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Multi-Level Analytical Hierarchy Process in Supplier Performance Evaluation for Mining Equipment Procurement

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Abstract

To successfully purchase and manage the supply chain, mining companies must evaluate the suppliers' performance. In the case of mining companies, the reliability of both equipment and services is essential to maintain the integrity of operations. Thus, this research seeks to present a structured approach to evaluating supplier performance based on the Analytical Hierarchy Process (AHP) methodology. Such a framework will help to fill the void for establishing a framework for systematically evaluating supplier performance using a specific set of criteria, such as Professionalism, Quality, Delivery Performance, Cost, and Support & Maintenance. The research uses expert opinions through pairwise comparison and AHP analysis with Super Decisions software for sensitivity analysis of supplier performance rankings based upon weights of selected criteria. The results show that AHP improves the transparency, consistency, and objectivity of supplier selection, and sensitivity analysis increases confidence levels of decision-making. The research contributes to managerial knowledge for improving purchasing efficiency, reducing risks of related supply chain activities, and developing long-term supplier partnerships for mining companies.

Keywords
Supplier performance evaluation; Analytical Hierarchy Process (AHP); Multi-criteria decision-making; Mining equipment procurement; Sensitivity analysis

1. Introduction
Multi-Criteria Decision Making (MCDM) is an approach that provides support for supplier performance assessment in a manufacturer setting, thereby enhancing the supplier performance assessment process. The effect of applying MCDM to supplier performance assessment in the mining sector is considerable due to the nature of the mining business, where operations depend heavily on the provision of reliable equipment and services (Olivares and Castillo-Vergara 2023). Due to increased demand for mining equipment, supplier relationships have become a critical aspect of obtaining or selecting the highest quality, price and service. A supplier assessment framework has enabled companies to mitigate their procurement risk associated with the upfront capital investment for the equipment.

Supplier selection in mining companies involves multiple facets and is highly complex; therefore, relying on cost-based measures alone is not sufficient for supplier evaluation. Several studies have shown that a combination of Sustainability, Resiliency, and Strategic Performance should be considered when making decisions regarding supplier selection (Mirzaee and Ashtab 2024; Becerra and Diaz 2025). Multiple studies demonstrated the necessity for a complete transformational vendor performance evaluation. By implementing multi-criteria decision-making (MCDM) methods, mining companies can assess vendor performance based on various factors such as environmental sustainability, social responsibility, quality of products and services, and compliance with contracts (Olivares and Castillo-Vergara 2023; Sahoo et al. 2024). In mid-scale to small-scale mining companies, there are two prominent considerations in choosing suppliers: how much the supplier values the environment and communities, and how much value they place on the quality of the product or service (Olivares and Castillo-Vergara 2023). The Analytical Hierarchy Process (AHP) method is very effective in doing an assessment of how well different suppliers perform, because it provides an effective means to deal with complex challenges, striving for continuous and objective improvements. Support in Sustainability and faster, correct operational decisions also come from Decision Support Systems (DSS) (Nurprihatin et al. 2021; Andry et al. 2023).

The purpose of this proposed study is to develop a comprehensive system to assess supplier performance using AHP in such a way that it aims to enhance the supplier assessment method of an existing large-scale mining corporation in Indonesia towards an objective approach to supplier development.

AHP combines hard data with the use of expert knowledge. This allows decision-makers to involve their knowledge, experience, and preferences in the decision-making process, maintaining the systematic nature of the same (Nurprihatin et al. 2022a). The important criteria used in the decision-making process using AHP include professionalism, quality, service performance, cost, and technical support. Previous research has shown that the use of AHP in decision-making increases the degree of objectivity, consistency, and efficiency in the assessment of suppliers and procurement decision-making (Ismail et al. 2025; Safavi et al. 2025; Cihan and Kabak 2025).

This study examines how to assess suppliers of equipment used in a mining company. This research provides insights that can create an efficient procurement process, an environmentally friendlier, sustainable supply chain, or both. The research will also explore comparisons in supplier assessment methods to explain how AHP can help unlock existing challenges in supplier assessment in the mining industry. Thus, it will help improve organizational efficiency.

2. Problem Formulation
At present, it is not possible in the organization to correctly assess supplier performance, properly manage suppliers, or develop a supplier association because no organized process is in place that focuses on supplier assessment. It has been acknowledged that supplier assessment tools are not adequate, particularly in an adept environment of purchase, whereas AHP is an appropriate technique that aims to address adept purchase circumstances that involve risk variables (Prakash et al. 2023). Therefore, AHP gives a scientific solution in mathematics for supplier liability and plays an important role in fulfilling strategic goals, such as decreased costs, enhanced services, and maximum efficiency in the supply chain(Manik 2023). In this regard, this research work proposes an AHP approach for supplier performance

assessment. The purpose of this work is to enable decision-making, improve the precision of supplier selection, enhance supplier relations, and achieve efficient mining equipment procurement.

The literature review on supplier selection is organized around closely linked research questions. The study points out that the key criteria and sub-criteria applied for judging the performance of suppliers include cost, quality, delivery performance, technical support, safety, environmental, and financial issues. The study also considers the operational factors applied for judging suppliers, including durability, lead time, availability of spare parts, and time response. The impact of sensitivity analysis on accuracy during the process of supplier assessment and AHP for increasing accuracy through expert opinions will also be examined.

The assumption in this study is that supplier performance data is truthful and available, that supplier selection criteria weights are constant throughout the time period of the analysis, that AHP is an appropriate model of supplier performance in mining procurement, whereas some limitations are associated with the subjective nature of expert opinion, possible inaccuracies in some supplier performance data, limited time period of supplier performance assessment, and limited number of supplier selection criteria considered.

