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A Sustainability-Oriented TOPSIS Framework for Supplier Evaluation and Selection

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Abstract

Supplier selection plays a vital role in enhancing the efficiency and competitiveness of supply chain management (SCM). Selecting the most appropriate supplier mitigates procurement risk, enhances product quality, and guarantees timely delivery. This study establishes a Multi-Criteria Decision-Making (MCDM) framework based on the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to assess and identify the most appropriate plastic raw material supplier for RFL Group. Four supplier alternatives from China were assessed using eleven criteria covering operational, economic, relational, and environmental dimensions, including lead time, reliability, carbon emission rate, quality of raw material, response time, return ability, warranties and claims policies, geographical location, and quantity discount. The criteria were selected based on supplier-selection literature, organizational procurement requirements, and expert judgment. The criterion weights were determined using an expert-based weighting procedure and then applied in the TOPSIS calculation. The results show that Shandong Liangshan Quanxing Plastics Co., Ltd. achieved the highest relative closeness (C_i^*=0.6695). Sensitivity analysis using ±10% changes in key criterion weights confirmed the stability of the final ranking. Comparative AHP-rating synthesis also selected supplier S as the strongest alternative. The study contributes by integrating sustainability-related evaluation, particularly carbon emission rate, into a transparent TOPSIS-based supplier-selection model and by demonstrating how MCDM can support practical procurement decision-making in the plastic manufacturing sector.

1. Introduction

A supplier could be an upstream procedure within the company or an outside provider. Coordination of the flow of goods, services, and information between SC entities such as manufacturers, distributors, suppliers, and customers, is necessary for SCM (Asadabadi et al., 2023).

A strategic choice in supply chain management is choosing a supplier. The sourcing strategy of the manufacturer or customer determines which suppliers are chosen. Through supply chain optimization, it contributes to increased supply chain efficiency. The entire supply chain may get confused as a result of choosing the wrong supplier (Ramakrishnan & Chakraborty, 2020).

The effectiveness and efficiency of the supply chain depend on the strategic choice of the best supplier (Rashidi et al., 2020), (Sun & Cai, 2021). To fulfill the value of end users, save lead times at various supply chain stages, and increase quality and flexibility, a strategic partnership with the appropriate supplier must be integrated into the supply chain (Kumar Bera et al., 2021), (Rahman et al., 2017).

The primary goals of the supplier selection process are to minimize purchase risk, optimize total value for the buyer, and foster intimate, long-lasting relationships between buyers and suppliers. These goals are beneficial in assisting the business in achieving "Just-In-Time" (JIT) manufacturing. Furthermore, as more businesses adopt JIT and Total Quality Management (TQM) principles, the supplier selection challenge has grown in significance. (Özek & Yildiz, 2020). In terms of determining supplier selection criteria, making supplier selection decisions, and keeping track of supplier performance, purchasing and supply management assist the management of the supplier network (Kahraman et al., 2022), (Paradowski & Szyjewski, 2022).

The procedure of supplier selection has progressively transitioned from a conventional cost-quality-delivery framework to a sustainable procurement approach. Sustainable Supply Chain Management underscores that supplier assessment must encompass economic, operational, environmental, and relational performance metrics. Procurement decisions must not only minimize costs and enhance service quality but also promote environmental sustainability (Sun & Cai, 2021). This study categorizes quantity discounts and warranties as indicators of economic and risk-related performance; lead time, reliability, response time, facility and handling, returnability, and raw material quality as indicators of operational performance; organizational attitude as an indicator of relational performance; and carbon emission rate as an indicator of the environmental dimension in sustainable supplier selection.

The process of identifying a supplier that can offer the client goods or services that are appropriate in terms of quality, cost, quantity, and timing is known as supplier selection or evaluation (Zulqarnain et al., 2024), (Okwu & Tartibu, 2020), (Rhamadan Siregar, 2025). There are numerous methods and algorithms that have been applied to the selection of suppliers (Özek & Yildiz, 2020). Analytical Hierarchy Process (AHP) and Data Envelopment Analysis (DEA) are two examples of these methods. The two main branches of multi-criteria decision making (MCDM) models are multi-objective (MODM) and multi-attribution (MADM) models. Because supplier selection issues involve a wide range of characteristics, MADM models are useful tools for choosing a supplier. Typically, these elements don't have the same dimensions, such as cost, delivery time, dependability, quality, and so forth (Xiong et al., 2020), (Paradowski & Szyjewski, 2022). The decision-makers (DMs) are assisted by MCDM procedures when assessing a group of options (Ramadhanti & Pulansari, 2022), (Asadabadi et al., 2023). TOPSIS (Technique for Order-Preference by Similarity to Ideal Solution) is one of the most well-known MADM model approaches. Using a combination of quantitative factors (such cost, time, distance, etc.) and qualitative factors (including relationship quality, quality assurance, and dependability), TOPSIS assesses all options collectively (Xiong et al., 2020), (Putri & Pulansari, 2022). TOPSIS is suitable for supplier selection because it ranks alternatives according to their closeness to a positive ideal solution and distance from a negative ideal solution. This logic is useful when decision-makers need to evaluate suppliers across several benefit and cost criteria simultaneously. Although TOPSIS does not independently generate criteria weights, it becomes effective when combined with a transparent weighting procedure, as applied in this study (Ramakrishnan & Chakraborty, 2020). As a result, TOPSIS is employed solely for selecting a single option from a set of alternatives, irrespective of the suitability of the chosen option. Over the course of the last ten years, TOPSIS has been effectively implemented in the following domains: supplier evaluation and selection, inter-company comparison, risk assessment, facility location selection, robot selection, operating system selection, software outsourcing issues, partner selection, customer evaluation, weapon selection, and performance evaluation (Rhamadan Siregar, 2025).

