WENSLO and MACONT methods in making more accurate and accountable supplier selection decisions.

B. Alternative Assessment Data

Alternative assessment data is an important component in the supplier evaluation process because it represents a quantitative measure of each alternative's performance against the established criteria. This data is collected from relevant sources and systematically organized to accurately reflect the actual condition of each supplier. The accuracy and consistency of the assessment data are crucial in determining the quality of the evaluation results, as all subsequent stages of analysis rely on the information presented in the data. Therefore, the preparation of alternative assessment data that is clear, measurable, and comparable serves as the main foundation to support rational and data-driven decision-making. Table 2 shows the alternative assessment data used in this study.

Table 2. Alternative evaluation data

Alternative	C1	C2	C3	C4	C5
Supplier A1	85	7	350000	88	86
Supplier A2	88	6	300000	90	89
Supplier A3	80	5	420000	84	81
Supplier A4	92	7	280000	91	90
Supplier A5	87	6	330000	86	85
Supplier A6	90	8	400000	89	91
Supplier A7	83	4	250000	82	83
Supplier A8	89	6	310000	88	88
Supplier A9	86	5	270000	85	84

Based on the alternative assessment data that has been compiled, it can be concluded that each supplier exhibits different performance characteristics for each criterion, whether in terms of quality, timeliness, price, supply capacity, or responsiveness. These variations in scores reflect the real conditions in the supplier selection process, where no single alternative is superior across all criteria. Therefore, this assessment data serves as an important and objective basis for the next stage of analysis using a multi-criteria decision-making method, so that the resulting rankings are expected to be more rational, transparent, and accountable.

C. Weight Calculation Using WENSLO

Weight calculation using the WENSLO method is carried out to obtain the importance level of each criterion objectively based on the variation pattern of alternative evaluation data. This method utilizes the difference between the maximum and minimum values as well as the trend of data changes for each criterion to illustrate the relative contribution of the criteria in the decision-making process. With this approach, WENSLO can reduce reliance on the subjective judgments of decision-makers and produce more consistent weights that reflect the actual data conditions. The resulting weights are then used as the main input in the value aggregation process, thus playing an important role in determining the evaluation results and the final ranking of suppliers.

The stages in the WENSLO method begin with the preparation of a decision matrix, which is a representation of the performance data of each alternative against all criteria used as the basis for calculation using (1) to represent the performance of each alternative against all criteria based on the assessment data in Table 2.

$$X = \begin{bmatrix} x_{11} & x_{12} & x_{13} & x_{14} & x_{15} \\ x_{21} & x_{22} & x_{23} & x_{24} & x_{25} \\ x_{31} & x_{32} & x_{33} & x_{34} & x_{35} \\ x_{41} & x_{42} & x_{43} & x_{44} & x_{45} \\ x_{51} & x_{52} & x_{53} & x_{54} & x_{55} \\ x_{61} & x_{62} & x_{63} & x_{64} & x_{65} \\ x_{71} & x_{72} & x_{73} & x_{74} & x_{75} \\ x_{81} & x_{82} & x_{83} & x_{84} & x_{85} \\ x_{91} & x_{92} & x_{93} & x_{94} & x_{95} \end{bmatrix} \qquad X = \begin{bmatrix} 85 & 7 & 350000 & 88 & 86 \\ 88 & 6 & 300000 & 90 & 89 \\ 80 & 5 & 420000 & 84 & 81 \\ 92 & 7 & 280000 & 91 & 90 \\ 87 & 6 & 330000 & 86 & 85 \\ 90 & 8 & 400000 & 89 & 91 \\ 83 & 4 & 250000 & 82 & 83 \\ 89 & 6 & 310000 & 88 & 88 \\ 86 & 5 & 270000 & 85 & 84 \end{bmatrix}$$

The next step is to calculate the normalized values to equalize the scale of values across criteria so that they can be compared fairly using (2). Table 3 shows the overall normalization calculation results in the WENSLO method.