The assessment of suppliers' performance is a strategic behavior that enables successful procurement, ensures consistency of quality, and reduces risks associated with supply chains. Suppliers' quality management is a strategic process of assessing suppliers' performance, and its aims include improvement of procurement validity and correction of non-compliance problems (Patil 2024). Suppliers' performance risk directly impacts supply chain performance; error-free suppliers' performance ensures stronger strategic planning and lower aggregate strategic risk (Zaman et al. 2024). Systematic assessment of dimensions such as quality, delivery, pricing, and technical support enhances sourcing decisions, competitiveness, and customer satisfaction, while enabling early risk identification and continuous supplier development (Zavadskas et al. 2020; Nurprihatin et al. 2022c; Baskir 2023; Lin et al. 2023). Improvements and evaluations must be made to maintain the level of customer satisfaction (Nurprihatin et al. 2022b). Factors that are considered important in evaluating are professionalism, quality, delivery, cost, and technical support are presented in Table 1.(Zavadskas et al. 2020; Chaozhou et al. 2021; Baskir 2023; Lin et al. 2023). Tables 2 to 6 include sub-criteria associated with each criterion. It is observed that a comprehensive multi-criteria technique, such as AHP, offers a robust basis in practical supplier selection, supply chain management, and functioning in a dynamic business environment.

Table 1. Related works of main criteria

No	**Author(s)**	**Purpose**	**Multi-Criteria Decision-Making Methods**	**Criteria**				
				Professionalism	**Quality**	**Delivery Time**	**Cost**	**Technical Support**
1	(Lin et al. 2023)	Supplier Selection	AHP	✓	✓			
2	(Chaozhou et al. 2021)	Service Evaluation of Automobile Inspection	AHP-Fuzzy Comprehensive Evaluation	✓				
3	(Zavadskas et al. 2020)	Supplier Selection	Fuzzy AHP		✓	✓	✓	
4	(Baskir 2023)	New Lean Management Tool	QFD - AHP					✓
5	This Paper	Supplier Selection	AHP	✓	✓	✓	✓	✓

Table 2. Related works of professionalism sub-criteria

No	Author(s)	Purpose	Multi-Criteria Decision-Making Methods	Sub-Criteria		
				Historical Performance	Legal Compliance	Ethical Behavior
1	(Baki 2022)	Green Supplier Selection	ARAS (Additive Ratio Assessment)	✓	✓	No
2	(Chang et al. 2023)	Competency Based Medical Education	ANP-VIKOR	✓		✓
3	(Rasmussen et al. 2023)	Supplier Selection	Fuzzy AHP	✓		
4	(Jain and Singh 2020)	Supplier Selection	Fuzzy Inference System (FIS)	✓	✓	✓
5	This Paper	Supplier Selection	AHP	✓	✓	✓

Table 3. Related works of quality sub-criteria

No	Author(s)	Purpose	Multi-Criteria Decision-Making Methods	Sub-Criteria			
				Compliance with Specifications	Product Reliability	Defect Rate	User's Satisfaction
1	(Baki 2022)	Green Supplier Selection	ARAS (Additive Ratio Assessment)		✓	✓	
2	(Hidayat et al. 2023)	Supplier Selection	Fuzzy-AHP & TLS	✓		✓	
3	(Fan et al. 2021)	Suitability Evaluation	Fuzzy comprehensive evaluation (FCE) & AHP		✓		✓
4	(Liou et al. 2021)	New Lean Management Tool	QFD - AHP	✓		✓	✓
5	This Paper	Supplier Selection	AHP	✓	✓	✓	✓

Table 4. Related works of delivery sub-criteria

No	Author(s)	Purpose	Multi-Criteria Decision-Making Methods	Sub-Criteria			
				On-Time Delivery	Lead-Time	Flexibility	Reliability
1	(Baki 2022)	Green Supplier Selection	ARAS (Additive Ratio Assessment)		✓		
2	(Hidayat et al. 2023)	Supplier Selection	Fuzzy-AHP & TLS	✓		✓	
3	(Voeng and Kritchanchai 2019)	Supplier Selection	AHP	✓		✓	✓
4	(Wang et al. 2022)	Supplier Selection	FAHP & FTOPSIS	✓	✓		

No	Author(s)	Purpose	Multi-Criteria Decision-Making Methods	Sub-Criteria			
				On-Time Delivery	Lead-Time	Flexibility	Reliability
5	(Fagundes et al. 2021)	Supplier Selection Risk	Fuzzy Extended AHP	✓	✓		✓
6	This Paper	Supplier Selection	AHP	✓	✓	✓	✓

Table 5. Related works of cost sub-criteria

No	Author(s)	Purpose	Multi-Criteria Decision-Making Methods	Sub-Criteria			
				Discounts	Competitive Pricing	Payment Terms	Cost Transparency
1	(Baki 2022)	Green Supplier Selection	ARAS (Additive Ratio Assessment)	✓	✓	✓	
2	(Wang et al. 2022)	Supplier Selection	FAHP & FTOPSIS	✓	✓		
3	(Sharma and Joshi 2023)	Supplier Selection	SWARA	✓	✓	✓	✓
4	(Pradana et al. 2022)	Distributor Selection	AHP	✓		✓	✓
5	This Paper	Supplier Selection	AHP	✓	✓	✓	✓

Table 6. Related works of technical support/service sub-criteria

No	Author(s)	Purpose	Multi-Criteria Decision-Making Methods	Sub-Criteria	
				After-Sales Support	Warranty Coverage
1	(Baki 2022)	Green Supplier Selection	ARAS (Additive Ratio Assessment)	✓	✓
2	(Voeng and Kritchanchai 2019)	Supplier Selection	AHP	✓	✓
3	(Wang et al. 2022)	Supplier Selection	FAHP & FTOPSIS	✓	
4	(Modibbo et al. 2022)	Supplier Selection	Fuzzy TOPSIS	✓	✓
5	This Paper	Supplier Selection	AHP	✓	✓

3. Methods
3.1 Hierarchy Structure Development
The evaluation process for evaluating suppliers is structured hierarchically, as shown in Figure 1. In this assessment, the use of objectives, criteria, and sub-criteria, along with the alternatives, provides the foundation for a systematic and comprehensive supplier evaluation.