Previous supplier-selection studies have applied several MCDM approaches, including AHP, DEA, TOPSIS, Fuzzy TOPSIS, BWM, and hybrid decision models. AHP is useful for deriving criteria weights through pairwise comparison but becomes time-consuming when many criteria are involved. DEA is effective for efficiency analysis but is less direct for ranking suppliers according to closeness to ideal and negative-ideal performance. Fuzzy methods are useful when expert judgments are highly uncertain, but they require additional linguistic scales and fuzzy conversion rules. TOPSIS was selected in this study because it provides a simple, transparent, and reproducible ranking procedure for evaluating multiple suppliers across both benefit-type and cost-type criteria. Although TOPSIS has been widely used in supplier-selection research, many studies focus on general supplier ranking without presenting a transparent calculation process using real industrial procurement criteria. Moreover, limited studies have applied a sustainability-oriented TOPSIS framework to plastic raw-material supplier selection in a developing-country manufacturing context. The present study addresses this gap by evaluating four Chinese suppliers of RFL Group using eleven operational, economic, relational, and environmental criteria. The novelty of the study lies in combining traditional supplier-performance indicators with carbon emission rate and validating the ranking through sensitivity analysis.

J. of Technology Management and Business Vol. 13 No. 1 (2026) p. 44-60

The study makes three contributions. First, it develops a structured TOPSIS-based supplier-selection framework for RFL Group's plastic raw-material procurement. Second, it integrates sustainability into supplier evaluation by including carbon emission rate as an environmental criterion. Third, it improves decision reliability by incorporating sensitivity analysis to examine whether the supplier ranking remains stable under changes in criteria weights.

The primary objective of this study is to identify and select the most suitable supplier for RFL Group using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method within multi-criteria decision-making (MCDM) framework. To achieve this, the following specific objectives were formulated: to identify and evaluate the key criteria affecting supplier selection in supply chain management, and to apply the TOPSIS method for ranking and selecting the most suitable supplier for RFL Group and demonstrate the effectiveness of TOPSIS as a reliable and systematic multi-criteria decision-making tool for supplier evaluation.

2. Materials and Methods

This study used a case-based quantitative MCDM approach to evaluate and rank plastic raw-material suppliers for RFL Group. The research process consisted of seven stages: identification of supplier alternatives, selection of evaluation criteria, determination of criterion weights, construction of the decision matrix, normalization of supplier scores, TOPSIS ranking, and validation through sensitivity analysis. The TOPSIS method was selected because it can compare multiple suppliers simultaneously and identify the alternative closest to the positive ideal solution and farthest from the negative ideal solution.

2.1 Case Organization and Supplier Alternatives

The case organization of this study is RFL Group, a plastic manufacturing company that imports plastic raw materials from China. Four supplier alternatives were considered based on RFL Group's supplier list and procurement relevance. The alternatives were Dongguan Sunmei Plastic Raw Material Co., Ltd. (D), Jiangsu Huaao High-Tech Development Co., Ltd. (J), Shandong Liangshan Quanxing Plastics Co., Ltd. (S), and Xiamen Keyuan Plastic Co., Ltd. (X). These alternatives represent the supplier set evaluated in the TOPSIS model.

Table 1 *Supplier alternatives considered in the study*

SL	Name of company	Location	Relation with RFL	Company Rating
01	Dongguan Sunmei Plastic Raw Material Co., Ltd (D)	Chengdu, China	3	Good
02	Jiangsu Huaao High-Tech Development Co., Ltd. (J)	Jiangsu, China	2	Good
03	Shandong Liangshan Quanxing Plastics Co., Ltd. (S)	Shenzhen, China	4	Good
04	Xiamen Keyuan Plastic Co., Ltd. (X)	Foshan, China	1	Good

2.2 Criteria Selection and Justification

The supplier evaluation criteria were selected based on supplier-selection literature, procurement relevance, and the operational requirements of RFL Group. The criteria represent four dimensions of supplier performance: operational performance, economic performance, relational performance, and environmental sustainability. Operational criteria include lead time, reliability, quality of raw material, response time, return ability, and facility and handling. Economic criteria include quantity discount and warranties and claims policies. Relational performance is represented by the attitude of each supplier toward the organization. Environmental sustainability is represented by carbon emission rate. This structure ensures that the supplier evaluation does not depend only on cost but also considers reliability, quality, risk, cooperation, and sustainability.

Table 2 *Criteria classification and justification*

SL	Criteria	Type	Performance dimension	Justification
01	Lead time	Cost	Operational	Shorter lead time supports production continuity and reduces inventory uncertainty.
02	Reliability	Benefit	Operational	Reliable suppliers reduce supply disruption and procurement risk.
03	Carbon emission rate	Cost	Environmental	Lower carbon emission supports sustainable procurement and green supply chain goals.
04	Quality of raw material	Benefit	Operational/ quality	Higher raw-material quality improves production efficiency and product quality.
05	Response time	Benefit rating	Operational	Faster and more effective supplier response improves coordination.
06	Return ability	Benefit	Risk management	Strong return ability reduces loss from defective or unsuitable materials.
07	Facility and handling	Benefit	Operational	Better facilities and handling improve material safety and logistics performance.
08	Warranties and claims policies	Benefit	Economic/risk	Strong warranty policies protect the buyer against defects and procurement losses.
09	Attitude towards organization	Benefit	Relational	Cooperative supplier attitude supports long-term buyer-supplier relationships.
10	Geographical location	Benefit rating	Logistical	A favorable location supports delivery convenience and logistics reliability.
11	Quantity discount	Benefit	Economic	Higher discount improves procurement cost efficiency.

Lead time and carbon emission rate were treated as cost criteria because lower actual values are preferred. Response time and geographical location were treated as benefit ratings because the scores used in the decision matrix represent better responsiveness and location suitability, respectively.

