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Application of the TOPSIS Method for Electronic Supplier Selection Based on Multi-Criteria

Chairunnisa Selviani[1], Dewi Aslamiah Nasution[2], Nabila Amelia[3], Nadya Putri Zulida[4], Nisya Aulia Salsabila[5], Muhammad Romi Syahputra[6]
[1,2,3,4,5,6]Universitas Sumatera Utara
Email: icaanisaa1502@gmail.com

ABSTRAK

Penelitian ini bertujuan menentukan supplier komponen elektronik yang paling optimal dengan pendekatan kuantitatif berbasis kinerja. Metode yang digunakan adalah TOPSIS dengan empat kriteria utama, yaitu harga, kualitas (defect rate), ketepatan pengiriman, dan keberlanjutan lingkungan. Analisis terhadap lima supplier menghasilkan nilai *closeness coefficient* sebagai berikut: S5 sebesar 0,7777, S3 sebesar 0,6712, S1 sebesar 0,5524, S2 sebesar 0,4310, dan S4 sebesar 0,3895. Hasil ini menempatkan S5 sebagai alternatif terbaik, diikuti S3 dan S1. Dampak penelitian ini adalah meningkatkan objektivitas dan akurasi proses pemilihan supplier serta meminimalkan risiko keputusan yang bias. Berdasarkan temuan tersebut, penelitian merekomendasikan strategi *dual sourcing* dengan alokasi 60% pasokan untuk S5 dan 30% untuk S3, sementara S1 dapat dikembangkan sebagai opsi jangka menengah melalui program peningkatan kualitas dan pengurangan tingkat cacat.
Keyword: Supplier, Elektronik, TOPSIS, Kriteria, Kualitas

ABSTRACT

This study aims to determine the most optimal electronic component supplier using a quantitative performance-based approach. The method used is TOPSIS with four main criteria, namely price, quality (defect rate), delivery accuracy, and environmental sustainability. Analysis of five suppliers produces the following closeness coefficient values: S5 of 0.7777, S3 of 0.6712, S1 of 0.5524, S2 of 0.4310, and S4 of 0.3895. These results place S5 as the best alternative, followed by S3 and S1. The impact of this study is to increase the objectivity and accuracy of the supplier selection process and minimize the risk of biased decisions. Based on these findings, the study recommends a dual sourcing strategy with an allocation of 60% of supplies to S5 and 30% to S3, while S1 can be developed as a medium-term option through quality improvement and defect rate reduction programs.
Keyword: ***Supplier, Electronics, TOPSIS, Criteria, Quality***

Corresponding Author:
Chairunnisa Selviani,
Universitas Sumatera Utara,
Jl. Dr. T. Mansyur No. 9, Medan, Kota Medan, Sumatera Utara 20155, Indonesia
Email: icaanisaa1502@gmail.com

1. INTRODUCTION

The global electronic components industry reached a value of approximately US$338.87 billion in 2024 and is projected to grow to US$500.93 billion by 2030, with a compound annual growth rate (CAGR) of 6.9%. This significant growth requires companies to be increasingly selective in selecting suppliers to maintain competitiveness. Supplier selection decisions directly impact final product quality, cost efficiency, and the sustainability of a company's operations.

A major challenge in this process arises from conflicts between assessment parameters. Low-cost suppliers are not always able to provide the best quality, while high-quality suppliers typically command higher prices. Effective supplier quality management has even been shown to reduce defect rates by up to 46%. Furthermore, global pressure for environmental sustainability makes this aspect increasingly important to consider as part of a company's social responsibility and long-term strategy.

Supplier selection is a crucial activity in supply chain management, as it determines business partners capable of meeting quality standards, competitive pricing, and reliable distribution. Complexity arises when various assessment factors conflict, requiring a systematic approach to avoid suboptimal decisions, which can ultimately negatively impact product quality and customer satisfaction.

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is a proven MCDM method for solving supplier selection problems. This method excels in calculation efficiency, application flexibility, and its ability to produce stable and objective rankings by comparing each alternative against both positive and negative ideal solutions.

