

## APPLICATION OF MULTI-CRITERIA DECISION MAKING (MCDM) IN DETERMINING SUPPLIER PRIORITY THROUGH AN AHP-WEIGHTED SCORING APPROACH

Kartinah Pratiwi<sup>1</sup>; Hamdan Amarrudin<sup>2\*</sup>

<sup>1,2</sup>Management, Economics and Business Faculty, Pelita Bangsa University  
Bekasi, Indonesia

**Author's email:**

<sup>1</sup>kartinahpratiwi18@gmail.com; <sup>2</sup>hamdanamar@pelitabangsa.ac.id

**\*Corresponding author:**

hamdanamar@pelitabangsa.ac.id

**Abstract.** Supplier performance evaluation is a critical mechanism in manufacturing supply chain governance. PT Aman Pelumas Nusantara experiences variability in supplier performance related to delivery reliability, cost stability, and quality consistency. This study develops an integrated Analytic Hierarchy Process (AHP) and Weighted Scoring model to evaluate three active base oil supplier. AHP is used to derive criterion weights, while Weighted Scoring aggregates supplier performance into a composite score. The result show that quality is dominant criterion (0.497), followed by delivery time (0.189), service (0.118), cost (0.114), and administrative compliance (0.083). Supplier B achieved the highest overall score (0.610), indicating the strongest alignment with the operational requirements of the company. The model improves objectivity and decision consistency in supplier evaluation.

**Keywords:** AHP; Decision Making; Supplier Evaluation; Supply Chain Management; Weighted Scoring

### 1. INTRODUCTION

Supplier performance plays a critical role in ensuring the stability and efficiency of supply chain systems, particularly in manufacturing industries that depend on continuous raw material availability. In such environments, delays or inconsistencies in supplier performance can directly affect production continuity, inventory levels, and operational costs. Therefore, an effective supplier evaluation system is essential to support strategic procurement decisions (Manik, 2023; Christopher, 2016; Monczka et al., 2021)

In the lubricant manufacturing industry, base oil is a key raw material that requires high consistency in quality and timely delivery. However, variability in supplier performance remains a persistent issue in many companies, particularly in developing supply chain systems where evaluation practices are still largely descriptive and experience-based. This condition limits the ability of firms to systematically assess supplier performance across multiple criteria (Abdulla & Baryannis, 2024; Gidiagba & al., 2022; Zeng et al., 2020).

This issue is also reflected in PT Aman Pelumas Nusantara. Based on operational data in 2024, supplier delivery performance shows noticeable variation across suppliers, as presented in Table 1.1.

**Table 1.1** On-Time Delivery Performance of Base Oil Suppliers at  
PT Aman Pelumas Nusantara (2024)

| Supplier | Target OTD | Actual OTD | Gap | Delay     |
|----------|------------|------------|-----|-----------|
| A        | 100        | 82         | 18  | 3–7 days  |
| B        | 100        | 91         | 9   | 1–3 days  |
| C        | 100        | 76         | 24  | 5–10 days |

Source: Internal Data of PT Aman Pelumas Nusantara, 2024

The data indicate substantial differences in supplier reliability. Supplier C exhibited the largest performance gap compared with the company's delivery target, resulting in longer

delivery delays than the other suppliers. Such variability may disrupt production scheduling, increase inventory holding costs, and reduce overall supply chain efficiency (Christopher, 2016).

Despite these operational challenges, the current supplier evaluation practice at PT Aman Pelumas Nusantara is still largely qualitative and depends on managerial judgement. Although practical, this approach limits objectivity, consistency, and transparency when comparing supplier performance across multiple evaluation criteria (Hosseini, S., & Khaled, 2019).