2.3 Data Source and Scoring Procedure

Supplier performance data were obtained from RFL Group's supplier evaluation information and consultation with personnel involved in procurement and supply-chain operations. The suppliers were evaluated using a 1-9 rating scale, where 1 indicates very poor performance and 9 indicates excellent performance. For qualitative criteria such as supplier attitude, warranties and claims policies, return ability, and facility handling, scores were assigned based on expert judgment. For operational and environmental criteria such as lead time, response time, geographical suitability, and carbon emission rate, the scores were converted into comparable ratings before TOPSIS analysis. This ensured that all criteria could be analyzed within a single decision matrix.

J. of Technology Management and Business Vol. 13 No. 1 (2026) p. 44-60

Table 3 *Decision matrix of supplier performance scores*

Factors	Lead Time	Reliability	Carbon emission rate	Quality of raw material	Response time	Return ability	Facility and handling	Warranties and claims policies	Attitude toward organization	Geographical location	Quantity discount
Name of supplier	Relative importance matrix										
D	7	9	8	6	9	7	8	7	9	8	7
J	9	7	8	9	6	8	9	6	9	7	8
S	9	7	8	8	7	9	8	9	8	7	9
X	7	8	9	8	7	9	9	8	7	7	9

To improve judgment consistency, the experts' weight assessments were discussed collectively, and final weights were accepted only after consensus was reached among the four evaluators.

2.4 Weight Determination

The criterion weights were determined using an expert-based weighting approach. Procurement and supply-chain personnel assessed the relative importance of each criterion according to RFL Group's sourcing priorities, operational risk, cost considerations, and sustainability objectives. The individual important values were standardized to ensure the overall weight equals 1.00. Carbon emission rate received the highest weight because the company's supplier evaluation increasingly emphasizes environmental responsibility and sustainable procurement. Quantity discount received the second-highest weight because cost efficiency remains an important procurement objective. Reliability, response time, quality, warranties, and geographical location were also assigned meaningful weights because they directly influence operational continuity and procurement risk.

Table 4 *Criteria weights and justification*

SL	Criteria	Weight	Performance dimension	Justification
01	Lead time	0.05	Operational	Important for timely production and delivery planning.
02	Reliability	0.07	Operational	Reduces risk of supply disruption.
03	Carbon emission rate	0.4	Environmental	Represents environmental sustainability priority.
04	Quality of raw material	0.06	Operational/ quality	Supports product quality and process efficiency.
05	Response time	0.07	Operational	Improves coordination and problem-solving speed.
06	Return ability	0.02	Risk management	Reduces risk from defective or unsuitable materials.
07	Facility and handling	0.045	Operational	Indicates supplier capability in safe and efficient material handling.
08	Warranties and claims policies	0.065	Economic/risk	Protects buyer from quality and delivery-related losses.

SL	Criteria	Weight	Performance dimension	Justification
09	Attitude towards organization	0.035	Relational	Reflects cooperation and relationship quality.
10	Geographical location	0.065	Logistical	Affects logistics convenience and delivery reliability.
11	Quantity discount	0.12	Economic	Supports procurement cost reduction.

2.5 TOPSIS Calculation Procedure

TOPSIS ranks alternatives according to their distance from a positive ideal solution and a negative ideal solution. The positive ideal solution represents the best performance values across all criteria, while the negative ideal solution represents the worst performance values. The following steps were applied.

Step 1: Construct the decision matrix

$$X = \left[x_{ij}\right]_{m\times n}$$

Where x_{ij} is the performance score of suppliers i with respect to the criterion j, m is the number of suppliers, and n is the number of criteria.

Step 2: Normalize the decision matrix

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

where r_{ij} is the normalized value of supplier i under criterion j.

Step 3: Construct the weighted normalized matrix

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

where w_j is the weight of criterion j, and v_{ij} is the weighted normalized value.

Step 4: Determine positive and negative ideal solutions

For benefit criteria:

$$v_j^+ = \max_i(v_{ij}), \qquad v_j^- = \min_i(v_{ij})$$

For cost criteria:

$$v_j^- = \max_i(v_{ij}), \qquad v_j^+ = \min_i(v_{ij})$$

Thus:

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

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

where A^+ is the positive ideal solution and A^- is the negative ideal solution.

Step 5: Calculate separation distances

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

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

where S_i^+ is the distance from the positive ideal solution and S_i^- is the distance from the negative ideal solution.

Step 6: Calculate relative closeness

$$C_i^* = \frac{S_i^-}{S_i^+ + S_i^-}$$

where C_i^* is the relative closeness coefficient. The supplier with the highest C_i^* value is ranked first.

For example, the normalization of supplier D for lead time is calculated as follows. The squared sum of lead time scores is $7^2 + 9^2 + 9^2 + 7^2 = 260$, and the square root is $\sqrt{260} = 16.155$. Therefore, the normalized value for supplier D under lead time is $7/16.155 = 0.4337$. Since the weight of lead time is 0.05, the weighted normalized value is $0.4337 \times 0.05 = 0.0217$. This procedure was repeated for all suppliers and criteria.

2.6 Research Framework

TOPSIS The research framework consists of the following stages: identification of supplier alternatives, selection of evaluation criteria, determination of criteria weights, construction of the decision matrix, normalization, weighted normalization, determination of ideal and negative-ideal solutions, calculation of separation distances, calculation of closeness coefficients, final ranking, and validation through sensitivity analysis.