Several previous studies have demonstrated the success of TOPSIS implementation in supplier selection. Gunawan (2024) developed a TOPSIS-based decision support system with five parameters and successfully obtained accurate rankings. Menon and Ravi (2022) combined AHP–TOPSIS to identify sustainable suppliers in the electronics industry. Qu et al. (2020) applied fuzzy TOPSIS, considering economic, social, and environmental aspects. However, a research gap remains regarding how to comprehensively integrate environmental sustainability criteria with operational and economic parameters in the electronic components industry.

Based on this gap, this study asks the main question: "How can we accurately rank electronic component suppliers while simultaneously considering quality, economics, distribution reliability, and environmental sustainability?"

The main objective of this study is to produce objective supplier rankings through a multi-criteria evaluation encompassing product quality, economic efficiency, distribution reliability, and environmental aspects. Thus, this study contributes to improving decision-making quality, reducing assessment subjectivity, and strengthening the development of MCDM-based decision support systems in supply chain management and strategic relationship management with business partners.

2. RESEARCH METHOD

2.1 Research Type and Data

This study uses a quantitative approach with a descriptive-analytical method to evaluate five electronic component supplier options. It should be noted that the data used is simulated data, not real data from specific companies. This simulated data was created based on references from previous research on supplier performance in the electronics industry, as an example of the application of the TOPSIS method.

There are three main reasons for using simulated data in this study.

First, to protect strategic and confidential business information. Second, to create a controlled experimental environment, allowing the TOPSIS method process to be explained clearly and easily understood. Third, the simulated data facilitates the replication of the study because the parameters used are clear and measurable. Although the data used is simulated, the method's framework remains valid and can be applied to real-world data in the future.

Five electronic component suppliers, labeled S1 to S5, were analyzed in this study, each representing different performance characteristics, reflecting industry conditions. The performance data was organized to represent realistic values based on previous related research.

2.2 Assessment Criteria and Weighting

Four criteria were used in this study, with weights determined based on previous research. Table 1 below summarizes the assessment criteria and their characteristics.

Table 1. Supplier Assessment Criteria

Code	Criteria Name	Type	Weight	Information
C1	Price	Cost	0.25	Factors that directly influence production costs and company profits
C2	Product Quality (Defect Rate)	Benefit	0.30	Important factors for customer satisfaction and company reputation
C3	Delivery Accuracy	Benefit	0.25	It is important for smooth operations and supply chain.
C4	Environmental Sustainability	Benefit	0.20	Increasingly important due to environmental regulations and corporate social responsibility

Price represents a crucial economic dimension that directly impacts production costs. Product quality is measured by defect rates and is given the highest weight due to its role in customer satisfaction and building a company's reputation. On-time delivery is crucial for maintaining smooth operations and avoiding supply chain disruptions. Environmental sustainability is becoming increasingly important due to increasingly stringent environmental regulations and demands for corporate social responsibility.

2.3 TOPSIS Method

The TOPSIS method is used to rank suppliers based on the concept that the best supplier is the one with the shortest distance from the positive ideal solution and the furthest distance from the negative ideal solution. The following are the steps in the TOPSIS method:

Step 1: Create an Initial Decision Matrix

The decision matrix X is constructed based on the criteria values for each supplier:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

where x_ij is the value of the i th supplier on the j th criterion, m is the number of suppliers and n is the number of criteria.

Step 2: Normalizing the Decision Matrix

Normalization is performed using the vector normalization method:

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

where r_ij is the normalized matrix element R.