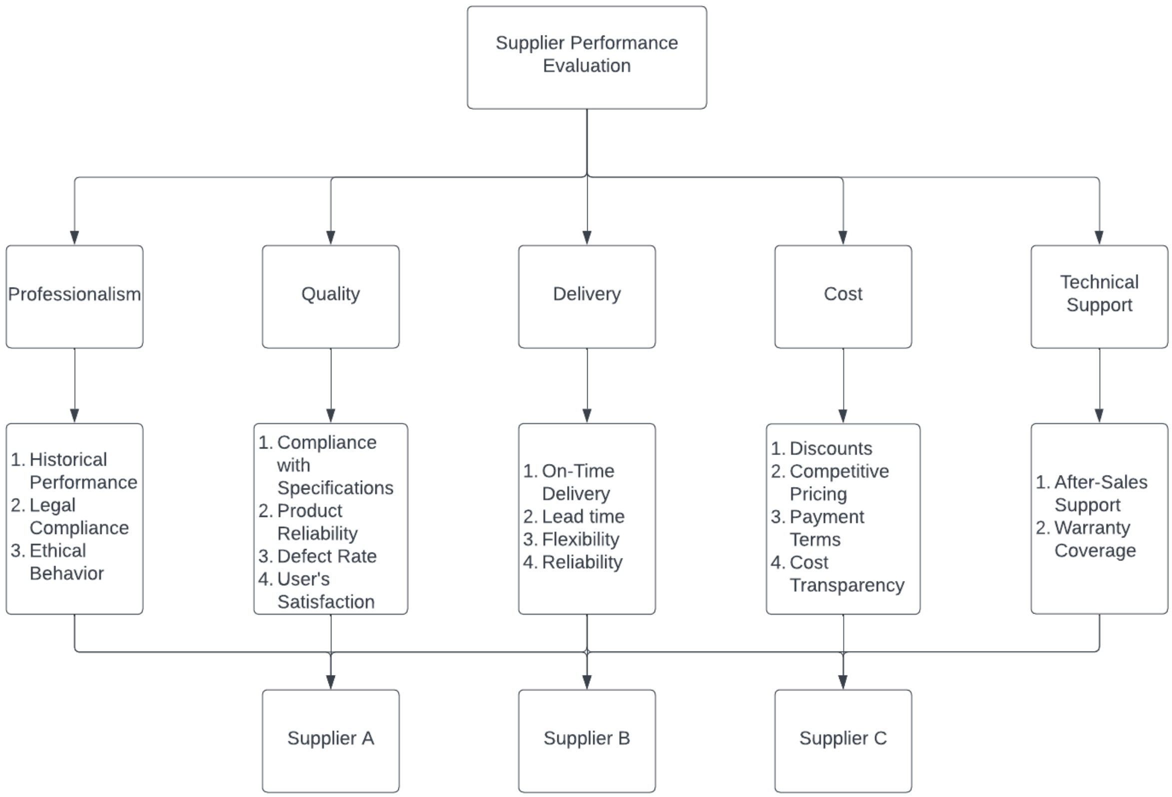


Figure 1. AHP hierarchy of supplier performance evaluation

3.2 Criteria Identification and Definition

The identification of the primary criteria used to evaluate supplier performance for the Material Requisition to Purchase Order process is critical. Criteria selected for evaluation of supplier performance are identified through consultation with team members within the purchasing department. Professionalism, quality, delivery time, cost/price, and technical support/maintenance are key criteria used to assess suppliers. Table 7 provides a listing of sub-criteria for each of these key criteria.

Table 7. Description for sub criteria

No.	Criteria	Sub-Criteria	Description
1.	Professionalism	Historical Performance	This sub-criterion assesses the supplier's past performance record with respect to professionalism, integrity, and transparency during past collaborations and whether the supplier retains a positive reputation based on the supplier's commitment to high standards or not.
		Legal Compliance	This sub-criterion examines how well the supplier is carrying out their business within legal frameworks to ensure that all practices, processes, and products of the supplier align with legal frameworks to avoid legal risk for the buyer.
		Ethical Behavior	This sub-criterion mainly focuses on the ethical performance of the supplier because issues like fairness, honesty, and integrity in dealings are important in building trust and a good working relationship with the buyer.

No.	Criteria	Sub-Criteria	Description
2.	Quality	Compliance with Specifications	This sub-criterion assesses how well the provided products or services meet the buyer's stipulated demands and standards. The aim is to ensure that products with stipulated standards are provided.
		Product Reliability	This sub-criterion evaluates the dependability and consistency of either the supplier's products or their services with regard to their regularity of meeting expectation levels and their functionality.
		Defect Rate	This measure quantifies the frequency of flaws or defects in the products supplied. A low failure rate signifies improved product quality and fewer interruptions.
		User Satisfaction	This sub-criterion requires getting feedback from users to determine the extent of satisfaction with products/services from the supplier.
3.	Delivery	On-Time Delivery	This sub-criterion assesses the supplier's ability to provide products or services on time, and the supplier's ability to process and prepare orders for delivery.
		Lead Time	This a sub-criterion looks at efficiency levels concerning order processing and preparation for dispatch. When a company has a shorter lead time, it means that orders are processed and shipped faster with minimal delays.
		Flexibility	This sub-criterion evaluates the ability of the supplier to respond to unforeseen events or changes in delivery times. Suppliers who can adapt to unforeseen events will help ensure a smooth flow process through the supply chain.
		Reliability	This sub-criterion assesses the supplier's dependability in meeting delivery requirements and avoiding delays, which contributes to efficient operations.
4.	Cost	Discounts	This sub-criterion takes into consideration the discount offered by the supplier. The discount may bring about savings to the business, making it cheaper to acquire from the supplier.
		Competitive Pricing	This sub-criterion evaluates how the supplier's pricing compares to alternatives in the market. Suppliers with competitive pricing contribute to cost-efficient procurement processes.
		Payment Terms	This sub-criterion evaluates the supplier's payment terms and conditions for flexibility and fairness, ensuring compliance with the organization's financial procedures.
		Cost Transparency	This sub-criterion examines the supplier's transparency in providing thorough cost breakdowns, eliminating hidden charges that could lead to unexpected costs.
5.	Technical Support/Service	After-Sales Support	This sub-criterion analyzes the supplier's commitment to help, troubleshoot, or assist even after completion of the first sale. Good after-sales service ensures that the delivered products or services continue to work properly.
		Warranty Coverage	This sub-criterion is concerned with the warranty provided by the supplier. The warranty may include how long it is applicable and how it covers maintenance and repair after purchase. A warranty is one of the factors that add value to what is provided by a supplier.

