Hybrid Fuzzy AHP-TOPSIS Framework for Wood Supplier Selection in the Furniture Enterprise

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**Abstract.**  This study aims to identify and analyze key aspects of supplier selection for wood in the furniture industry using a Hybrid Fuzzy AHP-TOPSIS approach. This method allows for a comprehensive evaluation based on criteria such as quality, price, delivery timeliness, flexibility, and risk. The main findings indicate that the quality of wood raw materials is the primary determining factor, with the quality criterion having the highest priority, while risk is given the lowest weight. This underscores the furniture industry's emphasis on procuring high-quality raw materials to meet consumer standards and expectations. Further analysis identifies Supplier 2 as the optimal choice based on the established criteria, demonstrating its ability to consistently meet or exceed expectations in terms of quality and other aspects. The study concludes that implementing Hybrid Fuzzy AHP-TOPSIS can effectively assist the furniture industry in selecting the optimal wood supplier, with a strong emphasis on quality as a key factor in decision-making.

**Keywords:** Hybrid Fuzzy AHP-TOPSIS, Wood Supplier Selection, Furniture Industry, Supply Chain Management

# INTRODUCTION

In an era of globalization and intensifying industrial competition, the furniture industry faces substantial challenges in ensuring business sustainability, heavily reliant on strategic and well-informed decisions in the selection of wood suppliers. The burgeoning demand for high-quality, environmentally sustainable wood is propelled by population growth, urbanization, lifestyle evolution, and rising incomes. As a significant sector within the global economy, the furniture industry must not only optimize the quality and availability of its wood products but also achieve cost efficiency and ensure optimal supply chain performance. Selecting the appropriate wood supplier is therefore a critical task; however, this process is often intricate and beset with uncertainties, encompassing the assessment of wood quality, resource sustainability, and the reliability of delivery schedules.

The literature indicates that employing a comprehensive and systematic supplier selection method can enhance overall supply chain performance. In this regard, integrating the Fuzzy Analytic Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) has been recognized as an effective framework to address uncertainties and subjectivities in the selection process. The Hybrid Fuzzy AHP-TOPSIS approach enables supplier evaluation based on various criteria, not only limited to price and quality but also including reliability, sustainability, and responsiveness. Therefore, this study emphasizes the importance of adopting more innovative and comprehensive methods in the supplier selection process to improve the effectiveness and efficiency of decisions made by furniture companies.

Research into global supplier selection practices reveals its criticality in ensuring a company's competitive edge in the marketplace. The Analytic Hierarchy Process (AHP), when augmented with fuzzy logic—Fuzzy AHP—has gained recognition as an effective tool for navigating the myriad factors pertinent to supplier selection, including cost, quality, and other considerations such as geopolitical conditions and geographic proximity [1-3].

An investigation at PT XYZ employing Fuzzy AHP for supplier performance evaluation identified price as the most crucial factor. According to this criterion, Supplier C was discerned as the optimal supplier [4]. A separate study conducted in Turkey evaluated suppliers based on price, quality, and additional factors using Fuzzy AHP, facilitating the company's identification of the most suitable supplier [5, 6]. Moreover, the application of a combined Fuzzy AHP and Fuzzy DEA approach by an automotive firm demonstrated the practicality and relevance of this method in real-world scenarios [7].

In light of this context, the present study aims to develop an innovative Hybrid Fuzzy AHP-TOPSIS framework tailored for wood supplier selection within the furniture industry, with a specific focus on the sector in Ngijo Village, Malang Regency. This endeavor is driven by the imperative to elucidate the factors influencing wood supplier selection and to demonstrate how the implementation of this framework can assist furniture companies in making more objective, precise, and efficient decisions. This research aspires to make a substantive contribution to the academic discourse on supplier selection strategies, particularly within the furniture industry, which is confronted with unique challenges pertaining to raw material quality and environmental sustainability.

# METHODS

This study employed two primary data collection methods: in-depth interviews and literature review. The interviews were conducted with key stakeholders in the furniture industry of Ngijo Village, Malang Regency, including furniture business owners, procurement managers, and industry experts. The primary objective of these interviews was to gain insight into their perspectives on crucial criteria for wood supplier selection and their preferences regarding supplier attributes. In addition, a comprehensive literature review was conducted to gather secondary data relevant to wood supplier selection, the application of Fuzzy AHP and TOPSIS methods, and the general challenges within the furniture industry's supply chain. This secondary data enriched the analysis and ensured that the developed framework aligned with industry needs.

The analysis utilized a combination of the Fuzzy Analytic Hierarchy Process (F-AHP) to determine the weight of the criteria and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) for evaluating and ranking wood suppliers. The process involved several key steps as outlined below:

## Weight Determination using F-AHP

The determination of weights using F-AHP [8] involves the following steps:

1. Create a hierarchy based on the problem and establish a pairwise comparison matrix between criteria using triangular fuzzy numbers (TFNs).
2. Calculate the synthetic fuzzy value (Si) using the corresponding in Eq. 1:

(1)

1. Determine the vector value (V) and the defuzzification ordinate (d’).

When determining the vector weight, if for each fuzzy matrix, M2 ≥ M1, where M2 is (l2, m2, u2) and M1 is (l1, m1, u1), the vector value is computed using Eq. 2:

(2)

The vector values are calculated using Eq. 3:

(3)

1. Use the appropriate formula to obtain the defuzzified values shown in Eq. 4:

(4)

1. Normalizing Fuzzy Weight Values (W)

Normalize the weight values, converting them into non-fuzzy numbers using Eq. 5:

(5)

The normalized weights are then obtained as Eq. 6:

(6)

## Ranking with TOPSIS [9]

1. Normalization of the Decision Matrix (R) shown in Eq. 7:

(7)

where:

= the normalized element,

= the original decision matrix element,

i = 1,2,…,m indicates the alternatives,

j = 1,2,…,n indicates the criteria,

m = the number of alternatives,

n = the number of criteria.