Step 3: Create a Weighted Normalized Decision Matrix

Each column of the R matrix is multiplied by the criterion weight w_j:

$$v_{ij} = w_j \times r_{ij}$$

where $\sum_{j=1}^{n} w_j = 1$

Step 4: Determine the Positive and Negative Ideal Solutions

Positive ideal solution (A^+):

$$A^+ = \{v_1^+, v_2^+, \dots, v_n^+\}$$

dimana:

$v_j^+ = \max(v_{ij})$ if j is the benefit criterion

$v_j^+ = \min(v_{ij})$ if j is the cost criterion

Negative ideal solution (A^-):

$$A^- = \{v_1^-, v_2^-, \dots, v_n^-\}$$

dimana:

$v_j^- = \min(v_{ij})$if j is the benefit criterion

$v_j^- = \max(v_{ij})$ if j is the cost criterion

Step 5: Calculating Euclidean Distance

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2}$$

The distance of each alternative from the negative ideal solution:

$$D_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}$$

Step 6: Calculating the Closeness Coefficient

$$CC_i = \frac{D_i^-}{D_i^+ + D_i^-}$$

where $0 \leq CC_i \leq 1$

Step 7: Ranking Alternatives

The alternative with the highest CC_i value is the best alternative.

2.4 Sensitivity Analysis

To test the robustness of the ranking results, a sensitivity analysis was conducted on four criteria weighting scenarios reflecting different strategic priorities: Original Scenario (balanced weights), Focus on Quality ($w_2 = 0.45$), Priority on Cost ($w_1 = 0.45$), and Focus on Sustainability ($w_4 = 0.35$).

3. RESULTS AND DISCUSSION

3.1 Supplier Simulation Data

The simulation dataset used in this research is designed to represent the real-world conditions of electronic component suppliers with varying levels of capability. Table 2 presents the performance profiles of the five alternative suppliers analyzed.

Table 2. Electronic Component Supplier Performance Data (Simulation)

Supplier	Company name	C1: Price (Rp/unit)	C2: Defect Rate (%)	C3: On-Time Delivery (%)	C4: Green Index
S1	PT Elektronika Jaya	675.000	2.5	92	75
S2	CV Mitra Komponen	570.000	3.8	88	65
S3	PT Techno Supply	780.000	1.8	95	82
S4	UD Global Electronics	615.000	4.2	85	58
S5	PT Green Component	720.000	2.1	90	88

The information in Table 2 shows the differences in capabilities between suppliers. Supplier S2 has the most competitive price of Rp 570,000, but at the expense of a relatively high defect rate of 3.8%. S3 performs very well with the lowest defect rate (1.8%) and high on-time delivery (95%), despite its higher price of Rp 780,000. S5 received the highest sustainability score (88), indicating a strong commitment to environmental aspects. S4 performs the worst in most assessment aspects.

3.2 TOPSIS Method Calculation

Decision Matrix Normalization

The normalization procedure is executed using the vector normalization formula. For example, for element S1 in the price parameter (C1):

$$r_{11} = \frac{675.000}{\sqrt{675.000^2 + 570.000^2 + 780.000^2 + 615.000^2 + 720.000^2}} = \frac{675.000}{1.514.859} = 0.4456$$

The same process is performed for all elements of the matrix, resulting in a normalized matrix R.

Weighted Normalized Matrix

Each element of the normalized matrix is multiplied by the corresponding criterion weight. For element S1 in the price criterion:

$$v_{11} = w_1 \times r_{11} = 0.25 \times 0.4456 = 0.1114$$

The results of the weighted normalized matrix calculation are shown in Table 3.

Table 3. Weighted Normalized Matrix

Supplier	C1	C2	C3	C4
S1	0.1114	0.1106	0.1142	0.0902
S2	0.0943	0.1681	0.1092	0.0781
S3	0.1290	0.0797	0.1179	0.0986
S4	0.1017	0.1858	0.1055	0.0697
S5	0.1190	0.0929	0.1117	0.1058

Positive and Negative Ideal Solutions

Based on the type of criteria (cost or benefit), positive and negative ideal solutions are determined:

- C1 (Harga - Cost): $A^+ = 0.0943$ (minimum), $A^- = 0.1290$ (maximum)
- C2 (Defect Rate - Cost): $A^+ = 0.0797$ (minimum), $A^- = 0.1858$ (maximum)
- C3 (On-Time Delivery - Benefit): $A^+ = 0.1179$ (maximum), $A^- = 0.1055$ (minimum)
- C4 (Green Index - Benefit): $A^+ = 0.1058$ (maximum), $A^- = 0.0697$ (minimum)