Supplier evaluation is widely recognised as a Multi-Criteria Decision-Making (MCDM) problem because procurement decisions involve multiple conflicting criteria, including quality, cost, delivery performance, service, and administrative compliance. The Analytic Hierarchy Process (AHP) is one of the most widely applied MCDM methods for determining the relative importance of evaluation criteria through pairwise comparisons (Saaty, 1980). However, AHP primarily focuses on weighting criteria rather than ranking alternatives. Therefore, it is frequently integrated with other evaluation methods, such as the Weighted Scoring method, to obtain comprehensive supplier performance rankings (Tavana, 2020). Phan Ha et al 2025.

Previous studies have demonstrated the effectiveness of integrating AHP with scoring-based methods in improving supplier evaluation objectivity and decision consistency (Ariadi & Abdi, 2025; Gidiagba & al., 2022; Ulutas & Topcu, 2021). Nevertheless, limited studies have examined this integrated approach within the lubricant manufacturing industry, particularly for evaluating base oil suppliers in Indonesia. Therefore, this study proposes an integrated AHP and Weighted Scoring model to evaluate supplier performance at PT Aman Pelumas Nusantara. The proposed framework is expected to improve transparency, consistency, and reliability in procurement decision-making while supporting long-term supplier performance improvement.

## **2. LITERATURE REVIEW**

### ***2.1 Supply Chain and Supplier Performance***

Supplier performance is a key determinant of supply chain efficiency and operational stability in manufacturing systems. In modern supply chain networks, suppliers are not only considered as external resource providers but also strategic partners that directly influence production continuity, cost efficiency, and product quality. In highly dependent manufacturing environments, variability in supplier performance can introduce operational risks such as production delays, increased inventory costs, and disruption in production scheduling (Christopher, 2016; Monczka, 2021). Therefore, structured supplier evaluation systems are required to ensure consistent performance monitoring and decision-making reliability.

### ***2.2 Supplier Evaluation Criteria***

Supplier evaluation is a critical component in supply chain management as it directly influences operational performance, cost efficiency, and production continuity. In manufacturing industries, supplier performance is typically assessed based on multiple criteria such as quality, cost, delivery reliability, service level, and administrative compliance. The complexity of these criteria makes supplier evaluation a multi-dimensional decision problem that cannot be solved using single-criterion approaches.

Recent studies emphasize that supplier evaluation has shifted from subjective assessment toward structured decision-making systems that rely on quantitative models. This shift is driven by the need for transparency, consistency, and traceability in procurement decisions (Tijo M Joy, K.S. Aneesh, 2023).

### ***2.3 Analytic Hierarchy Process (AHP)***

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making method developed (Saaty, 1980). AHP decomposes complex decision problems into hierarchical structures and uses pairwise comparisons to determine relative weights among criteria. AHP is widely used due to its ability to transform qualitative judgments into quantitative weights and its inclusion of a consistency ratio (CR) to validate decision reliability. According to (Saaty, 1980), AHP provides a

structured and mathematically consistent framework for decision-making under multiple criteria conditions.

Recent studies indicate that the Analytic Hierarchy Process (AHP) improves decision consistency by providing a structured framework for decomposing complex decision problems into hierarchical criteria and performing systematic pairwise comparisons. AHP has been widely applied in supplier selection studies to determine criterion priorities such as quality, cost, delivery performance, and service level, particularly in multi-criteria decision-making environments. Although AHP effectively determines criterion priorities, it does not directly produce final rankings of alternatives. Therefore, many recent studies recommend integrating AHP with alternative ranking methods to enhance decision effectiveness in supplier evaluation.

#### *2.4 Weighted Scoring Method*

Weighted Scoring is a multi-criteria decision-making technique used to evaluate alternatives based on predefined weighted criteria. Each alternative is assigned a score for each criterion, which is then multiplied by its corresponding weight to generate a final aggregated performance value. This method is widely used in decision-support systems due to its simplicity, transparency, and ease of implementation. However, its effectiveness strongly depends on the accuracy and consistency of the weighting process, making it sensitive to the method used for weight determination. Recent studies highlight that Weighted Scoring performs better when integrated with structured weighting approaches in multi-criteria environments (Zavadskas et al., 2020; Phan & al., 2021).