3.3 Pairwise Comparison

Carried out within the procurement department, this study aims to assess performance measurements of suppliers based on the AHP methodology. The technique is beneficial for a methodical and scientific process. The AHP is an MCDM method that is an established Analytical Aid for Supplier Performance Evaluation. It is the method chosen for the Evaluation of Supplier Performance, and it develops a Consistent Scale through Pairwise Comparison

(Canhasi-Kasemi and Vardari 2022). To make it all manageable and relatively simple, a structured nine-point scale is utilized to assess the relative importance of each criterion and sub-criterion, as shown in Table 8.

Table 8. Comparison scale table

Scale Value	Definition	Explanation
1	Equal importance	The two elements *i* and *j* are equally important.
2	Intermediate importance between 1 and 3	Slight to moderate preference of element *i* over *j*.
3	Moderate importance	Moderate preference of element *i* over element *j*.
4	Intermediate importance between 3 and 5	Moderate to strong preference of element *i* over *j*.
5	Strong importance	Strong preference for element *i* over *j*.
6	Intermediate importance between 5 and 7	Strong to very strong preference for one element over the other.
7	Very strong importance	Very strong preference of element *i* over *j*.
8	Intermediate importance between 7 and 9	There is a very strong to extremely strong preference for one element over the other.
9	Extremely strong importance	Extremely strong preference of element *i* over *j*.

In this strategy, a comparison is made between each pair of criteria (Criteria *i* vs. Criteria *j*). A representative sample of members from the procurement division received AHP questionnaires. The questionnaire was filled out by four responsive participants within the study. The data that form the basis of this analysis and evaluation are created from the summary of the responses of these four individuals. The individuals who are selected for participation in this study had a high degree of experience and had a great deal of involvement in procurement-related activities; thus, the information collected for this study reflects the perspective of the procurement division. The participation of these individuals was on a voluntary basis and enhances the credibility of this research, as it provides relevant information regarding the supplier performance evaluation process as it relates to the procurement division. After receiving the results from the questionnaires, the Geometric Mean can be calculated to obtain an average of the results as given by Equation (1) (Stofkova et al. 2022).

$$GM = \sqrt[n]{X_1 \times X_2 \times X_3 \times \ldots \times X_n} \tag{1}$$

The variable *n* represents the total number of entries on the form. After calculating the Geometric Mean of all respondents, the mean was used to create the criteria comparison matrix described in Equation (2) (Stofkova et al. 2022).

$$A = \begin{pmatrix} 1 & a_{12} & \ldots & a_{1k} \\ 1/a_{12} & 1 & \ldots & a_{2k} \\ \ldots & \ldots & \ldots & \ldots \\ 1/a_{1k} & 1/a_{2k} & \ldots & 1 \end{pmatrix} \tag{2}$$

Once the Geometric Mean has been populated in this fashion, a new matrix of Geometric Means for the comparison of each criterion (as opposed to all of the columns) allows us to normalize the comparisons between criteria. Each element in this new Geometric Mean comparison matrix will have its column total applied to it; after that is completed, the eigenvalues of the normalized criterion comparison will be calculated using row averages as they apply to the criterion comparisons matrix. The eigenvalues are derived mathematically using a formula, which can also be found in Equation (3), and will be evaluated accurately by mathematical techniques, through our significant review of the given methodology through AHP (Stofkova et al. 2022).

$$Eigenvalue = \frac{A_{ij}}{\sum A_{ij}} \tag{3}$$

The only way to calculate the magnitude of the alternatives' and criteria's weights is to sum the eigenvalues associated with the particular element in a row and divide that sum by the total number of elements in that row; that average eigenvalue will then become a critical component of the AHP model and can be found in Equation (4).

$$W_i = \frac{\sum GM_n}{n} \tag{4}$$

where
$n = number\ of\ elements$
$\sum GM_n = Total\ Geometric\ Mean\ in\ a\ row$

3.4 Checking the Consistency Ratio (CR)

The comparisons must be checked for their level of consistency for the comparisons among pairs in the AHP to be reliable. The consistency ratio, as a tool, is a vital measure for the evaluation of the reliability and consistency of the comparisons (Stofkova et al. 2022).

1. The first step consists of dividing the result of the matrix multiplication by the eigenvalue obtained from Equation (5).
$$X_i = \frac{(w_i)}{(\sum w_i)} \tag{5}$$
where
X_i = consistency vector representing the relative weight of the criterion or alternative
w_i = the weight of the criterion or alternative.
$\sum w_i$ = the sum of all weights
2. The consistency vector value (λ) is calculated by averaging the data obtained in the first step, as seen in Equation (6).
$$\lambda_{max} = \left(\sum a_{ij}\right) \times X_i \tag{6}$$
where
λ_{max} = consistency vector value
a_{ij} = the elements of the comparison matrix
3. Once the consistency vector value has been determined, the next step involve calculating the consistency index with formula as shown in Equation (7).
$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{7}$$
where
n = number of criteria or alternatives that are being compared
4. Calculation of CR is using Equation (8).
$$CR = \frac{CI}{RI} \tag{8}$$

RI = Average random consistency index as in Table 9 (Canhasi-Kasemi and Vardari 2022).

Table 9. Average random consistency index

Number of Elements	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Random Index	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

In case the value of CR is found to be below 0.10, then the consistency of pairwise comparisons can be deemed acceptable. This threshold value is typically used to assess the accuracy of the judgments made throughout the comparison process. If the consistency ratio is less than 0.10, it implies that the variance of judgments does not affect the reliability of decisions.

It becomes particularly beneficial in dealing with the inconsistency ratio when using Super Decision. The program is quick to calculate the inconsistency ratio, so that determining the level of consistency in paired comparisons will not be a daunting task for a decision-maker. It is easy to discover conditions when the judgements presented in the pairwise comparisons may lack consistency by using the software's built-in inconsistency ratio. This attribute improves the quality of the decision-making process by following the principles of AHP. The summarization of the framework for this paper is depicted in Figure 2.