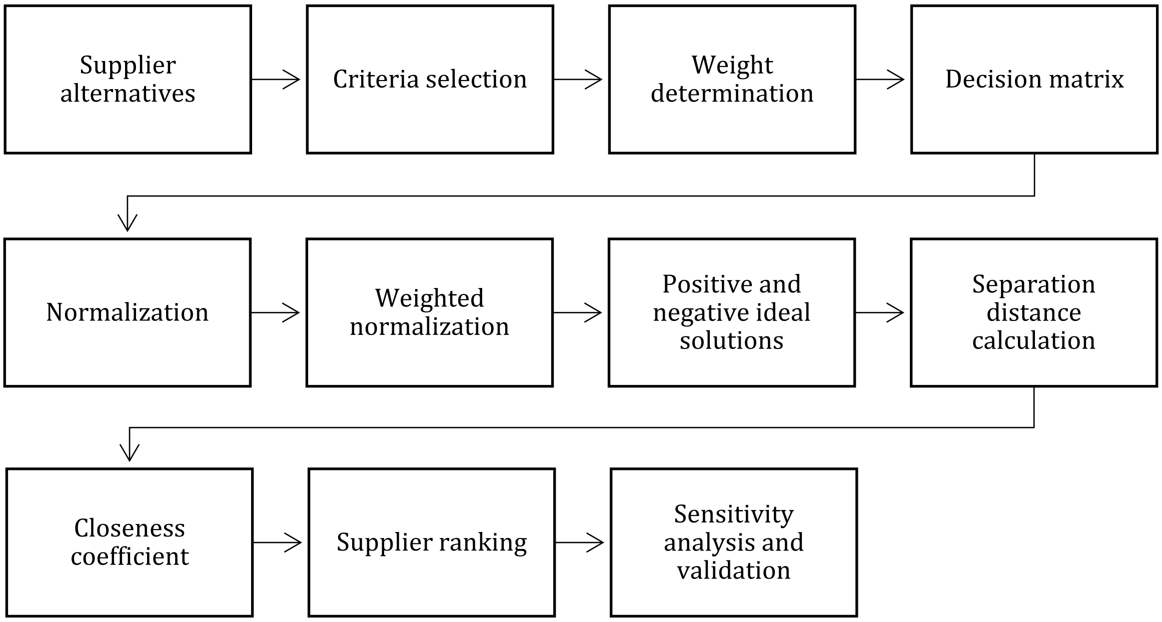

Fig. 1 *Proposed TOPSIS-based supplier-selection framework*

Fig. 1 summarizes the methodological flow of the study and directly responds to the need for a clearer analytical framework. It shows how the study moves from supplier identification and criteria selection to TOPSIS calculation, final ranking, and robustness validation.

2.7 Validation Procedure

To test the robustness of the TOPSIS result, this study conducted sensitivity analysis and comparative ranking validation. Sensitivity analysis was performed by changing selected criterion weights by ±10% and recalculating the TOPSIS ranking. The selected criteria included carbon emission rate, quantity discount, reliability, response time, quality of raw material, warranties and claims policies, and lead time because these criteria represent environmental, economic, operational, and risk-related supplier-performance dimensions. After each weight adjustment, the remaining weights were proportionally normalized so that the total weight remained equal to 1.00.

Table 5 *Sensitivity analysis scenarios*

Scenario	Weight adjustment	Purpose
Base case	Original criterion weights	Represents the original TOPSIS ranking
Scenario 1	Carbon emission rate +10%	Tests stronger environmental priority
Scenario 2	Carbon emission rate −10%	Tests lower environmental priority
Scenario 3	Quantity discount +10%	Tests stronger cost-saving priority
Scenario 4	Quantity discount −10%	Tests lower cost-saving priority
Scenario 5	Quality of raw material +10%	Tests stronger quality priority
Scenario 6	Quality of raw material −10%	Tests lower quality priority
Scenario 7	Reliability +10%	Tests stronger operational reliability priority
Scenario 8	Reliability −10%	Tests lower operational reliability priority
Scenario 9	Lead time +10%	Tests stronger delivery-time priority
Scenario 10	Lead time -10%	Tests lower delivery-time priority
Scenario 11	Warranties and claims policies +10%	Tests stronger procurement-risk protection priority
Scenario 12	Warranties and claims policies -10%	Tests lower procurement-risk protection priority
Scenario 13	Response time +10%	Tests stronger responsiveness priority
Scenario 14	Response time -10%	Tests lower responsiveness priority

To further validate the TOPSIS result, an AHP-rating synthesis approach was applied as an alternative MCDM aggregation procedure. This validation was conducted to examine whether the top-ranked supplier remained consistent when the supplier scores were evaluated using normalized priority ratings instead of TOPSIS distance-based ranking.

For benefit criteria, where higher values indicate better performance, the priority rating of supplier i under criterion j was calculated as:

$$p_{ij} = \frac{x_{ij}}{\sum_i x_{ij}}$$

For cost criteria, where lower values are preferred, the reciprocal form was used:

$$p_{ij} = \frac{1/x_{ij}}{\sum_i 1/x_{ij}}$$

where x_{ij} represents the performance score of supplier i under criterion j, and p_{ij} represents the normalized priority rating. The final comparative score for each supplier was then calculated by multiplying each priority rating by its corresponding criterion weight and summing across all criteria:

$$AHP_i = \sum_j w_j p_{ij}$$

where w_j is the weight of criterion j, and AHP_i is the final AHP-rating synthesis score of supplier i. The suppliers were ranked according to their AHP_i values and compared with the TOPSIS ranking. This validation was not intended to replace TOPSIS; rather, it was used to test whether the preferred supplier remained stable under another MCDM aggregation logic. A consistent top-ranked supplier across both methods indicates stronger reliability and robustness of the final supplier-selection decision.