#### *2.5 Integration of AHP and Weighted Scoring*

The integration of AHP and Weighted Scoring provides a robust multi-criteria decision-making framework for complex evaluation problems. AHP is used to derive the relative importance of criteria through structured pairwise comparisons, while Weighted Scoring aggregates alternative performance into a single comparable score. This hybrid approach improves decision quality by separating the weighting phase from the evaluation phase, thereby reducing subjectivity and improving transparency. Recent MCDM studies confirm that hybrid AHP-based models enhance decision stability and consistency in supplier evaluation and industrial decision-making contexts (Ariadi & Abdi, 2025; Abdulla & Baryannis, 2024b).

#### *2.6 Research Gap*

Although numerous studies have applied AHP and Weighted Scoring separately for supplier evaluation, relatively few have investigated the integration of these methods in evaluating base oil suppliers within the lubricant manufacturing industry. Moreover, previous studies have predominantly focused on general manufacturing contexts without specifically addressing procurement characteristics in Indonesian lubricant companies. Accordingly, this study contributes to the literature by proposing an integrated AHP–Weighted Scoring framework for evaluating supplier performance at PT Aman Pelumas Nusantara.

### **3. RESEARCH METHODS**

#### *3.1 Research Design*

This study employed a quantitative research design with a descriptive approach to evaluate supplier performance in a structured and objective manner. The quantitative approach was selected because it enables systematic measurement of decision criteria based on numerical data and expert judgments (Sugiyono, 2020; Saaty, 1980).

According to Sugiyono (2020), quantitative research is a method based on positivism philosophy used to examine specific populations or samples through structured data collection and statistical analysis. In addition, modern supply chain studies emphasize the use of Multi-Criteria Decision Making (MCDM) methods to solve complex evaluation problems involving multiple conflicting criteria (Sugiyono, 2020b). Therefore, this study integrated the Analytic

Hierarchy Process (AHP) and Weighted Scoring method as a hybrid decision-making model to ensure objective and systematic supplier evaluation (Abdulla & Baryannis, 2024b).

### 3.2 Research Location and Period

The research was conducted at PT Aman Pelumas Nusantara, Indonesia, a company engaged in lubricant distribution. The study focused on base oil suppliers due to their critical role in production continuity and supply chain performance. The research was conducted over a three-month period in 2025 during stable procurement activities to ensure that supplier performance data accurately reflected operational conditions.

### 3.3 Population and Sample

The population in this study consisted of employees involved in procurement and supply chain management at PT Aman Pelumas Nusantara. The sample was selected using purposive sampling technique. According to (Sugiyono, 2019), purposive sampling is a technique for selecting samples based on specific considerations aligned with research objectives. The respondents consisted of five experts from procurement, warehouse, and quality control departments who had direct experience in supplier evaluation.

### 3.4 Research Object and Respondents

The objects of this study were three active base oil suppliers supplying raw materials to PT Aman Pelumas Nusantara. These suppliers were selected based on their active involvement in procurement activities and availability of complete performance data. The respondents consisted of five internal experts involved in procurement and supply chain activities, including purchasing staff, quality control personnel, and warehouse officers. The respondents were selected based on their experience and direct involvement in supplier evaluation processes.

### 3.5 Operational Definition of Variables

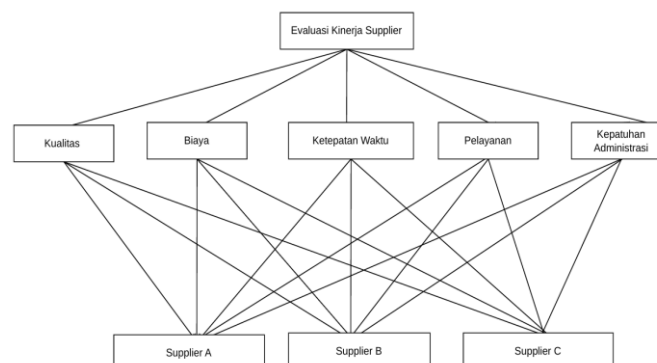
The variables in this study were defined based on supplier evaluation criteria in the AHP model. Each variable represents a measurable aspect of supplier performance.

