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A Decision Support System for Selecting the Optimal Supplier Using the AHP and TOPSIS Methods with a Quantitative Approach in a Manufacturing Company

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Selecting the right supplier is a strategic decision for manufacturing companies as it has a direct impact on product quality, delivery timeliness and operational cost efficiency. In practice, many companies still select suppliers based on previous collaboration experience and subjective assessments without considering comprehensive and measurable criteria; consequently, the decisions made are prone to causing quality discrepancies and delivery delays. This study aims to design and implement a decision support system based on the integration of the Analytical Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods to determine the weightings of criteria and rank supplier alternatives within a manufacturing company. The research employs a quantitative approach with a case study of five active suppliers selected via purposive sampling, using four evaluation criteria: price, quality, delivery punctuality and service; the data were processed using Microsoft Excel. The results of the study show that the quality criterion received the highest weight of 0.467 with a consistency ratio of 0.011, whilst the TOPSIS results ranked Supplier 3 as the best alternative with a preference value of 0.7454. These findings demonstrate that the integration of AHP and TOPSIS results in a more objective and measurable decision regarding supplier selection than an assessment based on a single criterion alone; it can therefore serve as a practical guide for procurement management in improving the effectiveness of supplier evaluation for raw materials in manufacturing companies.
Keywords: decision support system, Analytical Hierarchy Process, TOPSIS, supplier selection.

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1. Introduction

Manufacturing companies are, by their very nature, heavily reliant on the availability of raw materials supplied by external parties to ensure the continuity of their production processes. This reliance makes the selection of suppliers one of the strategic decisions that directly impacts product quality, delivery timeliness and the company's operational cost efficiency. In practice, many companies still select suppliers based solely on previous experience of working together or subjective assessments, without considering comprehensive and measurable criteria; consequently, the decisions taken are prone to causing quality issues, delivery delays, or additional costs that are detrimental to the company [1]. A similar phenomenon has also been observed in companies operating in the pharmaceutical manufacturing sector, where the evaluation of raw material suppliers is still often carried out manually, resulting in inconsistent outcomes that are difficult to account for objectively [2]. Empirical evidence from recent industrial studies further reinforces the urgency of this issue. A case study on material supplier selection in a stainless-steel manufacturing company found that the absence of clear, structured supplier evaluation criteria led to recurring delivery delays and material non-conformities, resulting in additional rework costs and disruptions to the production schedule [3]. Similarly, an empirical study on supply chain risk management practices in the pharmaceutical

manufacturing sector reported that companies lacking a systematic supplier evaluation and risk-mitigation approach experienced significantly higher rates of operational disruption compared to those with structured evaluation systems [4]. These findings confirm that the absence of a systematic, criteria-based decision support approach to supplier selection remains a pressing and unresolved problem in the manufacturing sector.

This issue is becoming increasingly urgent to resolve, given the ever-tighter competition in the manufacturing sector in the era of Industry 4.0, where supply chain efficiency and the ability to select the right business partners are key determinants of a company's competitiveness [5]. Choosing the wrong supplier not only disrupts the production process, but can also undermine customer confidence due to a decline in the quality of the final product. Therefore, an approach is needed that can assist decision-makers in evaluating various supplier alternatives in a systematic, objective and measurable manner, rather than relying solely on intuition or habit [6]. The use of multi-criteria decision-making methods has become a widely adopted solution due to their ability to accommodate various evaluation criteria which are often conflicting, such as price, quality and delivery time within a single structured evaluation framework [7].

This study focuses specifically on the application of a combination of the Analytical Hierarchy Process (AHP) and the Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS) in developing a decision support system for the selection of the optimal supplier in a manufacturing company. The AHP method is used to determine the priority weights of each evaluation criterion through a process of pairwise comparisons between criteria, whilst the TOPSIS method is utilised to rank supplier alternatives based on their proximity to the positive ideal solution as well as their distance from the negative ideal solution [8]. This study employs a quantitative approach, with evaluation criteria limited to the aspects of price, quality, delivery punctuality and service, given that these four aspects are commonly used in various studies on multi-criteria supplier selection [9]. These criteria have been restricted to ensure that the research findings remain focused and can be directly applied to real-world business conditions, without neglecting key aspects of the raw materials procurement process.