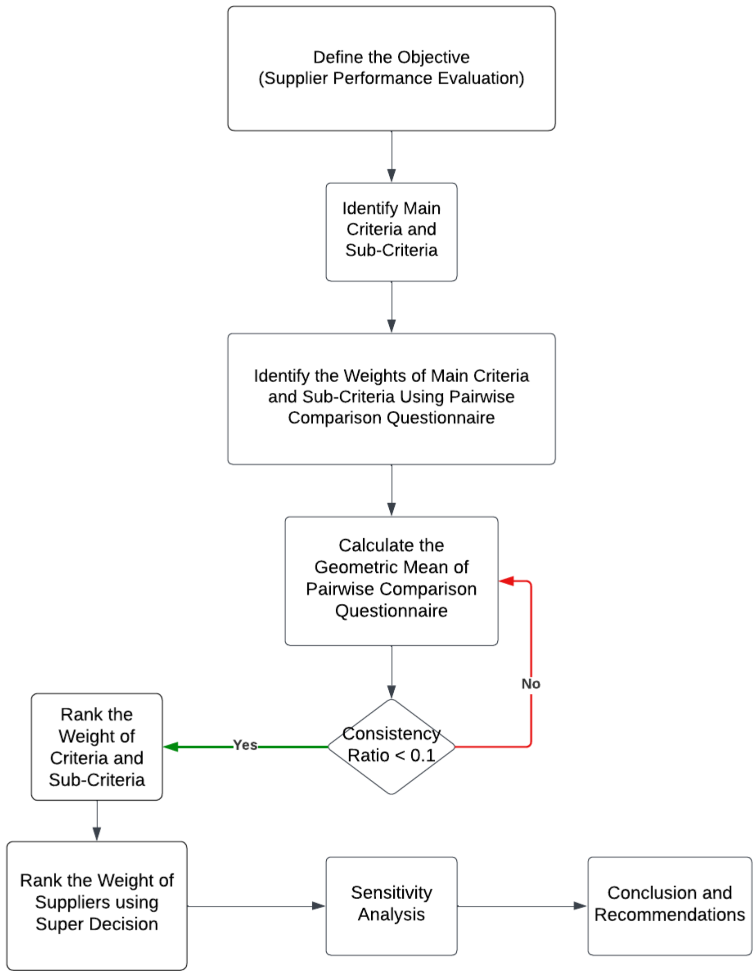


Figure 2. Supplier performance evaluation framework

4. Results and Discussion

4.1 Ranking and Determining Weight of Main Criteria

The first step revolves around establishing the weighted decision for the criteria. For this purpose, we employ the method of comparison for criterion ranking. Based on the survey results, a super matrix for the aspect criteria is presented in Table 10. After the calculation of the comparison matrix, it is proceeded to enter this information into Super Decision software to establish the ranked weights of the criteria as indicated in Figure 3.

Table 10. Pairwise comparison of main criteria

Criteria	Professionalism	Quality	Delivery	Cost	Technical Support
Professionalism	1	1.414	3.464	1.732	3.936
Quality	0.707	1	4.472	2.060	4.356
Delivery	0.289	0.224	1	0.310	1.861
Cost	0.577	0.485	3.224	1	3.873
Technical Support	0.254	0.230	0.537	0.258	1

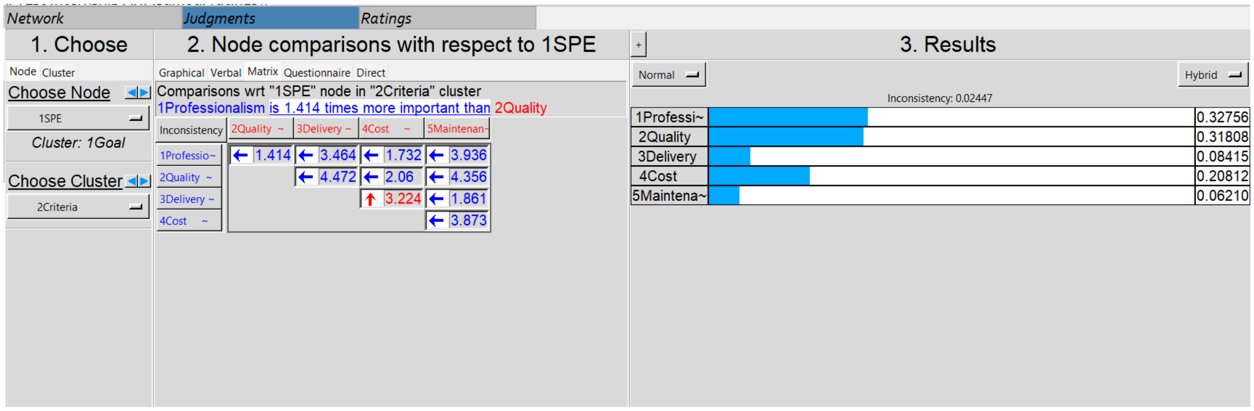


Figure 3. Pairwise comparison of criteria in Super Decision

The findings of the weighting method for the evaluation criteria demonstrate a hierarchy of importance among criteria, ranking professionalism, quality, cost, delivery, and technical support in that order. Professionalism is the most important in terms of weight distribution, with a weight of 32.8%, followed by quality at 31.8%. Cost accounts for 20.8% of the total, while delivery and technical support account for 8.4% and 6.2%, respectively. These weight values represent the relative importance of each criterion in the evaluation of supplier performance, giving a formal basis for decision-making and resource allocation that is aligned with organizational priorities. Table 11 shows the weighted result and criteria ranking. The element of criteria weighting has an inconsistency ratio or a consistency ratio of 0.02. The consistency ratio on the aspect criteria is less than 0.10 (CR 0.10), therefore it is stated to be consistent, and the respondents' evaluations of the data are deemed appropriate.

Table 11. Ranked weights of criteria

Code	Ranking	Criteria	Weight
P	1	Professionalism	32.8%
Q	2	Quality	31.8%
C	3	Cost	20.8%
D	4	Delivery	8.4%
M	5	Technical Support	6.2%

4.2 Ranking and Determining Weight of Sub-Criteria

The weights and sub-criteria ranking are presented in Table 12. The weighting result shows how much each sub-criterion of an aspect receives relative importance. From this result, it appears that Legal Compliance receives the most weight of 56.2%, followed by Warranty Coverage with 55.1%, whereas Defect Rate follows with 46.6%. The weights on each sub-criterion must be reviewed to ensure that they have good consistency to obtain overall consistency in weighting an aspect criterion. Table 13 presents an inconsistency value attributed to each criterion of an aspect. Consistency in weights of sub-criterions on various criteria includes professionalism = 0.027, quality = 0.048, cost = 0.076, delivery = 0.035, and technical support = 0.000. As each criterion of this study had values less than 0.10, this means that there is an excellent correlation between the survey administered to determine data and these data; therefore, the data collected from respondents' assessment of data is suitable.

