# A TOPSIS–AHP-Based Approach for Outsourcing Service Provider Selection: A Case Study in the Automotive Industry

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## Abstract

*El This study addresses supply chain management in the automotive industry, a highly competitive sector in which outsourcing plays a critical role in cost reduction and operational flexibility. A representative case involves the subcontracting of cardboard box manufacturing for glass packaging, whose efficiency directly affects production performance. To optimize supplier selection, a hybrid multicriteria decision-making (MCDM) approach integrating the Analytic Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) was applied. AHP was employed to determine the relative weights of the evaluation criteria through pairwise comparisons, while TOPSIS was used to rank suppliers based on their relative closeness to the ideal solution, incorporating both quantitative and qualitative factors. The methodology was implemented in a real-world automotive case study, assessing cardboard packaging suppliers according to four key criteria: unit cost, quality, delivery time, and environmental sustainability. The integration of expert judgment with verifiable technical data ensured a robust and objective evaluation of the available alternatives. The results revealed that, among the shortlisted candidates, the selected supplier emerged as the most favorable option. This supplier demonstrated a competitive unit cost and acceptable delivery time, despite exhibiting comparatively lower performance in environmental sustainability. This finding highlights the necessity of balancing organizational priorities in accordance with economic and operational constraints. In conclusion, the study demonstrates that the application of multicriteria decision-making methods (AHP–TOPSIS) constitutes an effective decision-support tool for supplier selection, enabling improved operational efficiency and enhanced competitiveness within the automotive supply chain.*

**Keywords:** *Automotive Industry, Outsourcing, Supplier Selection, Analytic Hierarchy Process.*

## Introduction

This research is motivated by the logistical challenges faced by the automotive industry as a consequence of the COVID-19 pandemic. These events exposed the vulnerability of global supply chains, leading to delivery delays, customer attrition, and adverse impacts on organizational profitability [01]. In response to this crisis, automotive firms intensified their reliance on outsourcing as a strategic mechanism to reduce costs and enhance operational efficiency. Consequently, the accurate selection of external partners has become a critical requirement for ensuring business continuity and long-term organizational success [02].

Within this dynamic context, the present study seeks to contribute an effective decision-making solution by proposing a structured framework for the evaluation and selection of outsourcing service providers [03]. The primary objective was to develop a hybrid AHP–TOPSIS model capable of optimizing the outsourcing of key processes, such as the manufacturing of cardboard boxes used for glass packaging in the automotive sector [04]. This research not only provides an immediately applicable and practical tool for improving subcontracting processes in the automotive industry, but also establishes a solid methodological foundation that, although validated within this sector, demonstrates strong potential for adaptation and extension to other industrial contexts.

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The automotive industry is a highly competitive sector in which outsourcing serves as a strategic lever for cost reduction and increased flexibility [01]. In this outsourcing context aimed at optimizing supplier selection, a hybrid multicriteria decision-making (MCDM) approach combining the Analytic Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) was employed [05].

## Topsis Method

The TOPSIS method (Technique for Order Preference by Similarity to the Ideal Solution) is a multicriteria decision-making approach that evaluates and ranks alternatives based on their relative closeness to the ideal solution. In this study, TOPSIS was applied to rank suppliers according to their proximity to the ideal solution, integrating both quantitative and qualitative factors [06]. The implementation of the TOPSIS method consists of the following eight steps.

*Step 1. Construction of the decision matrix*

The performance information of the alternatives $(m)$ with respect to the evaluation criteria $(n)$ is organized into a decision matrix $D = [x_{ij}]$, where $x_{ij}$ represents the performance of alternative $i$ under criterion $j$.

Step 2. Normalization of the decision matrix

To eliminate scale differences among the criteria, the decision matrix is normalized using vector normalization, as shown in Equation (1):

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

Step 3. Assignment of criteria weights

The relative importance of each criterion is determined using Saaty's scale [05] and the pairwise comparison method, resulting in a comparison matrix $P = [p_{ij}]$ . The normalized weights $(W_j)$ are computed using the geometric mean method. The consistency of the pairwise comparisons is verified through the maximum eigenvalue $(\lambda_{max})$, the Consistency Index (CI), and the Consistency Ratio (CR), which is considered acceptable when $CR < 0.10$.