Distance and Closeness Coefficient Calculation

The distance of each supplier to the positive and negative ideal solutions is calculated using the Euclidean distance formula. For example, for S1:

$$D_1^+ = \sqrt{(0.1114 - 0.0943)^2 + (0.1106 - 0.0797)^2 + (0.1142 - 0.1179)^2 + (0.0902 - 0.1058)^2} = 0.0389$$

$$D_1^- = \sqrt{(0.1114 - 0.1290)^2 + (0.1106 - 0.1858)^2 + (0.1142 - 0.1055)^2 + (0.0902 - 0.0697)^2} = 0.0803$$

$$CC_1 = \frac{0.0803}{0.0389 + 0.0803} = 0.6738$$

The same calculations were performed for all suppliers, and the final results are shown in Table 4.

3.3 Supplier Ranking Results

Table 4. TOPSIS Calculation Results and Final Ranking

Ranking	Supplier	Company name	D^+	D^-	CC	Category
1	S5	PT Green Component	0.0287	0.1004	0.7777	Very good
2	S3	PT Techno Supply	0.0354	0.1107	0.7577	Good
3	S1	PT Elektronika Jaya	0.0389	0.0803	0.6738	Pretty good
4	S2	CV Mitra Komponen	0.0931	0.0400	0.3005	not enough
5	S4	UD Global Electronics	0.1130	0.0273	0.1946	Inadequate

Table 4 shows that PT Green Component (S5) received the top ranking with the maximum proximity coefficient value (0.7777). This value indicates that S5 has the closest distance to the positive ideal solution and the furthest distance from the negative ideal solution compared to other competitors. S5's superiority comes from a good combination of three main aspects: the highest sustainability score (88 points), the lowest defect rate (2.1%), and good delivery accuracy (90%), despite its price being at a moderate level (Rp 720,000/unit).

PT Techno Supply (S3) ranked second with a CC of 0.7577. This supplier demonstrates excellent operational performance with the lowest defect rate (1.8%) and the highest delivery accuracy (95%). However, its premium pricing strategy (Rp 780,000/unit) presents a trade-off that must be considered. S3 is suitable for applications that prioritize maximum reliability and resilience to quality failures.

PT Elektronika Jaya (S1), ranked third (CC = 0.6738), demonstrated balanced performance across all parameters with no significant weaknesses. This supplier could be a realistic choice for medium-priority components that do not require specific top-tier performance.

CV Mitra Komponen (S2) and UD Global Electronics (S4) ranked at the bottom with CC scores of 0.3005 and 0.1946, respectively. These two suppliers demonstrated significant weaknesses in quality (high defect rates) and sustainability (low green index), making them not recommended for establishing long-term strategic relationships.

3.4 Analysis of Trade-offs Between Criteria

The evaluation results demonstrate a typical trade-off pattern in multi-criteria decision-making (MCDM), consistent with the DSS concept, which emphasizes that every purchasing decision involves performance trade-offs across dimensions. The finding that S2 has the lowest price (Rp 570,000) but the highest defect rate (3.8%) reinforces the principle that decisions in the electronics supply chain cannot rely solely on cost parameters, as poor quality can increase the costs of both internal and external failures. Conversely, S3, with the highest price (Rp 780,000) but the lowest defect rate (1.8%), demonstrates the cost quality trade-off phenomenon often mentioned in Total Cost of Ownership (TCO) theory. Calculations show that a 1% reduction in the defect rate requires an additional cost of Rp 70,000 Rp 75,000 per unit, consistent with the literature that improving the reliability of electronic components requires significant marginal cost investments.

In the sustainability dimension, the cost per green point comparison shows that S5 (Rp 8,182/point) is more efficient than S3 (Rp 9,512/point). These findings support the ecological DSS theory that environmental performance can be optimized without excessive cost increases if suppliers have mature manufacturing processes. No supplier excels across all parameters, so selection decisions must follow the compensatory model principle in DSS that is, strengths in one aspect can offset weaknesses in others. In this context, S5 is the most balanced supplier because it consistently ranks second or third in almost all criteria. This phenomenon is important in the electronics industry, which is highly sensitive to quality and continuity of supply, where suppliers with balanced performance tend to present lower operational risks.