The Professionalism criteria occupy a prominent place in the complete analysis of the processed data, thereby expounding the importance of these standards in the evaluation of suppliers. The Technical Support criterion, on the other hand, has the lowest priority. In terms of sub-criteria, Legal Compliance is the most important, while Reliability is the least important. Notably, although not being clustered together, the highest priority criteria and the accompanying sub-criteria are inherently interconnected.

Table 12. Ranked weights of sub-criteria

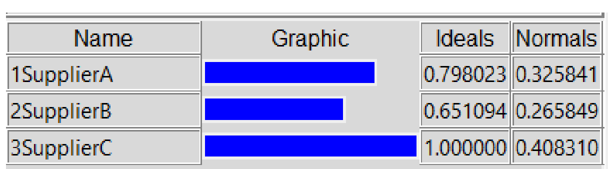
Code	Sub-Criteria	Weight	Ranking
P2	Legal Compliance	56.2%	1
M2	Warranty Coverage	55.1%	2
Q3	Defect Rate	46.6%	3
M1	After-Sales Support	44.9%	4
D2	Lead Time	42.8%	5
C1	Discounts	38.7%	6
P1	Historical Performance	32.4%	7
D3	Flexibility	31.3%	8
C4	Cost transparency	28.4%	9
Q1	Compliance with Specification	24.6%	10
Q4	User's Satisfaction	18.6%	11
C3	Payment Terms	16.8%	12
D1	On-Time Delivery	16.5%	13
C2	Competitive Pricing	16.1%	14
P3	Ethical Behavior	11.4%	15
Q2	Product Reliability	10.2%	16
D4	Reliability	9.4%	17

Table 13. Inconsistency of value of criteria against sub-criteria

Criteria	Inconsistency Ratio
Professionalism	0.027
Quality	0.048
Cost	0.076
Delivery	0.035
Technical Support	0.000

4.3 Ranking and Determining Weight of Supplier

The determination of supplier priorities for each sub-criterion has been completed following the supplier acquisition process. As a result, a supplier ranking has been established, indicating their performance and relevance within the analyzed sub-criteria. Using the Synthesize option in Super Decision takes the structured input from the decision-maker, including pairwise comparisons and criteria weights, and computes a synthesized result that aids in making informed decisions by considering both the data-driven judgments and the interrelationships among elements. The resultant weightage scores and rankings of suppliers are presented in Figure 4 and Table 14.



Name	Graphic	Ideals	Normals
1SupplierA		0.798023	0.325841
2SupplierB		0.651094	0.265849
3SupplierC		1.000000	0.408310

Figure 4. Synthesized model of AHP from Super Decision

Table 14. Ranked weights of supplier

Supplier	Weight	Ranking
Supplier C	40.8%	1
Supplier A	32.6%	2
Supplier B	26.6%	3

For the sub-criteria of “Ethical Behavior”, “Defect Rate”, and “User’s Satisfaction”, all suppliers get the same weight of 33%. Supplier A is a priority in “cost transparency” (43.6%), “on-time delivery” (65.6%), “Product reliability” (41.3%), and “Cost transparency" (43.6%). Supplier B is a priority in “Competitive Pricing” (55.8%), “Flexibility” (61.4%), and “Warranty Coverage” (62.5%). Supplier C is a priority in “Historical Performance” (45.8%), “Legal Compliance” (54%), “Compliance with Specification” (41.3%), “Discounts” (60.5%), “Payment Terms” (44%), “Lead Time” (54.7%), “Reliability” (50.9%) and "After-Sales Support” (49.3%).

Based on the weighing data provided, supplier C appears to be the most suitable choice with a significant weight of 40.8%. Supplier C wields considerable influence for many sub-criteria, thus affirming its selection as a supplier. Supplier C scores high for many important sub-criteria, such as Legal Compliance. The second preference is that of Supplier A, weighing 32.6%. This criterion choice is based on the relative strengths of supplier A’s performance among the criteria and sub-criteria, thus being a preferred choice without necessarily being the best choice. On the other hand, supplier B ranks the lowest among the choices, weighing 26.6%. This is based on the relative performance of supplier B among the criteria and sub-criteria defined, thus placing it among the lower ranks.

After determining the ranks of the suppliers, we proceed to verify the consistency ratio for the sub-criteria. This step ensures that there is consistency in the decision, as indicated in Table 15. It is important to note that for all criteria, the consistency ratio remained at or below 0.10, which indicates that the decision was highly consistent. The ratings obtained from the respondents can be relied upon because a CR of 0.10 shows that the pairwise comparison process in the evaluation of the criteria was consistent and accurate.

Table 15. Inconsistency of value of sub-criteria against suppliers

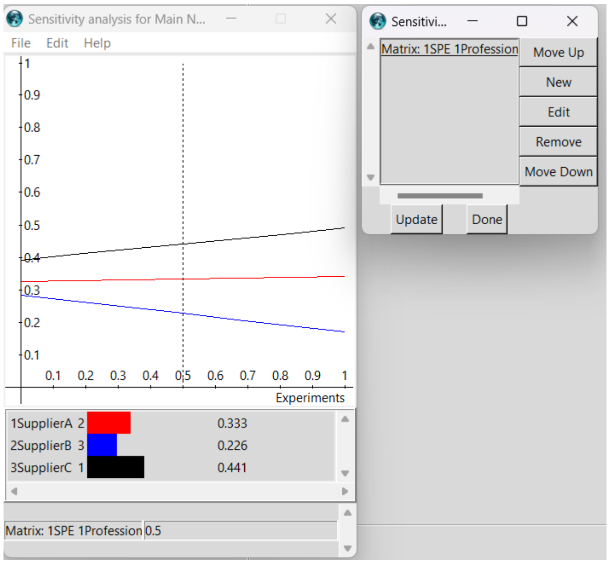
Code	Sub-Criteria	Inconsistency Ratio
P2	Legal Compliance	0.008
M2	Warranty Coverage	0.017
Q3	Defect Rate	0.000
M1	After-Sales Support	0.051
D2	Lead Time	0.083
C1	Discounts	0.077
P1	Historical Performance	0.008
D3	Flexibility	0.071
C4	Cost transparency	0.028
Q1	Compliance with Specification	0.051
Q4	User’s Satisfaction	0.000
C3	Payment Terms	0.024
D1	On-Time Delivery	0.018
C2	Competitive Pricing	0.017
P3	Ethical Behavior	0.000
Q2	Product Reliability	0.052
D4	Reliability	0.033