Step 4. Construction of the weighted normalized matrix

Each normalized value is multiplied by its corresponding weight to obtain the weighted normalized matrix:

$$V_{ij} = W_j \times r_{ij}$$

Step 5. Determination of the ideal solutions:

- **Positive ideal solution $(v^+)$:** composed of the best values for each criterion.

- **Negative ideal solution $(v^-)$:** composed of the worst values for each criterion.

Step 6. Calculation of Euclidean distances:

The Euclidean distance of each alternative from the positive and negative ideal solutions is calculated as follows:

$$S_i^+ = \sqrt{\sum \left(v_{ij} - v_j^+\right)^2}, S_i^- = \sqrt{\sum \left(v_{ij} - v_j^-\right)^2}$$

Step 7. Determination of the relative closeness:

The relative closeness of each alternative to the ideal solution is obtained using the preference index:

$$c_i = \frac{S_i^-}{S_i^- + S_i^+}$$

A higher value of $C_{ij}$, indicates that the alternative is closer to the ideal solution

Step 8. Ranking of alternatives:

Finally, the alternatives are ranked in descending order according to their $C_i$ values, allowing the identification of the optimal alternative.

*Ahp–Topsis Method*

The Analytic Hierarchy Process (AHP), proposed by Saaty [07], [08], is a multicriteria decision-making tool that enables the decomposition of complex problems into a hierarchical structure [09]. This method assigns relative weights to evaluation criteria through pairwise comparisons, using a nine-point numerical scale that transforms subjective preferences into quantifiable values [10]. AHP is grounded in mathematical principles based on matrix and vector operations, which allow the consistency of the judgments to be assessed [11]. When the Consistency Ratio (CR) is lower than 0.10, the judgments are considered acceptable.

The TOPSIS method (Technique for Order Preference by Similarity to the Ideal Solution), developed by Hwang and Yoon [12], identifies the best alternative by evaluating its closeness to the positive ideal solution (best performance) and its distance from the negative ideal solution (worst performance) [13]. The alternative closest to the ideal solution is regarded as the most appropriate option.

In the combined AHP–TOPSIS approach, criteria weights are first determined using AHP and subsequently incorporated into the TOPSIS model to evaluate and rank the available alternatives. The procedure is carried out through the following stages:

1.      **Construction of the decision matrix:** alternatives and evaluation criteria are organized into a structured matrix.

2.      **Normalization of the matrix:** differences in measurement units are eliminated to ensure data comparability.

3.      **Determination of weights using AHP:** pairwise comparisons are conducted and the consistency of judgments is verified.

4.      **Construction of the weighted normalized matrix:** normalized values are multiplied by the corresponding criterion weights.

5.      **Determination of the positive and negative ideal solutions:** the best and worst criterion values are identified.

6. **Calculation of Euclidean distances:** the separation between each alternative and the ideal and non-ideal solutions is measured.

7. **Computation of the relative closeness coefficient ($C_i$):** the proximity of each alternative to the ideal solution is determined.

8. **Ranking of alternatives:** alternatives are ranked in descending order according to their $C_i$ values, with the highest score representing the most favorable option.

This hybrid approach was applied to the selection of suppliers within the outsourcing process of cardboard box manufacturing for glass packaging in the automotive industry, enabling a structured, quantitative, and consistent evaluation of the available alternatives.

*Criteria For Supplier Selection in the Automotive Sector*

A comprehensive literature review was conducted to identify and validate the criteria applied in supplier selection. This process aimed to ensure that the selected criteria have been widely recognized and employed in previous studies, thereby supporting their relevance and applicability to the present research.

In the automotive sector case study, four key criteria were considered: unit cost, quality, delivery time, and environmental sustainability [14]. Among these, the performance associated with the environmental sustainability criterion was found to be comparatively lower than that of the other criteria [15]. Consequently, it is necessary to balance organizational priorities in accordance with the economic and operational constraints of the specific context [16].