Based on the above, this study aims to design and implement a decision support system based on the AHP and TOPSIS methods to determine the weights of criteria and rank supplier alternatives in a manufacturing company. More specifically, this study is aimed at identifying the criteria that have the greatest influence on the supplier selection process, calculating the weights of each criterion using the AHP method, and determining the order of priority of the best suppliers through TOPSIS calculations. Consequently, the results of this study are expected to serve as an objective and measurable reference for decision-makers in selecting the supplier best suited to the company's needs, whilst reducing the risk of decision-making errors, which have hitherto been influenced by subjective factors.

The problem of selecting the wrong supplier is also reflected in various industry findings which indicate that errors in supplier evaluation are one of the main causes of supply chain disruptions in the manufacturing sector, particularly in industries that are highly dependent on external supplies of raw materials and operate in a business environment that demands continuous supply chain efficiency [5].

Unlike previous studies, which generally applied only a single decision-making method either AHP or TOPSIS this study demonstrates its novelty through the sequential integration of both methods, whereby the criterion weights derived from the AHP serve as direct input for the TOPSIS ranking process in a case study of a manufacturing company that considers four evaluation criteria simultaneously [8].

2. Literature Review and Statement of the Problem

Various previous studies have shown that the combination of the Analytical Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is a widely used approach to resolving supplier selection problems across various industrial sectors, due to its ability to combine the weighting of subjective criteria with the objective and measurable ranking of alternatives [10]. Research into shipbuilding companies has shown that the integration of AHP and TOPSIS provides supplier evaluation results that are more structured and can be logically justified by procurement management compared to single methods [11]. A similar pattern was also found in a study on the selection of suppliers of sugarcane and soap raw materials, in which criteria such as price, quality, delivery reliability and supply capacity consistently emerged as the key determining factors in prioritising the best suppliers [12], [13].

Conceptually, the AHP method was developed based on the principle of breaking down complex problems into a hierarchical structure comprising objectives, criteria and alternatives; pairwise comparisons are then carried out between elements at each level of the hierarchy to produce priority weights through a mathematical synthesis process [10]. Meanwhile, the TOPSIS method is based on the principle that the best alternative is the one that is closest to the positive ideal solution and furthest from the negative ideal solution; thus, the ranking process can be carried out simultaneously whilst taking into account all evaluation criteria without neglecting the conflicting trade-offs between them [11].

This pattern is further corroborated by several recent case studies applying the integrated AHP-TOPSIS framework across diverse industrial contexts. In the construction industry, the sequential application of AHP and TOPSIS was shown to produce supplier rankings that were more objective and logically defensible than those generated by either method used independently, confirming the complementary strength of combining subjective criterion weighting with objective alternative ranking [14]. In the food distribution sector, the same integrated approach applied to perishable-product supplier evaluation revealed that delivery and quality consistently emerged as the most influential criteria, a pattern consistent with earlier findings in this line of research [15]. Likewise, a study on raw-material supplier selection among small and medium-sized food enterprises found that the AHP-TOPSIS integration yielded more consistent, easily justifiable rankings compared to single-method approaches, reinforcing the theoretical linkage between criterion weighting and objective ranking that underpins the hypothesis development in this study [16].

Although these studies have demonstrated the effectiveness of combining AHP and TOPSIS, most are still limited to single case studies with a relatively small number of criteria; consequently, few have tested the consistency of the results of these two methods in manufacturing companies with more diverse evaluation criteria. This gap forms the basis for the formulation of the research problem, namely how to determine the appropriate criterion weights using the AHP method and how to prioritise suppliers using the TOPSIS method in manufacturing companies. Based on this research problem, two hypotheses are proposed: H1: there are specific criteria that have the most dominant influence on supplier selection; and H2: the integrated application of AHP and TOPSIS produces a more objective supplier priority ranking than an assessment based on a single criterion alone.