- **Quality** refers to the consistency and conformity of base oil with company specifications.
- **Cost** refers to price competitiveness and price stability offered by suppliers.
- **Delivery Time** refers to the ability of suppliers to deliver materials on schedule.
- **Service** refers to communication responsiveness and coordination quality.
- **Administrative Compliance** refers to completeness and accuracy of procurement documents.

These criteria were used as the basis for pairwise comparisons in AHP and performance scoring in Weighted Scoring.

### 3.6 Research Model

The decision-making model in this study was structured using the Analytic Hierarchy Process (AHP) hierarchy, as illustrated below:



**Figure 3.1** AHP Research Model

The model consists of three hierarchical levels:

1. Goal level: evaluating supplier performance
2. Criteria level: quality, cost, delivery time, service, and administrative compliance
3. Alternative level: three base oil suppliers

This hierarchical structure was used to simplify complex decision problems into a structured evaluation system.

### 3.7 Data Collection Methods

Data were collected using observation, interviews, and documentation. According to Sugiyono (2020), multiple data collection techniques are recommended to improve data validity in quantitative research. Therefore, this study applied:

- Observation of procurement processes
- Interviews with procurement experts for AHP judgments
- Documentation of supplier performance records

This triangulation approach ensured data reliability and consistency.

### 3.8 Data Analysis Method

Data analysis was conducted using a two-stage MCDM approach.

#### a. Analytic Hierarchy Process (AHP)

AHP was used to determine the relative weights of evaluation criteria. The process involved (Saaty, 1990).

1. Structuring the hierarchy model
2. Conducting pairwise comparisons using a scale of 1–9
3. Normalizing the comparison matrix
4. Calculating priority weights
5. Testing consistency using Consistency Ratio (CR)

The Consistency Ratio was calculated as:

- $CI = (\lambda_{\max} - n) / (n - 1)$
- $CR = CI / RI$

A CR value less than 0.1 indicated acceptable consistency.

#### b. Weighted Scoring Method

After determining criteria weights using AHP, the Weighted Scoring method was applied to rank suppliers (Tavana, M, 2020). The formula used was:

$$TotalScore_i = \sum (W_j \times S_{ij})$$

Where:

- $W_j$  = weight of criterion j (from AHP)
- $S_{ij}$  = performance score of supplier i on criterion j

The supplier with the highest total score was considered the best-performing supplier.

## 4. RESULTS AND DISCUSSION

### 4.1 Result

#### a. Results of Criteria Weighting Using AHP

The Analytic Hierarchy Process (AHP) was applied to determine the relative importance of supplier evaluation criteria. The results of pairwise comparison analysis showed that all judgments were consistent, with a Consistency Ratio (CR) of 0.08, which is below the acceptable threshold of 0.10.

The final weights of criteria are presented as follows:

- Quality : 0.497
- Cost : 0.114
- Delivery Time : 0.189
- Service : 0.118
- Administrative Compliance: 0.083

The results indicate that quality is the most dominant criterion in supplier evaluation, followed by delivery performance. This demonstrates that operational reliability is prioritized over cost considerations in the procurement decision-making process.

*b. Supplier Performance Evaluation Using Weighted Scoring*

Based on the AHP-derived weights, the Weighted Scoring method was applied to evaluate three base oil suppliers. The final aggregated scores are presented below:

| Supplier   | Final Score |
|------------|-------------|
| Supplier A | 0.152       |
| Supplier B | 0.610       |
| Supplier C | 0.238       |

The results show that Supplier B achieved the highest performance score, indicating superior performance across most evaluation criteria. Supplier C ranked second, while Supplier A demonstrated the lowest overall performance.