It presents a summary matrix compiling selected studies from the literature that employ the criteria considered in this research.:

| Article Title | Author | Key Focus | Type of Study | Data | Key Insights |
|---|---|---|---|---|---|
| **Criterion: Quality** | | | | | |
| A multicriteria decision system for carrier selection using AHP | Mohsen, B. M. [17] | The article highlights service quality as the primary criterion in logistics provider selection, ensuring operational excellence. | A case study employing the Analytic Hierarchy Process (AHP), enabling informed and strategic decision-making. | Comprehensive data on quality and sustainability criteria were collected, ensuring an integrated and accurate evaluation of suppliers. | The study reveals that prioritizing service quality enhances customer satisfaction and strengthens organizational competitiveness. |
| A systematic literature review on logistics service outsourcing | Abbasi, S., Sıcakyüz, Ç., Ghasemi, P., & Santibanez Gonzalez, E. D. R. [18] | The study focuses on logistics service provider selection, emphasizing quality as a fundamental criterion. | A systematic literature review analyzing relevant publications addressing quality in logistics. | A total of 12,458 publications from 2010 to 2023 were analyzed, identifying trends in logistics service quality. | Quality is assessed using multicriteria methods and is shown to be critical for sustainability and efficiency in supply chains. |

| | | | | | |
|---|---|---|---|---|---|
| Mathematical modeling and simulation in construction supply chain management | Chen, Z., & Hammad, A. W. A. [19] | The article addresses quality in construction supply chain management through mathematical modeling aimed at process optimization. | A systematic literature review evaluating 179 relevant studies, ensuring analytical robustness. | Data were collected from multiple academic databases using rigorous inclusion and exclusion criteria to ensure relevance and quality. | Emerging trends and effective modeling techniques are identified, highlighting the need for optimization and simulation to enhance supply chain quality. |
| **Criterion: Unit Cost** | | | | | |
| Technology multiplier effects: A framework for analyzing innovation prospects in production segment allocation | Stamer, F., Girke, R., Yang, S., Chun, J.-H., & Lanza, G. [20] | The key focus is on optimizing unit costs in make-or-buy decision-making processes. | An empirical study combining a literature review with a case study approach. | Data were obtained from case studies across various industries, analyzing production decisions and associated costs. | Five sub-criteria are identified: unit costs, transaction costs, disruption risk, capital expenditures, and innovation considerations. |
| **Criterion: Sustainability** | | | | | |
| DEA-driven risk management framework for oil supply chains | Hatami-Marbini, A., Asu, J. O., Hafeez, K., & Khoshnevis, P. [21] | The study focuses on risk management in oil supply chains, prioritizing environmental sustainability. | An empirical study employing both qualitative and quantitative analyses to assess risks and sustainability. | Data were collected through surveys and expert interviews within the Nigerian oil supply chain. | The findings emphasize the need to mitigate environmental risks to ensure sustainability and protect community health. |
| Integrated data envelopment analysis, multicriteria decision-making, and cluster analysis methods: Trends and perspectives | Schmidt de Oliveira, M., Steffen, V., de Francisco, A. C., & Trojanc, F. [22] | The article emphasizes sustainability through the integration of analytical methods for environmental decision-making. | A systematic review examining methodological applications in sustainability contexts. | Data were gathered from multiple sources to evaluate the efficiency and effectiveness of sustainable practices across sectors. | The integration of DEA, MCDA, and CA supports more informed and sustainable decisions, optimizing resources and minimizing environmental impacts. |
| **Criterion: Lead Time** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Supply chain digitalization: An integrated MCDM approach for selecting interorganizational information systems in an electronic supply chain | Deepu y Ravi [23] | The study focuses on reducing lead time in the adoption of interorganizational information systems. | A conceptual study analyzing factors influencing lead time in system integration. | Alternative scores reflecting lead time associated with different IOIS adoption decisions are presented. | Effective lead time management is essential for improving coordination and overall supply chain effectiveness. |
| Improving partnerships with third-party logistics providers: A DLARCS supply chain paradigm approach | Zarbakhshnia, N., & Karimi, A. [24] | The article focuses on optimizing lead time in the selection of third-party logistics providers (3PLs). | An empirical study applying evaluation methods to measure lead time performance in logistics operations. | Data were collected from industry experts to assess the impact of lead time on operational efficiency. | Reducing lead time is critical for enhancing competitiveness and customer satisfaction within the supply chain. |