Table 3. Normalization calculation results using the WENSLO method

Alternative	C1	C2	C3	C4	C5
Supplier A1	0.1090	0.1296	0.1203	0.1124	0.1107
Supplier A2	0.1128	0.1111	0.1031	0.1149	0.1145
Supplier A3	0.1026	0.0926	0.1443	0.1073	0.1042
Supplier A4	0.1179	0.1296	0.0962	0.1162	0.1158

Supplier A5	0.1115	0.1111	0.1134	0.1098	0.1094
Supplier A6	0.1154	0.1481	0.1375	0.1137	0.1171
Supplier A7	0.1064	0.0741	0.0859	0.1047	0.1068
Supplier A8	0.1141	0.1111	0.1065	0.1124	0.1133
Supplier A9	0.1103	0.0926	0.0928	0.1086	0.1081

After that, the class intervals of the criteria are determined, which function to group the normalized values into certain ranges so that the data distribution patterns can be analyzed more systematically using (3). Table 4 shows the overall calculation results of the degree of dispersion in the WENSLO method.

Table 4. Class intervals of the criteria calculation results using the WENSLO method

C1	C2	C3	C4	C5
0.0037	0.0178	0.0140	0.0028	0.0031

Based on these intervals, the slope of the criteria is calculated, which reflects the rate of change or sensitivity of the criteria values to differences between alternatives using (4). Table 5 shows the results of the overall calculation of the criteria slope using the WENSLO method.

Table 5. Criterion slope calculation results using the WENSLO method

C1	C2	C3	C4	C5
33.8812	7.036864	8.92256	45.34868	40.50106

The next stage is the formation of the criterion envelope, which consists of upper and lower bounds representing the overall range of criterion values using (5). Table 6 presents the results of the overall calculation of the criteria envelope formation using the WENSLO method.

Table 6. Criterion envelope formation calculation results using the WENSLO method

C1	C2	C3	C4	C5
0.0683	0.3020	0.2638	0.0552	0.0670

From this envelope, the criterion envelope proportion is then calculated, indicating the relative contribution of each criterion compared to the others using (6). Table 7 shows the results of the overall calculation of the criteria envelope proportion values using the WENSLO method.

Table 7. Criterion envelope proportion calculation results using the WENSLO method

C1	C2	C3	C4	C5
0.0020	0.0429	0.0296	0.0012	0.0017

The final stage is determining the criterion weights, which are obtained from the envelope proportion and the criterion slope, so that the resulting weights are objective, reflect the data characteristics, and quantitatively represent the level of importance of the criteria using (7), resulting in final weights that are ready to be used in the evaluation and decision-making process as shown in Table 8.

Table 8. Criterion weights calculation results using the WENSLO method

C1	C2	C3	C4	C5
0.0261	0.5547	0.3821	0.0157	0.0214

The weighting results of the criteria using the MACONT method show that the On-Time Delivery criterion (C2) has the most dominant weight of 0.5547, confirming that delivery punctuality is the main factor in supplier evaluation. Furthermore, the Price criterion (C3) has a relatively high weight of 0.3821, indicating the importance of cost aspects in supporting procurement efficiency. Meanwhile, Material Quality (C1) has a weight of 0.0261, Responsiveness (C5) is 0.0214, and Supply Capacity (C4) is 0.0157, indicating that these three criteria act as supporting factors in the evaluation, although their influence is smaller compared to on-time delivery and price. Overall, this weight distribution reflects a decision-making focus on delivery reliability and cost efficiency in supplier selection.

D. Assessment of Alternatives Using MACONT

Alternative assessments using MACONT were conducted to obtain an overall alternative rating by considering the diverse data characteristics of each criterion. This method combines several normalization results into one comprehensive value, so as to balance the effect of differences in scale and direction of preference between criteria. Through the aggregation process that combines the approach of comprehensive normalized aggregation and mixed max–min deviation aggregation, MACONT can provide more stable and representative assessment results. This method is effectively used to objectively evaluate alternative performance and support more accurate decision-making.