3. Method

This study employs a quantitative method using a case study approach at a manufacturing company that has several active raw material suppliers. This approach was chosen because it enables the conversion of subjective assessments into measurable numerical data, on the assumption that each assessment criterion is independent of the others. Primary data was obtained through a paired-comparison questionnaire completed by the procurement department and production managers, who, as respondents, have direct

knowledge of the raw material supply process [17]. The assessment criteria namely price, quality, delivery punctuality and service were determined through initial discussions with the company before being organised into an AHP hierarchy. The weighting for each criterion was calculated using a comparative scale of one to nine, provided that the consistency ratio remained below 0.1 to ensure the validity of the assessment results. These weights were then used as input for the TOPSIS method to measure the distance of each supplier alternative from the positive and negative ideal solutions, thereby producing an objective ranking of suppliers [8]. The research sample consisted of five active suppliers selected using purposive sampling, based on a history of collaboration with the company spanning at least one year, and all calculations were processed using Microsoft Excel. To provide greater methodological transparency, the data collection process was carried out in two stages. First, a preliminary discussion was held with the procurement department to identify the relevant evaluation criteria and to select suppliers eligible for assessment. Second, a structured paired-comparison questionnaire was distributed directly to three respondents: the Procurement Manager, the Production Manager, and the Quality Control Supervisor, each of whom has a minimum of five years of direct working experience in supplier evaluation and raw material procurement. The questionnaire was completed individually by each respondent over a two-week period, after which the results were averaged using the geometric mean to obtain a single aggregated pairwise comparison matrix, thereby reducing the potential bias of individual subjective judgement.

The implementation of the AHP method followed four main stages: (1) structuring the decision hierarchy consisting of the goal, criteria, and supplier alternatives; (2) constructing the pairwise comparison matrix for the four criteria based on the aggregated respondent judgements; (3) calculating the eigenvector to obtain the priority weight of each criterion; and (4) testing the consistency ratio (CR) to ensure that the assigned weights were logically consistent, with a threshold of CR < 0.1. The resulting criterion weights were then used as direct input for the TOPSIS stage, which involved: (1) normalising the decision matrix; (2) constructing the weighted normalised matrix; (3) determining the positive and negative ideal solutions; (4) calculating the Euclidean distance of each supplier alternative to both ideal solutions; and (5) computing the relative closeness value to rank the suppliers from best to worst.

The five suppliers included in this study were selected using purposive sampling based on three specific criteria: (1) an active supply relationship with the company of at least one year, (2) a minimum transaction frequency of once per month during that period, and (3) availability of complete historical performance records required for the assessment. This sampling rationale was applied to ensure that the suppliers evaluated reflected the company's actual and most relevant pool of raw material partners, rather than an arbitrary or convenience-based selection.

4. Results and Discussion

Results of the Weighting of Supplier Selection Criteria Using the AHP Method

The initial stage of the analysis involved compiling a pairwise comparison matrix between criteria based on the results of questionnaires completed by the procurement department and production managers, who, as respondents, have a direct understanding of the raw material supply process. The four criteria compared price, quality, delivery punctuality and service were assessed on a scale of one to nine in accordance with the basic principles of AHP. The results of these pairwise comparisons are presented in Table 1.

Table 1. Pairwise Comparison Matrix Between Criteria

Criteria	Price	Quality	On-time Delivery	Service
Price	1	1/3	1/2	2
Quality	3	1	2	4

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Criteria	Price	Quality	On-time Delivery	Service
On-time Delivery	2	1/2	1	3
Service	1/2	1/4	1/3	1

The comparison values in Table 1 reflect the respondents' perception that quality is considered more important than delivery punctuality, price or service, as evidenced by the comparison values in the 'quality' row, which are consistently greater than one. The matrix was then analysed using the geometric mean to obtain the relative weights of each criterion, with the results shown in Table 2.

Table 2. AHP Outcome Criteria Weights and Consistency Ratios

Criteria	Weight	Ranking
Quality	0,467	1
On-time Delivery	0,278	2
Price	0,160	3
Service	0,095	4

The consistency ratio (CR) obtained was 0.011, well below the threshold of 0.1 required by Saaty; consequently, the comparison matrix can be deemed consistent and suitable for use as a basis for further decision-making. These results indicate that the assessments provided by the respondents are rational and do not contain any logical contradictions between criteria; consequently, the resulting weights are methodologically sound [18].

Results of the Ranking of Alternative Suppliers Using the TOPSIS Method

Once the criterion weights have been obtained, the next step is to construct a decision matrix based on the actual performance data of the five suppliers included in the research sample, comprising the unit price of raw materials, quality scores, the percentage of on-time deliveries, and service scores, as presented in Table 3.