## Methodology

The proposed decision support system required the evaluation of outsourcing service providers through a two-stage process:

Stage 1: Initial supplier selection conducted by the procurement team.

Stage 2: A decision support system based on the AHP–TOPSIS approach for the final evaluation of the shortlisted suppliers.

A structured methodology was introduced for the initial supplier screening. The steps of the decision support methodology are outlined as follows:

1.      Establish a procurement team responsible for the outsourcing service.

2.      Define the objective of the outsourcing initiative.

3.      Develop the functional specifications of the proposed task.

4.      Identify potential outsourcing service providers within the business environment.

5.      Evaluate the proposals submitted by the outsourcing service providers.

6.      Conduct site visits and inspect the suppliers' facilities by the procurement team.

7.      Collect references from the suppliers' previous clients.

8.      Perform the final selection using the AHP–TOPSIS approach and formalize the services to be provided by the selected suppliers

For any long-term business relationship, it is recommended that the contract comprehensively address key aspects such as scope of work, responsibilities, pricing, compensation, insurance, risks, penalties, and other critical issues related to performance and contract modification.

## Results

In the present study, a multicriteria decision-making (MCDM) approach was implemented based on the integration of two tools widely recognized in both the scientific literature and business management practice: the Analytic Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS). The primary objective was to develop a supplier evaluation and selection model tailored to the outsourcing process of cardboard box manufacturing for the packaging and dispatch of glass components used in the automotive sector. This type of analysis is particularly relevant in complex industrial environments, where supplier reliability, product quality, and delivery punctuality directly influence supply chain efficiency, production process stability, and final customer satisfaction.

The automotive sector is characterized by high technical requirements and the adoption of lean production systems, such as Just-in-Time (JIT), where delays or deficiencies in material deliveries may lead to significant economic losses and jeopardize operational continuity. In this context, supplier selection cannot be based solely on cost considerations; rather, it requires a comprehensive evaluation that incorporates multiple performance factors. The application of multicriteria methods such as AHP and TOPSIS enables a systematic structuring of the decision-making process, providing quantitative rigor and transparency to the final selection.

During the initial phase of the study, a supplier preselection process was conducted through a preliminary assessment of technical, operational, and contractual variables. As a result of this screening stage, three candidates were identified as meeting the minimum requirements established by the organization: SUPPLIER XX, SUPPLIER YY, and SUPPLIER ZZ. This stage proved particularly challenging, as most of the evaluated suppliers demonstrated adequate technical capabilities, verifiable experience in industrial packaging manufacturing, and satisfactory records of compliance with previous contracts. However, the final decision required moving beyond basic compliance criteria toward identifying the most balanced and strategically advantageous alternative in terms of overall performance.

Aware of the economic and operational constraints inherent in the current competitive environment, the organization opted to apply a scientific methodology that ensured objectivity, consistency, and traceability throughout the decision-making process. Consequently, the AHP–TOPSIS model was established as a suitable tool, enabling a structured evaluation of suppliers based on a hierarchically defined set of criteria. Senior management determined that the selection process should be grounded in four fundamental criteria:

- **Unit cost per cardboard box**, understood as an indicator of economic efficiency and profitability.

- **Product quality**, evaluated in terms of cardboard strength, dimensional uniformity, cutting precision, and compliance with technical specifications.

- **Delivery time**, considered a critical factor for logistics synchronization and the continuity of automotive production operations.

- **Environmental sustainability**, associated with both the origin of raw materials (recycled or certified sources) and environmentally responsible manufacturing practices.