The MACONT stages begin with the preparation of a decision matrix containing the performance values of each alternative against all criteria as the basis for evaluation using (1). The result of the MACONT decision matrix is the same as the result of the WENSLO decision matrix. The next stage is the normalization process using three different normalization techniques to ensure that data from various criteria are on a comparable scale and better represent the characteristics of the data using (8)-(10). Table 9, 10, and 11 shows the results of the MACONT normalization method calculations.

Table 9. First normalization calculation results using the MACONT method

Alternative	C1	C2	C3	C4	C5
Supplier A1	0.1090	0.0915	0.0999	0.1124	0.1107
Supplier A2	0.1128	0.1068	0.1165	0.1149	0.1145
Supplier A3	0.1026	0.1281	0.0832	0.1073	0.1042
Supplier A4	0.1179	0.0915	0.1249	0.1162	0.1158
Supplier A5	0.1115	0.1068	0.1059	0.1098	0.1094
Supplier A6	0.1154	0.0801	0.0874	0.1137	0.1171
Supplier A7	0.1064	0.1602	0.1398	0.1047	0.1068
Supplier A8	0.1141	0.1068	0.1128	0.1124	0.1133
Supplier A9	0.1103	0.1281	0.1295	0.1086	0.1081

Table 10. Second normalization calculation results using the MACONT method

Alternative	C1	C2	C3	C4	C5
Supplier A1	0.9239	0.5714	0.7143	0.9670	0.9451
Supplier A2	0.9565	0.6667	0.8333	0.9890	0.9780
Supplier A3	0.8696	0.8000	0.5952	0.9231	0.8901
Supplier A4	1.0000	0.5714	0.8929	1.0000	0.9890
Supplier A5	0.9457	0.6667	0.7576	0.9451	0.9341
Supplier A6	0.9783	0.5000	0.6250	0.9780	1.0000
Supplier A7	0.9022	1.0000	1.0000	0.9011	0.9121
Supplier A8	0.9674	0.6667	0.8065	0.9670	0.9670
Supplier A9	0.9348	0.8000	0.9259	0.9341	0.9231

Table 11. Third normalization calculation results using the MACONT method

Alternative	C1	C2	C3	C4	C5
Supplier A1	0.4167	0.2500	0.4118	0.6667	0.5000
Supplier A2	0.6667	0.5000	0.7059	0.8889	0.8000
Supplier A3	0.0000	0.7500	0.0000	0.2222	0.0000
Supplier A4	1.0000	0.2500	0.8235	1.0000	0.9000
Supplier A5	0.5833	0.5000	0.5294	0.4444	0.4000
Supplier A6	0.8333	0.0000	0.1176	0.7778	1.0000
Supplier A7	0.2500	1.0000	1.0000	0.0000	0.2000
Supplier A8	0.7500	0.5000	0.6471	0.6667	0.7000
Supplier A9	0.5000	0.7500	0.8824	0.3333	0.3000

The results of these three processes are then combined to obtain the final normalization value that comprehensively reflects the performance conditions of the alternatives using (11). Table 12 shows the results of the final normalization calculations using the MACONT method.

Table 12. Final normalization calculation results using the MACONT method

Alternative	C1	C2	C3	C4	C5
Supplier A1	0.4666	0.2907	0.4094	0.6032	0.5139
Supplier A2	0.6007	0.4434	0.5904	0.7204	0.6731
Supplier A3	0.2430	0.6070	0.1696	0.3687	0.2486
Supplier A4	0.7795	0.2907	0.6662	0.7791	0.7262
Supplier A5	0.5560	0.4434	0.4806	0.4859	0.4609
Supplier A6	0.6901	0.1450	0.2369	0.6618	0.7793
Supplier A7	0.3771	0.7900	0.7850	0.2515	0.3547
Supplier A8	0.6454	0.4434	0.5533	0.6032	0.6201
Supplier A9	0.5113	0.6070	0.7050	0.4273	0.4078

Next, the normalized values are processed through two aggregation mechanisms, namely comprehensive normalization aggregation using (7) and mixed maximum-minimum deviation aggregation using (8), to capture the total contribution of the criteria as well as the variation in the performance of alternatives. Table 13 shows the results of the comprehensive normalization aggregation and mixed maximum-minimum deviation aggregation calculations of the MACONT method.