1. Weighted Decision Matrix (V) shown in Eq. 8:

(8)

where:

wj​ is the weight of criterion j, indicating its relative importance.

1. Positive Ideal Solution (A+) and Negative Ideal Solution (A−) shown in Eq. 9 and Eq. 10:

A+ = {max(vij​) ∣ j∈J} ∪ {min(vij​) ∣ j∈J′} (9)

A− = {min(vij​) ∣ j∈J} ∪ {max(vij​) ∣ j∈J′} (10)

where:

J represents the benefit criteria,

′J′ represents the cost criteria.

1. Distance from Positive () and Negative Ideal Solutions () shown in Eq. 11 and Eq.12:

(11)

(12)

Relative Closeness to the Ideal Solution () shown in Eq. 13:

(13)

where:

​ is the relative closeness score of alternative iii to the ideal solution. A higher value indicates that alternative i is closer to the ideal solution and is therefore considered a better choice.

The alternative with the highest value is deemed the best option, being the closest to the ideal solution and the furthest from the negative ideal solution.

# RESULTS AND DISCUSSION

This study was conducted as a case analysis of the wood industry in Ngijo Village, Malang Regency, focusing on the selection of suppliers among five candidates, identified as Suppliers 1, 2, 3, 4, and 5. The evaluation encompassed 5 main criteria and 11 sub-criteria, as outlined in **TABLE 1**. The weights for these criteria and sub-criteria were calculated using the Fuzzy AHP method, and the results are presented in **TABLE 2**.

**TABLE 2** demonstrates that the 'Quality' criterion (A) received the highest weight, while the 'Risk' criterion (C) was assigned the lowest weight. Among the sub-criteria, 'Wood is not damaged/cracked' (A1) was deemed the most significant, while 'Price variability' (C2) was considered the least important. This emphasizes the wood industry's prioritization of quality to ensure the best possible outcomes.

**TABLE 1**. Criteria and Sub-criteria

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No | Criteria | Code | Sub-criteria | Code |
| 1 | Quality | A | Wood is not damaged/cracked | A1 |
| Shape and length as specified | A2 |
| 2 | Price | B | Wood price | B1 |
| Shipping cost | B2 |
| Discount | B3 |
| 3 | Risk | C | Supplier capacity limit | C1 |
| Price variability | C2 |
| 4 | Service | D | Availability of raw materials | D1 |
| Claim response | D2 |
| 5 | Delivery | E | On-time delivery | E1 |
| Quantity accuracy | E2 |

**TABLE 2**. Weight of Criteria and Sub-criteria

| Criteria | Weight | Sub-criteria | Wobot | Global Weight | Rank |
| --- | --- | --- | --- | --- | --- |
| A | 0.250 | A1 | 0.692 | 0.173 | 1 |
| A2 | 0.308 | 0.077 | 6 |
| B | 0.281 | B1 | 0.567 | 0.159 | 3 |
| B2 | 0.356 | 0.100 | 5 |
| B3 | 0.077 | 0.022 | 10 |
| C | 0.032 | C1 | 0.692 | 0.022 | 9 |
| C2 | 0.308 | 0.010 | 11 |
| D | 0.201 | D1 | 0.692 | 0.139 | 4 |
| D2 | 0.308 | 0.062 | 8 |
| E | 0.236 | E1 | 0.692 | 0.163 | 2 |
| E2 | 0.308 | 0.073 | 7 |

**TABLE 3**. Relative Closeness Score to the Ideal Solution

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Supplier |  |  |  |  | Rank |
| Supplier 1 | 0.04 | 0.05 | 0.09 | 0.54 | 2 |
| Supplier 2 | 0.03 | 0.06 | 0.09 | 0.64 | 1 |
| Supplier 3 | 0.05 | 0.04 | 0.09 | 0.44 | 5 |
| Supplier 4 | 0.05 | 0.04 | 0.09 | 0.49 | 4 |
| Supplier 5 | 0.04 | 0.05 | 0.09 | 0.53 | 3 |

The final stage in the supplier selection process for the wood industry in Ngijo Village involved calculations using the TOPSIS method, the results of which are summarized in **TABLE 3**. The final results indicate that Supplier 2 is recommended for continued partnership, demonstrating the highest suitability based on the established criteria.

# CONCLUSIONS

This study successfully applied the Hybrid Fuzzy AHP-TOPSIS framework for selecting wood suppliers in the furniture industry, revealing that the quality of raw materials is the primary criterion, followed by price, delivery timeliness, flexibility, and risk. These findings emphasize the significance of considering the physical integrity and condition of raw materials in the decision-making process. It is recommended that the wood industry establish strategic partnerships with suppliers to enhance synergy and conduct further studies to test the effectiveness of this framework in a broader context. Future research could include comparisons with alternative methods and application in various market situations to gain a more comprehensive understanding of supplier selection dynamics.

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