The Analytic Hierarchy Process (AHP) was initially employed to determine the relative weights of these criteria. Through pairwise comparisons and the construction of judgment matrices, the weights reflecting the strategic importance of each factor for the organization were established. This procedure enabled the transformation of qualitative perceptions into numerical values, providing an objective foundation for the subsequent evaluation phase.

Subsequently, the TOPSIS method was applied to rank the alternatives according to their proximity to the ideal solution. By normalizing the data, identifying the optimal values (positive ideal solution) and the least favorable values (negative ideal solution), and calculating the corresponding Euclidean distances, a final ranking was obtained that identified the supplier with the best overall performance. The integration of AHP and TOPSIS not only allowed for analytically rigorous prioritization of criteria, but also facilitated a comparative assessment of supplier performance based on quantifiable information.

This methodological approach offers significant benefits for supply chain management. It enhances transparency and traceability by grounding decisions in verifiable data, reduces subjectivity and human bias commonly associated with experience-based or intuitive evaluations, and simultaneously considers economic, technical, and environmental factors. As a result, the model contributes to the development of a more sustainable, resilient, and competitive supply chain.

The combined application of AHP and TOPSIS is therefore presented as a methodologically robust solution for addressing complex outsourcing decisions within the automotive sector. Its use ensures a comprehensive evaluation of suppliers and enables organizations to select strategic partners capable of meeting high standards of quality, efficiency, and sustainability, thereby safeguarding operational continuity and final customer satisfaction.

*Step 1: Construction of the Decision Matrix*

Based on the information provided by the procurement department of the automotive sector, the initial decision matrix was constructed (Table 1), which presents the performance of each supplier with respect to the defined criteria. This matrix constitutes the quantitative foundation for subsequent calculations, enabling the visualization of relative differences among the analyzed alternatives.

**Table 1. Supplier Performance with Respect to the Evaluation Criteria**

|  | UNIT COST PER CARDBOARD BOX | | QUALITY | DELIVERY TIME | SUSTAINABILITY |
|---|---|---|---|---|---|
| SUPPLIER XX | S/ | 212 | Good | 10 days | Good |
| SUPPLIER YY | S/ | 350 | Excellent | 14 days | Excellent |
| SUPPLIER ZZ | S/ | 275 | Excellent | 12 days | Excellent |

Step 2: Normalization of the Decision Matrix

In order to eliminate differences in measurement units and allow direct comparison between qualitative and quantitative criteria, the values were normalized using Equation (2). The results are presented in Table 2, which shows the relative weighting of each alternative and the resulting prioritization percentage.

**Table 2. Normalized Matrix**

| CRITERIA <br><br> SUPPLIER | UNIT COST PER CARDBOARD BOX | QUALITY | DELIVERY TIME | SUSTAINABILITY | PRIORITIZATION | % |
|---|---|---|---|---|---|---|
| SUPPLIER XX | 0.64 | 0.14 | 0.70 | 0.20 | 0.50 | 50% |
| SUPPLIER YY | 0.07 | 0.43 | 0.07 | 0.60 | 0.20 | 20% |
| SUPPLIER ZZ | 0.28 | 0.43 | 0.23 | 0.20 | 0.30 | 30% |

| WEIGHTING | 0.45 | 0.23 | 0.23 | 0.08 | 1.00 | 100% |
|-----------|------|------|------|------|------|------|

Step 3: Pairwise Comparison of Criteria

Subsequently, a pairwise comparison of the criteria was conducted using Saaty's scale [05], allowing the determination of relative weights through Equation (4). Table 3 details this process, indicating that unit cost emerged as the most relevant factor (45%), followed by quality and delivery time (both at 23%), while sustainability received a lower weight (8%).