Table 3. Decision Matrix (Supplier Performance Data)

Supplier	Price (Rp/unit)	Quality (skor 1-100)	On-time Delivery (%)	Service (skor 1-100)
Supplier 1	15.000	85	90	80
Supplier 2	13.500	78	85	75
Supplier 3	16.200	92	95	88
Supplier 4	14.000	80	88	82
Supplier 5	15.800	88	92	85

The decision matrix was then normalised using the vector normalisation method, and subsequently multiplied by the AHP-derived criterion weights to obtain a weighted decision matrix. Next, the positive and negative ideal solutions were determined based on the maximum and minimum values for each criterion, taking into account the nature of the criteria as benefits for quality, delivery punctuality and service, and cost for price. The distance of each alternative from these two ideal solutions is calculated using the Euclidean distance formula, which is then used to determine the preference value or closeness coefficient for each supplier, as shown in Table 4.

Table 4. Preference Values (Closeness Coefficient) and Final TOPSIS Rankings

Supplier	D+	D-	Preference Values (Ci)	Ranking
Supplier 1	0,0193	0,0197	0,5047	3
Supplier 2	0,0378	0,0129	0,2546	5
Supplier 3	0,0129	0,0378	0,7454	1
Supplier 4	0,0314	0,0128	0,2898	4
Supplier 5	0,0154	0,0270	0,6365	2

The results of the calculations show that Supplier 3 achieved the highest preference score of 0.7454, indicating the closest distance to the positive ideal solution and the furthest distance from the negative ideal solution compared with the other alternatives. The subsequent rankings, in order, are held by Supplier 5 (0.6365), Supplier 1 (0.5047), Supplier 4 (0.2898) and Supplier 2 (0.2546). This order of priority indicates that Supplier 3 consistently outperforms the others on the criteria of quality and delivery punctuality, even though the price offered is relatively higher than that of the other alternatives; thus, its strengths on the criteria with higher weightings are able to compensate for its weaknesses on the criteria with lower weightings.

Analysis of Dominant Criteria in Supplier Selection

The finding that quality criteria carry the greatest weight is consistent with the first hypothesis (H1), which states that certain criteria have the greatest influence on the supplier selection process. The dominance of quality criteria in this study indicates that manufacturing companies regard the consistency of raw material quality as a more crucial factor than price, given that raw materials that do not meet standards have the potential to cause defective products and greater production losses than the price difference between suppliers. This finding reinforces the results of previous research in the textile manufacturing sector, which also found that the quality of materials was one of the factors with the highest weighting in supplier selection [19].

A similar pattern was also found in a study on the selection of strategic raw material suppliers, in which product quality and service capacity were the criteria with the highest weightings, reflecting the company's focus on quality and long-term support from its supplier partners [18]. However, the predominance of quality criteria in this study contrasts with findings in the interior construction sector, where price criteria actually have a greater influence due to the nature of projects that demand strict budgetary efficiency. This difference indicates that the weighting of criteria in supplier selection is contextual and heavily influenced by industry characteristics, the type of raw materials, and the strategic orientation of each company [19].

The Effectiveness of Integrating AHP and TOPSIS in Supporting Objective Decision-Making

The second hypothesis (H2) states that the integrated application of AHP and TOPSIS produces a more objective ranking of suppliers than an assessment based on a single criterion alone. The results of this study support this hypothesis, as the final ranking is not determined by a single dominant aspect, but takes into account the contribution of all criteria proportionally according to their respective weights. If the decision were based solely on price, Supplier 2 should have been the top choice as it offered the lowest price; however, the results of the AHP-TOPSIS integration actually placed Supplier 2 in last place due to its relatively poor performance in terms of quality and delivery punctuality. This demonstrates that a multi-criteria approach can prevent decision-makers from falling into the trap of single-criterion bias, which risks overlooking other important aspects [20].