*C. Supplier Ranking Results*

The final ranking based on Weighted Scoring is as follows:

1. Supplier B (0.610)
2. Supplier C (0.238)
3. Supplier A (0.152)

The ranking reveals a significant performance gap between Supplier B and the other suppliers, indicating variability in supplier capability and consistency.

*4.2 Discussion*

The findings confirm that supplier evaluation in the lubricant manufacturing industry is highly dependent on quality and delivery performance. The dominance of quality as the most important criterion (0.497) reflects the critical role of raw material consistency in determining final product performance.

Supplier B demonstrates the best overall performance due to its strong consistency in quality, delivery reliability, service responsiveness, and administrative compliance. This aligns with MCDM literature stating that suppliers with balanced performance across multiple criteria tend to achieve higher aggregated scores in hybrid decision models.

Supplier C shows moderate performance, particularly due to competitive cost advantages; however, weaknesses in delivery performance reduce its overall ranking. Meanwhile, Supplier A exhibits the lowest performance, indicating inefficiencies in multiple operational dimensions.

The integration of AHP and Weighted Scoring improves decision-making objectivity by separating the weighting process from performance evaluation. This hybrid approach reduces

subjectivity and enhances transparency in supplier selection, consistent with previous studies in multi-criteria decision-making applications.

*c. Managerial Implications*

The findings provide several practical implications for procurement management at PT Aman Pelumas Nusantara. First, Supplier B should be maintained as the company's primary supplier due to its consistently superior performance across the evaluated criteria. Second, Supplier C should remain an alternative supplier; however, the company should collaborate with this supplier to improve delivery reliability and logistics performance. Third, Supplier A requires comprehensive performance improvement through regular performance monitoring, corrective action programs, and periodic evaluations. If no significant improvement is achieved, the company may consider reducing procurement allocation or replacing the supplier with a more reliable alternative.

More broadly, the implementation of an integrated AHP–Weighted Scoring framework enables procurement managers to establish a transparent, objective, and data-driven supplier evaluation system. Continuous supplier performance monitoring can also strengthen long-term supplier relationships, improve supply chain resilience, and support strategic procurement decision-making (Monczka et al., 2021).

## **CONCLUSION**

The study concluded that supplier evaluation using the integration of the Analytic Hierarchy Process (AHP) and Weighted Scoring method provides a structured and objective approach for assessing base oil supplier performance at PT Aman Pelumas Nusantara. The evaluation results indicated that quality was the most dominant criterion, followed by delivery punctuality, confirming that operational reliability plays a crucial role in supply chain performance. Furthermore, the application of the Weighted Scoring method revealed differences in supplier performance across all evaluated criteria, where Supplier A obtained the lowest overall score, indicating the need for improvement particularly in quality and service aspects. Supplier C was also identified as requiring improvement in delivery performance to meet company standards. Overall, Supplier B consistently obtained higher scores across most criteria, particularly in quality and delivery reliability. This indicates that Supplier B has stronger alignment with the operational requirements of PT Aman Pelumas Nusantara compared to other suppliers. The findings emphasize that a systematic and data-driven supplier evaluation model is essential to support objective decision-making in procurement activities and to ensure continuous improvement in supplier performance management within the company. The integration of AHP and Weighted Scoring proved effective in improving the transparency, consistency, and objectivity of supplier evaluation. Unlike conventional qualitative assessments, the proposed framework enables procurement managers to make evidence-based decisions supported by quantitative analysis. Therefore, this integrated model can serve as a practical decision-support tool for supplier evaluation in manufacturing companies with similar procurement characteristics (Saaty, 1990; Zavadskas et al., 2020; Abdulla & Baryannis, 2024).

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