**Table 3. Pairwise Comparison of Criteria**

| CRITERIA COMPARISON MATRIX | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CRITERIA** | **UNIT COST PER CARDBOARD BOX** | **QUALITY** | **DELIVERY TIME** | **SUSTAINABILITY** | **NORMALIZED MATRIX** | | | | **SUM** | **WEIGHTING (WI)** | **%** |
| **UNIT COST PER CARDBOARD BOX** | 1 | 2 | 2 | 5 | 0.45 | 0.46 | 0.46 | 0.42 | 1.79 | 0.45 | 45% |
| **QUALITY** | 1/2 | 1 | 1 | 3 | 0.23 | 0.23 | 0.23 | 0.25 | 0.94 | 0.23 | 23% |
| **DELIVERY TIME** | 1/2 | 1 | 1 | 3 | 0.23 | 0.23 | 0.23 | 0.25 | 0.94 | 0.23 | 23% |
| **SUSTAINABILITY** | 1/5 | 1/3 | 1/3 | 1 | 0.09 | 0.08 | 0.08 | 0.08 | 0.33 | 0.08 | 8% |

The consistency analysis yielded a maximum eigenvalue of $\lambda_{max} = 4.001$ and a Consistency Ratio (CR) of 0.002, well below the recommended threshold of 0.10 proposed by Saaty, confirming the validity and coherence of the evaluators' judgments.

*Step 4: Weighted Normalized Matrix*

Using the calculated weights, the weighted normalized matrix was constructed (Table 4), reflecting the adjusted performance of each supplier according to the relative importance of the criteria. This step enabled a more precise identification of the alternative offering the best overall balance.

**Table 4. Weighted Normalized Matrix**

| SUPPLIER | UNIT COST PER CARDBOARD BOX | QUALITY | DELIVERY TIME | SUSTAINABILITY | WEIGHTED TOTAL |
|----------|------|------|------|------|------|
| **SUPPLIER XX** | 0.2880 | 0.0322 | 0.1610 | 0.0160 | 0.4972 |
| **SUPPLIER YY** | 0.0315 | 0.0989 | 0.0161 | 0.0480 | 0.1945 |
| **SUPPLIER ZZ** | 0.1260 | 0.0989 | 0.0529 | 0.0160 | 0.2938 |

Step 5: Ideal and Negative-Ideal Solution Matrix

Using Equations (11) and (12), the positive ideal (best) and negative ideal (worst) solutions were calculated and are presented in Table 5.

**Table 5. Positive Ideal and Negative-Ideal Solution Matrix**

|       | Ideal (Best) |      | Negative-Ideal (Worst) |
|-------|--------------|------|------------------------|
| v1 +  | 0.2880       | v1-  | 0.0315                 |
| v2+   | 0.0989       | v2-  | 0.0322                 |
| v3+   | 0.1610       | v3-  | 0.0161                 |
| v4+   | 0.0480       | v4-  | 0.0160                 |

*Step 6: Separation Distance Table*

The Euclidean separation distances were calculated using Equations (13) and are shown in Table 6.

**Table 6. Separation Distances**

|      | Ideal (Best) |      | Negative-Ideal (Worst) |
|------|--------------|------|------------------------|
| s1+  | 0.0734       | s1-  | 0.2942                 |
| s2+  | 0.2942       | s2-  | 0.0734                 |
| s3+  | 0.1954       | s3-  | 0.1217                 |

*Step 7: Relative Closeness to the Ideal Solution*

The relative closeness of each alternative to the ideal solution was calculated using Equation (15) and is presented in Table 7.

**Table 7. Relative Closeness to the Ideal Solution for Each of the Suppliers**

| Relative Closeness | Value | Supplier     |
|--------------------|-------|--------------|
| C1                 | 0.801 | SUPPLIER XX  |
| C2                 | 0.200 | SUPPLIER YY  |
| C3                 | 0.384 | SUPPLIER ZZ  |

*Step 8: Supplier Ranking*

Based on the relative closeness values, the suppliers were ranked in descending order, as shown in Table 8.

**Table 8. Supplier Classification**

| Supplier     | Value | Rank |
|--------------|-------|------|
| SUPPLIER XX  | 0.801 | 1    |
| SUPPLIER YY  | 0.200 | 3    |
| SUPPLIER ZZ  | 0.384 | 2    |

Therefore, it is concluded that the selected supplier is SUPPLIER XX.