3. Result and Discussion

This study provides the TOPSIS-based multi-criteria decision-making approach for supplier assessment at RFL Group, utilizing four supplier alternatives and eleven evaluation criteria. Since the supplier alternatives, criteria, weights, and decision matrix have already been described in the Materials and Methods section. To ensure clarity and reproducibility, the outcomes are delineated sequentially. Initially, the normalization values are shown, succeeded by the normalized and weighted normalized matrices. Subsequently, the positive and negative ideal solutions are determined, followed by the computation of separation distances and closeness coefficients. Sensitivity analysis and comparison validation are employed to evaluate the robustness of the supplier rating.
TOPSIS is one of the popular approaches for selecting the best supplier among these criteria.

J. of Technology Management and Business Vol. 13 No. 1 (2026) p. 44-60

3.1 Normalization of the Decision Matrix

The decision matrix was normalized using vector normalization to convert all supplier scores into comparable, non-dimensional values, since the evaluation criteria differ in meaning and relative importance. The squared sum and square root values calculated from the supplier scores are presented in Table 6 and were used as the normalization denominators for each criterion.

Table 6 *Squared sum and square root values for normalization*

Factors	Lead Time	Reliability	Carbon emission rate	Quality of raw material	Response time	Return ability	Facility and handling	Warranties and claims policies	Attitude toward organization	Geographical location	Quantity discount
D	7	9	8	6	9	7	8	7	9	8	7
J	9	7	8	9	6	8	9	6	9	7	8
S	9	7	8	8	7	9	8	9	8	7	9
X	7	8	9	8	7	9	9	8	7	7	9
$\sum X_{ij}^2$	260	243	273	245	215	275	290	230	275	211	258
$(\sum X_{ij}^2)^{\frac{1}{2}}$	16.1	15.5	16.5	15.6	14.6	16.5	17.0	15.1	16.5	14.5	16.0

Table 6 provides the denominator values used to convert the original supplier scores into normalized values. For example, the normalization denominator for lead time is 16.1. Therefore, supplier D's normalized lead-time value is 7/16.1=0.4341. This process was repeated for all suppliers and criteria.

3.2 Normalized Decision Matrix

The normalized decision matrix is shown in Table 7. This table presents the relative performance of each supplier after removing the effect of scale differences among criteria.

Table 7 *Normalized decision matrix (r_{ij})*

Factors	Lead Time	Reliability	Carbon emission rate	Quality of raw material	Response time	Return ability	Facility and handling	Warranties and claims policies	Attitude toward organization	Geographical location	Quantity discount
D	0.43	0.58	0.51	0.38	0.61	0.42	0.47	0.46	0.54	0.55	0.44
J	0.50	0.50	0.51	0.58	0.41	0.48	0.53	0.40	0.54	0.48	0.50
S	0.50	0.50	0.51	0.51	0.48	0.54	0.47	0.60	0.48	0.48	0.50
X	0.43	0.51	0.55	0.51	0.48	0.54	0.53	0.53	0.42	0.48	0.56

Table 7 shows that no supplier dominates all criteria. Supplier D performs strongly in reliability, response time, supplier attitude, and geographical location. Supplier J performs strongly in lead time and quality of raw material. Supplier S performs strongly in return ability, warranties and claims policies, and quantity discount. Supplier X performs strongly in carbon emission rating, return ability, facility and handling, and quantity discount. This indicates that supplier selection is a multi-criteria problem and cannot be solved properly using a single factor such as price or quality alone.

3.3 Weighted Normalized Decision Matrix

After normalization, each normalized value was multiplied by its corresponding criterion weight. This step is important because all criteria do not have equal importance in RFL Group's supplier-selection decision. The weighted normalized matrix is presented in Table 8

Table 8 *Weighted normalized decision matrix (v_{ij})*

Factors	Lead Time	Reliability	Carbon emission rate	Quality of raw material	Response time	Return ability	Facility and handling	Warranties and claims policies	Attitude toward organization	Geographical location	Quantity discount
D	.021	.040	.204	.022	.042	.008	.021	.029	.018	.035	.052
J	.025	.035	.204	.034	.028	.009	.023	.026	.018	.031	.069
S	.025	0.035	.204	.030	.033	.010	.021	.039	.016	.031	.065
X	.021	0.035	.223	.030	.036	.010	.023	.034	.014	.031	.067

Table 8 shows the actual influence of each supplier score after considering criterion weights. Carbon emission rate has the highest weight in the model; therefore, differences in carbon emission performance strongly affect the final TOPSIS ranking. Quantity discount, reliability, response time, warranties and claims policies, and geographical location also influence the ranking, but to a lower extent than carbon emission rate.

J. of Technology Management and Business Vol. 13 No. 1 (2026) p. 44-60

3.4 Positive Ideal and Negative Ideal Solutions

The positive ideal solution represents the best possible performance across all criteria, while the negative ideal solution represents the least preferred performance. In this study, lead time and carbon emission rate were treated as cost-type criteria because lower actual values are preferred. The remaining criteria were treated as benefit-type criteria because higher scores indicate better supplier performance.

Table 9 *Positive ideal and negative ideal solutions*

Criterion	Type	Positive ideal (A^+)	Negative ideal (A^-)
Lead time	Cost	0.0217	0.0279
Reliability	Benefit	0.0404	0.0314
Carbon emission rate	Cost	0.1937	0.2179
Quality of raw material	Benefit	0.0345	0.023
Response time	Benefit	0.043	0.0286
Return ability	Benefit	0.0109	0.0084
Facility and handling	Benefit	0.0238	0.0211
Warranties and claims policies	Benefit	0.0386	0.0257
Attitude toward organization	Benefit	0.019	0.0148
Geographical location	Benefit	0.0358	0.0313
Quantity discount	Benefit	0.0651	0.0507

Table 9 establishes the benchmark used to measure each supplier's relative position. A supplier is preferred when it is closer to the positive ideal solution and farther from the negative ideal solution. This is the central logic of TOPSIS.