These findings are also consistent with research applying a combination of AHP and TOPSIS to sustainable electronics supply chains, which shows that the integration of these two methods is capable of producing rankings of alternatives that are more objectively justifiable than those produced by a single weighting method [21]. The advantages of the AHP-TOPSIS integration are further reinforced by research comparing the Analytical Network Process with TOPSIS, which confirms that combining criteria weighting and alternative ranking methods yields a more comprehensive evaluation than the application of either method in isolation [22]. Furthermore, the effectiveness of this integrated approach is also consistent with research that combines the Best-Worst Method with Fuzzy TOPSIS in the selection of sustainable suppliers, where the results of integrating multi-criteria methods have been shown to improve the consistency of rankings compared to the application of a single method [23].

Overall, the results of this study confirm that the combination of AHP and TOPSIS is effective as a basis for decision-making regarding supplier selection in manufacturing companies, as it is able to accommodate subjective assessments through the process of criterion weighting whilst producing an objective and measurable ranking of alternatives. This approach has proven capable of reducing the risk of evaluation bias which has traditionally been heavily influenced by the subjective considerations of decision-makers whilst providing a stronger and methodologically sound basis for determining the best supplier to ensure the continuity of the company's production processes.

Managerial Implications

The findings of this study have significant managerial implications for companies in formulating more systematic and measurable raw material procurement policies. Companies are advised to prioritise quality and on-time delivery as the key criteria in the supplier evaluation process, given that these two criteria account for more than seventy per cent of the total weighting; consequently, their contribution to the continuity of the production process is far greater than that of price or service criteria. Similar findings were also observed in the evaluation of suppliers of garment fabrics, where material quality and delivery timeliness were the key determinants of the success of the production process and therefore require greater attention than price considerations alone [19].

Furthermore, companies can utilise this AHP-TOPSIS framework as a dynamic decision-making tool that can be updated periodically in line with changes in market conditions, fluctuations in raw material prices, and changes in supplier performance over time. The continuous application of this framework also enables companies to re-evaluate suppliers that were previously ranked low, thereby giving them the opportunity to improve their performance before a decision to terminate the partnership is taken. This kind of continuous evaluation approach is in line with practices in the selection of interior design vendors using digital systems, which demonstrate that regularly updating vendor performance data can improve the accuracy and relevance of ranking results over time [24].

Limitations and Sensitivity of the Results

This study has limitations in that the number of criteria covers only four aspects namely, price, quality, delivery punctuality and service and the sample is restricted to five active suppliers; consequently, the ranking results obtained may change if an analysis were to be carried out using a wider variety of criteria or a greater number of alternatives. A small change in the weighting of the delivery timeliness criterion, for example, could potentially affect the positions of Supplier 1 and Supplier 5, which have relatively close preference values, given that the difference in closeness coefficients between these two suppliers is not particularly large compared to the differences with other suppliers at the extremes of the ranking. A similar limitation was also found in a study on the selection of thermal insulation material suppliers, which showed that the weight differences between closely ranked alternatives are prone to shifting positions if there are minor adjustments to the assessment parameters [20].

Another limitation lies in the data sources used, namely historical supplier performance data and respondents' subjective assessments via a paired-comparison questionnaire; consequently, the results of this study are highly dependent on the consistency and objectivity of the respondents in providing their assessments [25]. Therefore, further research is recommended to conduct a more comprehensive sensitivity analysis by gradually altering the weights of the criteria, as well as expanding the number of criteria and supplier alternatives evaluated, as recommended in research that integrates the Analytical Network Process with TOPSIS for the selection of sustainable raw material suppliers, so that the research findings can be generalised to the broader context of manufacturing companies [22].

5. Conclusion

This study successfully designed and implemented a decision support system based on the integration of AHP and TOPSIS for the selection of the optimal supplier in a manufacturing company. The AHP results showed that quality was the criterion with the highest weighting at 0.467, followed by delivery punctuality, price and service, with a consistency ratio of 0.011, indicating the validity of the assessment. The TOPSIS calculation ranked Supplier 3 as the best alternative with a preference value of 0.7454, proving that the integration of the two methods produces a more objective ranking than a single-criterion evaluation alone, thereby supporting both research hypotheses. These findings underscore the methodological contribution of the multi-criteria approach to raw material procurement management. The limited number of criteria and sample size should be noted for future research, which should expand the assessment variables and supplier alternatives to strengthen the generalisability of the findings within a broader manufacturing context.

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