## Discussion

The present study demonstrates the effectiveness and relevance of using multicriteria decision analysis tools, particularly the Analytic Hierarchy Process (AHP) and the Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS), in the strategic selection of suppliers within the automotive supply chain. In an environment characterized by high competitiveness, strong pressure to reduce costs, and increasing demands for sustainable practices, decision-making based on multiple criteria becomes essential to ensure operational efficiency and organizational adaptability.

The AHP method enabled the hierarchical structuring of the decision problem by decomposing it into levels ranging from the overall objective to the evaluation criteria and subcriteria. Through pairwise comparisons and the calculation of relative weights, it was possible to quantify the importance of key factors such as unit cost, product quality, delivery time, and sustainability. Additionally, the application of the TOPSIS method made it possible to classify and prioritize suppliers based on their relative distance from the ideal solution, defined as the theoretical scenario that simultaneously maximizes benefits and minimizes costs across all criteria.

Through the combined application of both tools, suppliers with an optimal balance among the evaluated factors were identified. Among them, SUPPLIER XX emerged as the most suitable alternative for the company under study. Although its performance in sustainability was slightly lower compared to competitors such as SUPPLIER YY and SUPPLIER ZZ, its balance between cost and delivery time positioned it as the most efficient option in the short term. This outcome reflects how, in situations of uncertainty or economic crisis, organizations may be compelled to prioritize profitability and operational continuity without disregarding their commitment to sustainability in the medium and long term.

The comparative analysis showed that SUPPLIER YY and SUPPLIER ZZ achieved higher scores in quality and sustainability indicators; however, they failed to maintain a balanced performance across all evaluated criteria. This finding confirms that supplier selection decisions should not be based on a single performance criterion, but rather on a systemic perspective that considers the interaction among economic, technical, and environmental factors. In this regard, the use of multicriteria methods helps reduce the subjectivity inherent in traditional evaluation processes, promoting more rational, transparent, and strategically aligned decision-making.

Furthermore, the study highlights the importance of formally incorporating sustainability as a criterion within supplier evaluation models. Although cost and quality have historically been the predominant factors, the demands of the global market and current environmental policies require a deeper integration of social responsibility and environmental management indicators. The application of AHP and TOPSIS provides a flexible framework that allows the adjustment of criterion weights as organizational priorities or environmental conditions evolve.

The results demonstrate that the adoption of multicriteria methodologies can generate additional benefits, such as the optimization of supplier negotiation processes, early identification of logistical risks, and continuous improvement in supply chain management. These contributions enhance firms' ability to adapt to sudden changes in demand, price fluctuations, or supply disruptions—factors that are particularly critical in the automotive industry, which is characterized by a high dependence on specialized suppliers and the need to maintain continuous production.

Therefore, it is concluded that the integration of tools such as AHP and TOPSIS not only contributes to the selection of the most appropriate supplier but also strengthens strategic decision-making in complex environments. This quantitative and systematic approach supports the alignment between operational objectives and corporate sustainability goals, promoting more efficient, competitive, and responsible management.

For future research, it is suggested to expand the application of the model by incorporating additional criteria related to technological innovation, process digitalization, and responsiveness to global crises. Additionally, the integration of hybrid methods combining multicriteria techniques with artificial intelligence algorithms could be explored, which would enhance result accuracy and enable the anticipation of supplier behavior under changing scenarios.

In summary, the findings of this study reaffirm that multicriteria analysis constitutes a key tool for optimizing the supplier selection process, strengthening the ability of automotive sector companies to adapt and thrive in a dynamic and highly competitive global environment.

# Conclusion

The present study proposes an innovative, comprehensive, and effective strategy for supplier selection in the automotive sector, focusing on resource optimization, reduction of operational costs, and improvement of the overall efficiency of the production system through process outsourcing. In a highly competitive environment, marked by pressure to shorten delivery cycles and the growing demand for sustainable practices, companies in this sector face the need to adopt tools that enable more structured, objective, and strategically aligned decision-making.