3.5 Sensitivity Analysis

A sensitivity analysis was conducted to assess decision robustness across various weighting scenarios, in accordance with the DSS principle that decisions should be stable despite changes in preferences or external conditions. The results show that S5 remained the highest ranked in three of the four scenarios (Original, Price

Priority, Sustainability), indicating strong decision stability. The very low Coefficient of Variation (CV) for S5, 3.08%, demonstrates that S5's closeness coefficient is insensitive to weighting changes. This reflects the supplier's comprehensive and adaptive characteristics to various strategic demands.

The Quality Focus scenario ($w_2 = 0.45$) ranked S3 first with a CC = 0.7924, consistent with quality-driven supply chain theory, where suppliers with the highest reliability automatically receive the highest preference scores when quality is given a high weighting. Meanwhile, in the Sustainability scenario ($w_4 = 0.35$), S5 achieved the highest CC (0.8156), aligning with green supply chain management literature that emphasizes the importance of ecological efficiency in the electronics industry, which faces stringent regulations regarding emissions and waste. On the other hand, S4 consistently ranked last in all scenarios, indicating a systemic internal problem that cannot be addressed simply by changing the criteria weights. The sensitivity results indicate that the decision is not only accurate in a single weighting scenario but also robust within the DSS framework, making it suitable for use as a basis for long-term strategic recommendations.

3.6 Strategic Recommendations

Based on the analysis results and DSS-based decision-making principles, a dual sourcing strategy is recommended to minimize risk, increase supply resilience, and optimize costs and quality in the electronics industry supply chain. S5 is recommended as the primary supplier with a 60% volume allocation due to its most balanced characteristics, stability in sensitivity analysis, and efficiency in the sustainability dimension critical attributes in the electronics industry facing demands for sustainability, innovation speed, and consistent production batches.

S3 with the best quality performance, is allocated 30% for critical components requiring low defect rates and high delivery accuracy. This aligns with supplier segmentation theory, which states that high-quality suppliers should be used for high-risk modules to prevent systemic defects in electronic products.

S1 is recommended as a supplier development strategy due to its relatively high potential. The 12-month performance improvement targets reducing the defect rate from 2.5% to 2.0%, increasing the green index from 75 to 80, and increasing on-time delivery from 92% to 93% are designed to align with continuous improvement standards in the electronics industry. If the target is achieved, S1's volume can be increased to 15–20% as a form of risk diversification.

S2 and S4 are recommended to be gradually reduced due to their performance not meeting quality and delivery standards, as well as high operational risk. S2 can be retained as a backup supplier with 100% quality inspection to prevent quality leakage, while S4 is recommended to be discontinued within six months because its performance demonstrates unacceptable instability in the electronic supply chain system.

4. CONCLUSION

This study demonstrates the effectiveness of the TOPSIS method for selecting electronic component suppliers, considering economic, quality, delivery, and sustainability aspects. PT Green Component (S5) was selected as the best supplier with a closeness coefficient of 0.7777, followed by PT Techno Supply (S3) with a value of 0.7577. These results emphasize the importance of balancing performance, particularly quality and environmental aspects, in supply chain decision-making.

This study provides theoretical contributions that strengthen TOPSIS's role as part of an objective and consistent decision support system. A quality weight of 0.30 is the most dominant factor and aligns with the concept of TQM, while the relationship between quality improvement and investment of IDR 70,000–IDR 75,000 per 1% reduction in defect rate supports the concept of TCO.

This study also provides practical benefits by demonstrating the stability of supplier rankings. S5 and S3 remained in the top two positions across all sensitivity scenarios with Coefficients of Variation of 3.08% and 4.51%, respectively. These findings can be used as a basis for developing procurement strategies, supplier segmentation, and risk management.

Further research can focus on integrating TOPSIS with weighting methods such as AHP or ANP, validating it with electronics industry data, and developing a web-based decision support system to facilitate operational implementation of the model.

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