3.5 Separation Distance Matrix

The separation distance from the positive ideal solution (S_i^+), the separation distance from the negative ideal solution (S_i^-) in tables 10 and 11.

Table 10 *Separation distance from the positive ideal solution* ($\boldsymbol{S_i^+}$)

Factors	D	J	S	X
Lead Time	0	0.00001225	0.00001225	0
Reliability	0	0.00003136	0.00003136	0.00002401
Carbon emission rate	0	0	0	0.000256
Quality of raw material	0.000144	0	0.00001764	0.00001764
Response time	0	0.000196	0.00008281	0.00003721
Return ability	0.00000576	0.00000144	0	0
Facility and handling	0.00000729	0	0.00000729	0
Warranties and claims policies	0.00008281	0.000169	0	0.00002116
Attitude toward organization	0	0	0.00000441	0.00001764
Geographical location	0	0.00002116	0.00002116	0.00002116
Quantity discount	0.00020736	0.00005184	0.00005184	0

J. of Technology Management and Business Vol. 13 No. 1 (2026) p. 44-60

Table 11 *Separation distance from the positive ideal solution* ($\boldsymbol{S_i^-}$)

Factors	Lead Time	Reliability	Carbon emission rate	Quality of raw material	Response time	Return ability	Facility and handling	Warranties and claims policies	Attitude toward organization	Geographical location	Quantity discount
D	0.00001225	0.00003136	0.000256	0	0.000196	0	0	0.00001521	0.00001764	0.00002116	0
J	0	0	0.000256	0.000144	0	0.00000144	0.00000729	0	0.00001764	0	0.00005184
S	0	0	0.000256	0.00006048	0.00002401	0.00000576	0	0.000169	0.00000484	0	0.00005184
X	0.00001225	0.00000049	0	0.00006048	0.00006241	0.00000576	0.00000729	0.00007056	0	0	0.00020736

3.6 Separation Distance, Closeness Coefficient and Final Ranking

The separation distance from the positive ideal solution (S_i^+), the separation distance from the negative ideal solution (S_i^-), and the relative closeness coefficient (C_i^*) were calculated for each supplier. The final TOPSIS ranking is presented in Table 12.

Table 12 *Relative closeness coefficient and ranking*

Supplier	(S_i^+)	(S_i^-)	(C_i^*)	Rank
Shandong Liangshan Quanxing Plastics Co., Ltd. (S)	0.016	0.0324	0.6695	1
Dongguan Sunmei Plastic Raw Material Co., Ltd. (D)	0.0207	0.0311	0.6004	2
Jiangsu Huaao High-Tech Development Co., Ltd. (J)	0.0237	0.0282	0.5432	3
Xiamen Keyuan Plastic Co., Ltd. (X)	0.0277	0.0209	0.4296	4

Table 12 shows that Shandong Liangshan Quanxing Plastics Co., Ltd. obtained the highest closeness coefficient ($C_i^* = 0.6695$). Therefore, Therefore, supplier S is ranked first, followed by supplier D, supplier J, and supplier X. This result indicates that supplier S is closest to the ideal supplier profile when all criteria and weights are considered together.

3.7 Sensitivity Analysis

Sensitivity analysis was conducted by changing selected criterion weights by ±10%. Sensitivity analysis is important because the TOPSIS ranking depends on the assigned criterion weights. If the ranking changes significantly after a small change in weight, the result may be considered unstable. However, if the ranking remains consistent, the decision outcome can be considered robust.

Table 13 *Sensitivity analysis of TOPSIS ranking*

Scenario	D	J	S	X	Ranking
Base case	0.6004	0.5432	0.6695	0.4296	S > D > J > X
Carbon emission rate +10%	0.6147	0.561	0.6817	0.4115	S > D > J > X
Carbon emission rate −10%	0.5857	0.5245	0.6571	0.4489	S > D > J > X
Quantity discount +10%	0.5887	0.5425	0.6741	0.4414	S > D > J > X
Quantity discount −10%	0.6121	0.5439	0.6653	0.4179	S > D > J > X
Quality of raw material +10%	0.5929	0.5475	0.6695	0.4326	S > D > J > X
Quality of raw material −10%	0.6077	0.5393	0.6696	0.4269	S > D > J > X
Reliability +10%	0.6025	0.5396	0.6624	0.4301	S > D > J > X
Reliability −10%	0.5985	0.5467	0.6763	0.4292	S > D > J > X
Lead time +10%	0.6014	0.5415	0.6661	0.4319	S > D > J > X
Lead time −10%	0.5995	0.5449	0.6727	0.4276	S > D > J > X
Warranties and claims policies +10%	0.5967	0.5358	0.6731	0.4333	S > D > J > X
Warranties and claims policies −10%	0.604	0.5503	0.6662	0.4262	S > D > J > X
Response time +10%	0.6057	0.5341	0.662	0.428	S > D > J > X
Response time −10%	0.5955	0.5521	0.6768	0.4312	S > D > J > X

The sensitivity analysis shows that supplier S remains the top-ranked supplier under all tested scenarios. This confirms that the final decision is stable and does not depend only on a single criterion weight. Therefore, the selection of Shandong Liangshan Quanxing Plastics Co., Ltd. can be considered robust under moderate changes in decision-maker priorities.

3.8 Comparative Validation

To further validate the TOPSIS result, a comparative ranking was performed using an AHP-rating synthesis approach. In this validation, the normalized supplier ratings were multiplied by the criteria weights to obtain an overall preference score for each supplier. The purpose of this comparison was not to replace TOPSIS but to examine whether the best supplier remains consistent under another MCDM aggregation logic.