This research is grounded in the integration of two multicriteria decision-making tools widely recognized for their methodological rigor and practical applicability: the Analytic Hierarchy Process (AHP) and the Technique for Order of Preference by Similarity to the Ideal Solution (TOPSIS). AHP, developed by Saaty, allows complex problems to be decomposed into a hierarchical structure consisting of levels that represent objectives, criteria, and alternatives, facilitating the assignment of weights to each criterion through pairwise comparisons. This quantitative approach makes it possible to incorporate both expert judgment and objective data, achieving a balance between mathematical precision and empirical knowledge.

The TOPSIS method complements the analysis by providing a systematic way to rank alternatives based on their proximity to the ideal solution, defined as the alternative that simultaneously maximizes benefits and minimizes costs or negative aspects. The integration of both methods offers a robust framework for supplier evaluation, as AHP establishes the weighting of criteria according to their strategic relevance, while TOPSIS identifies the alternative that best satisfies the set of defined requirements.

For the automotive supply chain, this methodology is particularly relevant due to the complexity of supply networks, the diversity of inputs, and the need to maintain high standards of quality and delivery reliability. By applying the proposed model, companies can objectively and systematically evaluate potential suppliers based on essential criteria such as unit cost, product quality, compliance with delivery times, and commitment to sustainability. This comprehensive evaluation enables evidence-based decision-making, significantly reducing the subjectivity that traditionally influences supplier selection processes.

The implementation of the AHP–TOPSIS approach provides multiple benefits. It enhances operational efficiency by identifying suppliers that offer the best balance between cost and performance, thereby optimizing the use of financial and logistical resources. It increases organizational competitiveness by improving responsiveness to changes in demand and ensuring continuity of supply. It also contributes to risk management by reducing dependence on suppliers with low reliability or inconsistent performance. Furthermore, the inclusion of sustainability as an evaluation criterion promotes responsible business practices aligned with global sustainable development goals and environmental regulations within the sector.

The proposed methodology also allows for the simulation of decision-making scenarios and the adjustment of criterion weights according to economic conditions or business priorities. During periods of crisis or budgetary constraints, cost-related criteria may become more relevant, whereas during phases of expansion or brand strengthening, quality and sustainability may assume greater importance. This flexibility makes the model a dynamic, adaptable, and sustainable decision-support tool over time.

The results obtained from the application of the model revealed that SUPPLIER XX emerged as the most suitable alternative for the outsourcing processes analyzed. This conclusion is supported by the balance achieved by SUPPLIER XX across the evaluated criteria, with particularly strong performance in cost and delivery time compliance. Although other suppliers achieved slightly higher scores in sustainability or quality, SUPPLIER XX demonstrated greater overall consistency in its performance, making it the best option to ensure the company's operational and financial stability in the short and medium term. This finding highlights the importance of adopting evaluation approaches that consider multiple dimensions of supplier performance. Historically, outsourcing decisions were predominantly based on price, often leading to risks related to quality failures, contractual non-compliance, or negative environmental impacts. In contrast, the AHP–TOPSIS methodology provides a holistic perspective that integrates economic,

technical, and social variables, enabling the selection of strategic partners that contribute to the sustainable development of the entire value chain.

Moreover, the methodological proposal presented in this study not only represents a practical tool for supply chain management but also constitutes an academic and applied contribution to the field of multicriteria analysis in the automotive industry. Its implementation promotes a data-driven decision-making culture, enhances the transparency of internal processes, and strengthens trust-based relationships between companies and suppliers. In the long term, this practice translates into greater adaptability to global crises and a more competitive positioning in international markets.

In conclusion, the combined application of AHP and TOPSIS proves to be an effective strategy for optimizing supplier selection in the automotive industry, offering an approach that balances technical rigor with strategic flexibility. When applied systematically, this model facilitates the identification of reliable business partners, enhances the efficiency of outsourcing processes, and contributes to the development of more sustainable, integrated, and resilient supply chains capable of addressing the challenges of the contemporary global environment.

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