4.4 AHP Sensitivity Analysis

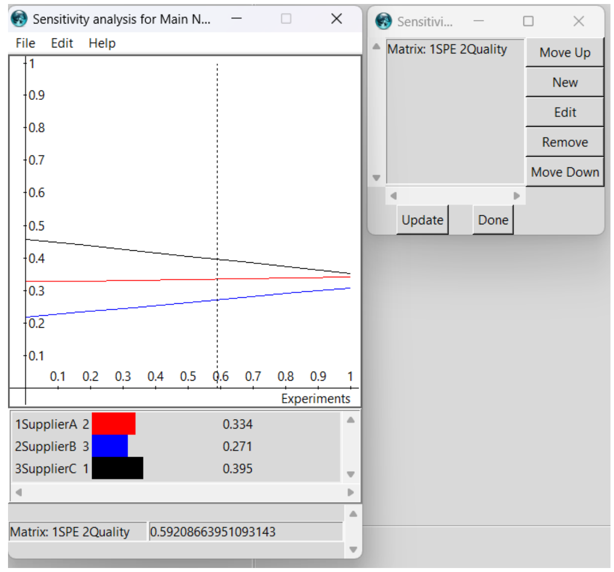
The sensitivity analysis of AHP considers the variability in input data, such as criterion weights or ratios of pairwise comparison, will significantly impact an AHP-generated solution. Super Decision helps to perform a sensitivity test to find out how robust the findings are if the input data varies or sometimes contains some level of uncertainty. Decision-makers can see how changing the weights assigned to criterion or the pairwise comparison values affect the overall priorities and rankings of alternatives. Sensitivity analysis allows decision-makers to understand how important conclusions are dependent on various pieces of information, in turning out what influences most in arriving at conclusions. It is carried out by altering the priority accorded to major criteria.

According to Figure 5, there will be no changes in the rank of the supplier when the weights of professionalism, quality, and cost criteria are changed. The ranking of suppliers is robust and will not change even if the decreasing or increasing value of the weight percentage from its original weight which are 32.8%, 31.8%, and 20.8% for professionalism, quality, and cost, respectively. Figure 5 also illustrates the rank of suppliers will change from Supplier

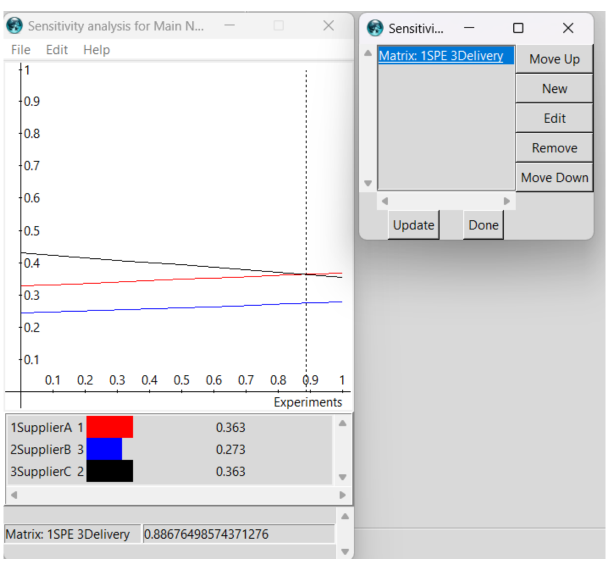
(C, A, B) to supplier (A, C, B) when the weight of delivery criterion is above 88.7%. Figure 6 shows how the rankings change for suppliers as increasing values in the weight for technical support from 6.2% to 32.6% bring about a change in ranking from Suppliers (C, A, B) to Suppliers (C, B, A), and then for a further increase in the weight to 71.3%, the ranking changes to Suppliers (B, C, A).



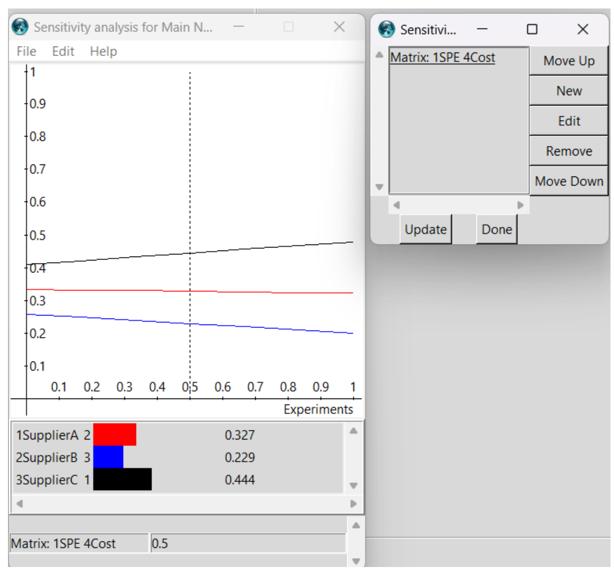
Sensitivity analysis with respect to professionalism



Sensitivity analysis with respect to quality



Sensitivity analysis with respect to delivery



Sensitivity analysis with respect to cost

Figure 5. Sensitivity analysis with respect to professionalism, quality, delivery, and cost