Table 14 *Comparative validation using AHP-rating synthesis*

Supplier	AHP-rating score	Comparative rank
S	0.2544	1
D	0.2535	2
X	0.2465	3
J	0.2456	4

The comparative validation also identifies supplier S as the best supplier. Although minor changes occur in the middle ranking positions, the top-ranked supplier remains unchanged. This confirms that the selection of supplier S is stable across both TOPSIS and comparative MCDM aggregation.

3.9 Interpretation of Supplier Performance

Supplier S achieved the highest TOPSIS score because it provides the most balanced performance across operational, economic, risk-related, and sustainability criteria. It performs strongly in return ability, warranties and claims policies, and quantity discount. These strengths are important because return ability reduces procurement risk, warranty support protects RFL Group against defective materials, and quantity discount improves cost efficiency.

Supplier D ranks second because it performs well in reliability, response time, supplier attitude, and geographical location. Supplier J ranks third because it performs strongly in lead time and raw-material quality but is weaker in response time and warranty support. Supplier X performs well in some criteria such as facility handling and quantity discount, but its distance from the ideal profile is larger when all weighted criteria are considered. These trade-offs demonstrate why TOPSIS is useful: it evaluates the total performance profile rather than selecting a supplier based on one criterion.

3.10 Comparison with Previous Studies

The findings are consistent with previous MCDM-based supplier-selection studies, which show that TOPSIS is effective for ranking suppliers under multiple and conflicting criteria. Similar to (Okwu & Tartibu, 2020) and (Ramakrishnan & Chakraborty, 2020), this study confirms that TOPSIS can integrate traditional supplier criteria with sustainability-related factors such as carbon emission rate. The study also aligns with (Asadabadi et al., 2023), who emphasized the usefulness of combining weighting and ranking approaches in supplier evaluation. In this study, TOPSIS was strengthened through sensitivity analysis and comparative validation, addressing the concern that supplier rankings may be influenced by criterion weights. Furthermore, the inclusion of carbon emission rate supports the sustainable supplier-selection perspective discussed by (Sun & Cai, 2021). Unlike studies that focus maily on cost, quality, and delivery, this research incorporates environmental performance into supplier evaluation for plastic raw-material procurement. Therefore, the study contributes to existing literature by applying a sustainability-oriented TOPSIS framework to a practical RFL Group supplier-selection case and by validating the ranking through robustness analysis.

3.11 Managerial Implications

The findings provide several managerial implications for RFL Group. First, the TOPSIS framework can support more objective supplier selection by combining multiple procurement criteria into one transparent ranking model. Second, the result suggests that RFL should prioritize suppliers that demonstrate balanced performance across cost, quality, reliability, risk management, and sustainability rather than focusing only on price or quantity discount. Third, the inclusion of carbon emission rate allows procurement managers to align supplier selection with sustainable supply chain objectives. Fourth, the sensitivity analysis shows that the selection of supplier S remains stable under moderate changes in weights, giving managers greater confidence in the final decision. Finally, the model can be reused periodically to monitor supplier performance and update sourcing decisions as supplier conditions change.

3.12 Limitations of the Study

This study has several limitations. First, the analysis considered only four suppliers from RFL Group's plastic raw-material supplier list; therefore, the findings may not represent all possible suppliers in the market. Second, the supplier scores were based on available evaluation information and expert judgment, which may include some subjectivity. Third, the criterion weights reflect the procurement priorities of the specific case organization; other organizations may assign different weights depending on their strategic goals. Fourth, the study used classical TOPSIS, which does not fully capture uncertainty in linguistic judgments. Finally, the model was applied to one industrial context, so further studies are required to test its generalizability in other sectors.

4. Conclusion

This study applied the TOPSIS method to evaluate and select the most suitable plastic raw-material supplier for RFL Group using eleven supplier-selection criteria. The criteria covered operational, economic, relational, and environmental dimensions, allowing the supplier-selection process to reflect both traditional procurement performance and sustainability concerns. The TOPSIS analysis identified Shandong Liangshan Quanxing Plastics Co., Ltd. as the most suitable supplier because it achieved the highest relative closeness to the ideal solution.

The study demonstrates that TOPSIS is an effective decision-support tool for supplier evaluation because it provides a transparent, systematic, and reproducible ranking procedure. The sensitivity analysis confirmed that supplier S remained the best alternative under moderate changes in key criterion weights, strengthening the reliability of the result and AHP-rating synthesis also identified supplier S as the best supplier. The study contributes to sustainable supplier-selection literature by integrating carbon emission rate with conventional criteria such as quality, reliability, lead time, warranty support, and quantity discount. For managers, the proposed framework offers a practical method for selecting suppliers based on balanced overall performance rather than single-factor judgment.

Future Recommendation

Future research may extend this study by applying hybrid MCDM methods such as AHP-TOPSIS, BWM-TOPSIS, DEMATEL-TOPSIS, or Fuzzy TOPSIS. AHP or BWM can be used to derive more consistent criterion weights, while DEMATEL can examine interrelationships among criteria. Fuzzy TOPSIS can be applied to handle uncertainty in qualitative judgments, especially for criteria such as supplier attitude, warranty support, reliability, and facility handling.

Future studies may also compare TOPSIS results with other ranking methods such as VIKOR, PROMETHEE, WASPAS, DEA, or Grey Relational Analysis to examine ranking consistency. In addition, the model can be expanded by including more suppliers, more sustainability indicators, real-time supplier-performance data, life-cycle assessment, and risk-related factors such as geopolitical instability, supply disruption, and currency fluctuation. Applying the proposed framework in other industries would also help test the generalizability of the model.

Summary of Novel Conclusions

This study provides a sustainability-oriented TOPSIS framework for supplier evaluation in RFL Group's plastic raw-material procurement context. By integrating qualitative and quantitative criteria, including carbon emission rate, the study extends conventional supplier evaluation beyond cost, quality, and delivery. The results revealed that Shandong Liangshan Quanxing Plastics Co., Ltd. achieved the highest closeness coefficient ($C_i^* = 0.6695$), making it the most suitable supplier among the alternatives evaluated. The revised model also improves methodological rigor through transparent criteria justification, expert-based weight determination, complete TOPSIS equations, sensitivity analysis, and comparative AHP-rating validation.