Table 13. Comprehensive and deviation aggregation calculation results using the MACONT method

Alternative	Comprehensive	Deviation
Supplier A1	-0.1650	-0.0440
Supplier A2	1.0384	0.0131
Supplier A3	0.3071	-0.0219
Supplier A4	0.4276	-0.0148
Supplier A5	-0.2196	-0.0056
Supplier A6	-0.1599	-0.0823
Supplier A7	1.1504	0.0917
Supplier A8	1.0080	0.0060
Supplier A9	1.1817	0.0419

The final stage of MACONT produces the final comprehensive score using (9). Table 14 shows the results of the final comprehensive score calculations of the MACONT method.

Table 14. Final comprehensive calculation results using the MACONT method

Alternative	Final Score
Supplier A1	-0.0921
Supplier A2	0.5220
Supplier A3	0.1487
Supplier A4	0.2106
Supplier A5	-0.1110
Supplier A6	-0.0980
Supplier A7	0.5953
Supplier A8	0.5053
Supplier A9	0.6000

Based on the final results of the MACONT method, the final score of supplier A1 was -0.0921, indicating performance still below the benchmark value. Supplier A2 recorded a positive score of 0.5220, reflecting relatively good performance. Supplier A3 scored 0.1487 and Supplier A4 scored 0.2106, both falling into the medium performance category. Suppliers A5 and A6 had scores of -0.1110 and -0.0980, respectively, indicating suboptimal performance. Furthermore, Supplier A7 showed excellent performance with a score of 0.5953, followed by Supplier A8 with a score of 0.5053. Finally, Supplier A9 had a score of 0.6000.

E. Ranking of Alternatives

The alternative ranking stage is a very important final part of the decision-making process because it serves to transform numerical calculation results into information that is easy to understand and can be directly used by decision-makers. At this stage, each supplier alternative is ranked based on the final scores produced by the evaluation method, where higher scores indicate better performance and closer alignment with the ideal condition. The ranking process not only provides an overview of the relative positions of each supplier but also helps identify the best alternatives, those with moderate performance, as well as alternatives that require attention or improvement. Thus, alternative ranking becomes an objective and systematic basis for determining supplier recommendations that best match the company's needs and priorities. Table 15 presents the ranking results using a combination of WENSLO and MACONT.

Table 15. Alternative ranking results

Alternative	Final Score	Rank
Supplier A9	0.6000	1
Supplier A7	0.5953	2
Supplier A2	0.5220	3
Supplier A8	0.5053	4
Supplier A4	0.2106	5
Supplier A3	0.1487	6
Supplier A1	-0.0921	7
Supplier A6	-0.0980	8
Supplier A5	-0.1110	9

Based on the results of the alternative rankings in Table 15, Supplier A9 ranks first with the highest final score of 0.6000, indicating performance closest to the ideal condition compared to the other alternatives. The second position is held by Supplier A7 with a score of 0.5953, followed by Supplier A2 in third place with a value of 0.5220, both reflecting very good performance. Supplier A8 is in fourth place with a score of 0.5053, still showing competitive performance. Furthermore, Supplier A4 and Supplier A3 occupy the fifth and sixth positions with scores of 0.2106 and 0.1487, respectively, which depict performance at a moderate level. In the lower-ranking group, Supplier A1 is in seventh place with a score of -0.0921, followed by Supplier A6 in eighth place with a score of -0.0980, and Supplier A5 in the last place with a score of -0.1110, indicating that these three suppliers have the lowest relative performance based on the MACONT method evaluation.

F. Discussion

The results of this study indicate that the implementation of a DSS based on a combination of WENSLO and MACONT is capable of providing a more objective and structured framework for evaluating textile suppliers. The use of WENSLO in the criterion weighting stage allows weights to be determined based on the characteristics of data distribution, thereby reducing the dominance of subjective assessments that often arise in conventional approaches. In the context of the textile industry, which is highly sensitive to material quality, timeliness, and price, objective weighting is crucial to ensure that each criterion is evaluated proportionally according to its contribution to the overall performance of suppliers.