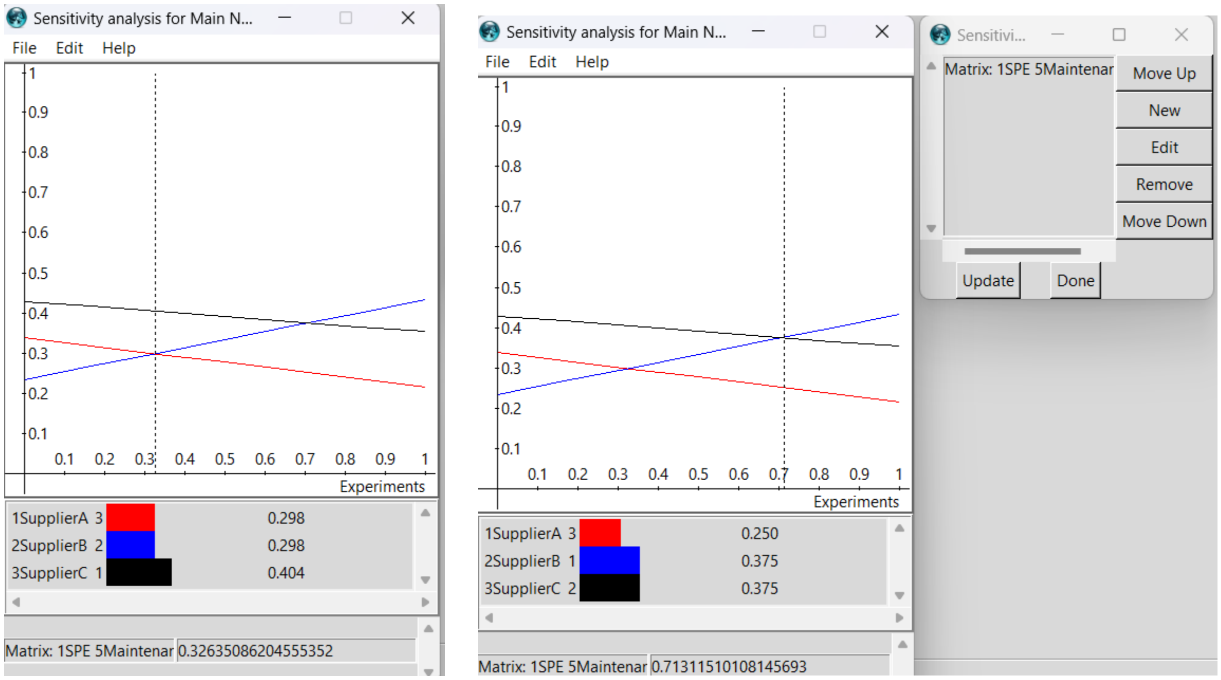


Figure 6. Sensitivity analysis with respect to tech support/maintenance

5. Conclusion

In conclusion, the use of AHP Sensitivity Analysis throughout Super Decision has offered an organized and complete framework for analyzing supplier performance and making educated decisions. The first step involves creating decisions with weights using pairwise comparisons, which determines the order of priorities for every criterion. By examining the consistency ratio, it can be ensured that the weights are valid and within acceptable restrictions.

Furthermore, the scoring of sub-criteria follows, with legal compliance, warranty terms, and rate of defects at the top of this list. The levels of inconsistency of the results of sub-criteria determine how reliable such results are. In any of the sub-criteria, the relative positions of suppliers reflect their strength in several categories at once.

In addition, sensitivity analysis performed in the software shows how stable the rank of the supplier is when changes are experienced in the weightings of the criteria. Most changes are minimal, and this decision-making is sound. This study will enable decision-makers to see how different variables could influence priorities in suppliers.

Application of the AHP technique on sensitivity analysis is an effective approach to be adopted by companies to maximize efficiency in their supplier evaluation process by unbiased assessment. The technique ensures that every organizational decision made is consistent with the goals and improves allocations by recognizing the weight given to criteria, sub-criteria, and suppliers by assessment.

The sensitivity analysis arrives at specific actions that need to be taken forward for enhancing the way suppliers are judged and choices made. Effective and proper supplier evaluation is extremely essential for the success of any organization. The main way to achieve this is by evaluating and updating the criteria and sub-criteria. In addition to purely financial metrics, it is required to expand the criteria by which we measure suppliers by incorporating factors that represent the broader strengths in support. Some of these factors could include innovation strengths, sustainability results, and response time.

Incorporating end users will introduce diverse perspectives into supplier selection to create a better-supplier selection process by overcoming evaluator bias. Sensitivity analysts will improve readiness by recognizing potential supply chain risks before an event occurs, making supply chains even more resilient for a better procurement function. Therefore, as a conclusion, insights from analyzing data empower managers to make better-informed, objective, and aligned decisions.

Future directions for continued research on sensitivity analyses seem promising. For example, an avenue for research and further development might include a comparison of the AHP with other available multi-criteria decision-making tools that have been developed, e.g., the Alternative Network Process, TOPSIS, or PROMETHEE, to assess their respective performance (robustness and stability) relative to using the Analytical Hierarchical Process for assessing supplier performance. Another avenue for future research and further development would be to determine new criteria and sub-criteria for evaluating suppliers that focus on newer elements of purchasing, such as sustainability performance, innovation capability, and ethical conduct. Future research should focus on improving the representation and accuracy of data and judgment for suppliers' performance by incorporating feedback from not only internal key personnel but from external sources as well.

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Ali Vaezi is on the faculty in the Department of Logistics and Supply Chain Management at Trent University in Canada. His main areas of research interest include supply chain strategy, logistics optimization, and the development of state-of-the-art decision-support models with a focus on complex, uncertain environments. He integrates analytical modeling with quantitative methods and data-driven approaches, enabling better network design, improved network performance, and enhanced resilience. His work often stands at the junction between supply chain analytics, sustainability, and risk management, dealing with contemporary challenges faced by organizations, such as disruption, environmental footprint, and the requirement of coordinated strategies across multi-tier supply networks. His findings have been either published or are forthcoming in international, peer-reviewed journals and conference proceedings, reflecting both theoretical and practical contributions to the field of supply chain and operations management. In addition to his research work, he teaches and supervises undergraduate and graduate students in how to translate theoretical models into industry-ready solutions. His general academic interests involve issues related to sustainable supply chain management, performance measurement, and the use of analytics to support managerial decisions for effective supply chain networking.

Williem is a faculty member in the Department of Informatics at President University, Bekasi Regency, West Java, Indonesia. His research interests and expertise encompass software development, system automation, information systems, and decision support systems, with a particular focus on applied programming for business, industrial, and supply chain applications. He has experience in both academic research and system implementation projects, contributing to the development of information-based and computational solutions that support managerial decision-making, system integration, and operational efficiency. His work emphasizes the practical application of information technology to solve operational and organizational challenges across diverse industrial domains.