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Conflict of Interest

The authors state that none of their personal ties or known conflicting financial interests might have appeared to have influenced the work described in this study.

Author Contribution

*The authors confirm contribution to the paper as follows: **study conception and design:** Md. Saifur Rahman, A.S.M. Tariq Hoque; **data collection:** A.S.M. Tariq Hoque; **analysis and interpretation of results:** Md. Hasan Ali, Md. Saifur Rahman, A.S.M. Tariq Hoque; Md. Rafiquzzaman; **draft manuscript preparation:** Md Hasan Ali, Md. Saifur Rahman, A.S.M. Tariq Hoque. All authors reviewed the results and approved the final version of the manuscript.*

References

Asadabadi, M. R., Ahmadi, H. B., Gupta, H., & Liou, J. J. H. (2023). Supplier selection to support environmental sustainability: the stratified BWM TOPSIS method. Annals of Operations Research, 322(1), 321–344. https://doi.org/10.1007/s10479-022-04878-y

Atthirawong, W. (2020). Application of TOPSIS Method to Green Supplier Selection for a Thai OTOP Producer. Current Applied Science and Technology, 20(1), 144–155. https://doi.org/10.14456/cast.2020.4

Kahraman, C., Cebi, S., Onar, S. C., & Öztayşi, B. (2022). Pharmaceutical 3PL supplier selection using interval-valued intuitionistic fuzzy TOPSIS. Notes on Intuitionistic Fuzzy Sets, 28(3), 361–374. https://doi.org/10.7546/nifs.2022.28.3.361-374

Kumar Bera, A., Kumar Jana, D., Banerjee, D., & Nandy, T. (2021). A group evaluation method for supplier selection based on interval type-2 fuzzy TOPSIS method A group evaluation method for supplier selection. In Int. J. Business Performance and Supply Chain Modelling (Vol. 12, Issue 1).

Okwu, M. O., & Tartibu, L. K. (2020). Sustainable supplier selection in the retail industry: A TOPSIS- and ANFIS-based evaluating methodology. International Journal of Engineering Business Management, 12. https://doi.org/10.1177/1847979019899542

Özek, A., & Yildiz, A. (2020). Digital supplier selection for a garment business using interval type-2 fuzzy TOPSIS. Tekstil ve Konfeksiyon, 30(1), 61–72. https://doi.org/10.32710/tekstilvekonfeksiyon.569884

Paradowski, B., & Szyjewski, Z. (2022). Comparative analyses of multi-criteria methods in supplier selection problem. Procedia Computer Science, 207, 4593–4602. https://doi.org/10.1016/j.procs.2022.09.523

Putri, F. K., & Pulansari, F. (2022). PVC Resin Supplier Selection with Integration of AHP and TOPSIS Methods. Jurnal Manajemen Industri Dan Logistik, 6(1), 84–98. https://doi.org/10.30988/jmil.v6i1.952

Rahman, M. S., Hasan Ali, M., & Hoque, A. S. M. T. (2017). Cost Minimization and Environmental Impact Reduction on the Basis of Green Supply Chain Management Concept. In International Conference on Mechanical, Industrial and Materials Engineering (Vol. 2017).

Ramadhanti, V. I., & Pulansari, F. (2022). Integration of fuzzy AHP and fuzzy TOPSIS for green supplier selection of mindi wood raw materials. Jurnal Sistem Dan Manajemen Industri, 6(1), 1–13. https://doi.org/10.30656/jsmi.v6i1.4332

Ramakrishnan, K. R., & Chakraborty, S. (2020). A cloud topsis model for green supplier selection. Facta Universitatis, Series: Mechanical Engineering, 18(3), 375–397. https://doi.org/10.22190/FUME200307036R

Rashidi, K., Noorizadeh, A., Kannan, D., & Cullinane, K. (2020). Applying the triple bottom line in sustainable supplier selection: A meta-review of the state-of-the-art. In Journal of Cleaner Production (Vol. 269). Elsevier Ltd. https://doi.org/10.1016/j.jclepro.2020.122001

Rhamadan Siregar, A. (2025). Optimizing Supplier Selection Through Hybrid BWM and AHP Integration. Jurnal Dan Penelitian Teknik Informatika, 9(4). https://doi.org/10.33395/sinkron.v9i4.15261

Rouyendegh, B. D., Yildizbasi, A., & Üstünyer, P. (2020). Intuitionistic Fuzzy TOPSIS method for green supplier selection problem. Soft Computing, 24(3), 2215–2228. https://doi.org/10.1007/s00500-019-04054-8

Sun, Y., & Cai, Y. (2021). A Flexible Decision-Making Method for Green Supplier Selection Integrating TOPSIS and GRA under the Single-Valued Neutrosophic Environment. IEEE Access, 9, 83025–83040. https://doi.org/10.1109/ACCESS.2021.3085772

Xiong, L., Zhong, S., Liu, S., Zhang, X., & Li, Y. (2020). An Approach for Resilient-Green Supplier Selection Based on WASPAS, BWM, and TOPSIS under Intuitionistic Fuzzy Sets. Mathematical Problems in Engineering, 2020. https://doi.org/10.1155/2020/1761893

Zulqarnain, R. M., Dai, H. L., Ma, W. X., Siddique, I., Askar, S., & Naveed, H. (2024). Supplier selection in green supply chain management using correlation-based TOPSIS in a q-rung orthopair fuzzy soft environment. Heliyon, 10(11). https://doi.org/10.1016/j.heliyon.2024.e32145