At the alternative evaluation stage, MACONT demonstrates its advantage in comprehensively combining several normalization techniques and aggregation strategies. This approach allows the system to capture not only the average supplier performance values but also the maximum and minimum deviations from the reference value. The calculation results show clear differentiation among suppliers, whether in the high, medium, or low-performance groups. This indicates that MACONT can enhance evaluation sensitivity without compromising the stability of the results, making the resulting rankings more reflective of the actual performance conditions of textile suppliers.

The integration of WENSLO and MACONT within a single DSS framework also provides an important methodological contribution. Most previous studies still rely on a single weighting method or one aggregation approach, which can potentially result in less consistent decisions when there are changes in data or criteria weights. The model proposed in this study offers a solution through a combination of objective weighting and mixed aggregation, thus minimizing bias and improving ranking consistency. Consequently, this DSS not only functions as a tool for selecting the best suppliers but also as an evaluation system that is adaptive to the complexity of multi-criteria decision-making.

The results of the alternative ranking indicate that the implementation of MACONT is able to provide a clear and consistent separation of supplier performance based on the final scores obtained. Supplier A9 and Supplier A7 occupy the top positions with very close scores, which suggests that both suppliers have superior performance overall across all evaluated criteria. This condition shows that the mixed aggregation approach in MACONT is effective in capturing the balance between average performance and extreme deviations in each criterion. The relatively high positive values for the top-ranked alternatives reflect the method's ability to identify suppliers that most closely approach the ideal conditions comprehensively, not just excelling in one or two specific aspects.

On the other hand, suppliers in the middle ranks such as Supplier A2, A8, A4, and A3 show more moderate performance variations. Although they do not achieve the highest scores, these alternatives still have positive values indicating that they still meet most of the evaluation criteria fairly well. The differences in ranking within this group reflect MACONT's sensitivity to small variations in assessment data, particularly in criteria with higher weights. This reinforces that this method not only evaluates absolute values but also considers the distribution and imbalance of performance across criteria, making the results more representative of the suppliers' actual conditions.

The group of suppliers with negative values, namely Supplier A1, A6, and A5, indicate significant weaknesses in one or more important criteria. Final scores below zero suggest that the performance of these suppliers is relatively far from the average reference and ideal values set in the model. These findings are important for decision-makers as they provide an early signal that suppliers at the lower rankings require further evaluation, performance improvement, or even consideration for not being prioritized in collaboration. Thus, the ranking results not only serve as a selection tool but also as a basis for supplier development strategies.

Practically, the findings of this study have significant implications for supply chain management in the textile industry. A DSS based on WENSLO and MACONT can be used as a reliable decision support tool for selecting and continuously monitoring supplier performance. This system assists decision-makers in identifying top-performing suppliers, potential suppliers that need development, and underperforming suppliers that require corrective actions. With a more objective, stable, and data-driven approach, the proposed DSS has the potential to improve efficiency, decision quality, and the competitiveness of textile companies in the long term.

5. CONCLUSION

The research results and discussions carried out can be concluded that the DSS for textile supplier performance evaluation based on a combination of WENSLO and MACONT is able to provide a more objective, consistent, and stable approach in multi-criteria decision-making. WENSLO plays a role in generating criteria weights that reflect the actual characteristics of the data, thereby reducing the subjectivity of the assessor, while MACONT integrates various normalization and aggregation techniques to comprehensively evaluate supplier alternatives. The ranking results show that Supplier A9 occupies the first rank, followed by Supplier A7 in second place, and Supplier A2 in third, indicating that these three suppliers have the best performance based on all the criteria used. These findings demonstrate that the proposed model is capable of clearly distinguishing supplier performance and providing relevant recommendations for decision-makers, thus not only contributing methodologically to the development of MCDM-based DSS, but also offering practical solutions that can support the enhancement of effectiveness and competitiveness in the textile industry.

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