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Fuzzy Analytic Hierarchy Process (FAHP) Based Performance Assessment of Textile Industry in Tirupur

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Abstract: This study explores the use of Fuzzy Analytic Hierarchy Process (FAHP) to evaluate and prioritize criteria in supply chain management within the textile industry of Tirupur district. Utilizing a detailed questionnaire reviewed by experts with over 30 years of industry experience, the study conducted pairwise comparisons of key criteria: cost (C1), quality (C2), time delivery (C3), and management and organization (C4). By applying FAHP, which effectively handles uncertainties in decision-making, the study determines the relative importance of these criteria. The findings provide a structured method for improving decision-making in textile supply chain operations, integrating fuzzy logic with the traditional AHP framework to enhance the management and optimization of supply chain processes.
Keywords: Fuzzy Analytic Hierarchy Process (FAHP), Textile Industry, Decision-Making, Criteria

I. INTRODUCTION

In the textile dyeing industry, selecting the right suppliers is a critical process that significantly influences the quality, cost, and sustainability of the final product. This industry involves complex operations where raw materials—such as dyes, chemicals, and fabrics—are integral to production success. Effective supplier selection is crucial for maintaining product quality, meeting regulatory standards, and achieving cost efficiency. The supplier selection process typically starts with an overview of the industry's supply chain, emphasizing the need for reliable and high-quality inputs. It addresses various challenges, including environmental concerns, the demand for innovation, and the need for consistent product quality. Companies must evaluate potential suppliers based on their ability to provide consistent quality, adhere to environmental and safety standards, demonstrate financial stability, and foster innovation.With the growing focus on sustainability and ethical sourcing, these factors have become increasingly important in the selection process. By choosing the right suppliers, companies can ensure they meet the stringent requirements of customers and regulators, manage costs effectively, and mitigate risks associated with supply chain disruptions. Overall, supplier selection in the textile dyeing industry is a complex, strategic endeavor that requires a comprehensive approach to align with the company's operational, financial, and ethical objectives.

II. LITERATURE REVIEW

In implementing Fuzzy Analytic Hierarchy Process (FAHP) for supplier selection in the textile industry, we aim to manage the uncertainty and subjectivity inherent in evaluating complex criteria such as cost, quality, and sustainability. FAHP enhances decision-making by using fuzzy numbers to capture the imprecision of human judgments, allowing for more flexible and accurate comparisons.

1) Chang, D.Y. (1996) introduced FAHP, integrating fuzzy logic with the AHP framework to better handle decision-making uncertainty.

2) Kannan et al. (2016) applied FAHP to select sustainable suppliers in the Indian textile industry, focusing on balancing cost, quality, and environmental impact.
3) Bhattacharya & Sarkar (2017) used FAHP to assess and select suppliers based on environmental performance, highlighting the growing importance of sustainability.
4) Mangla et al. (2017) combined FAHP with other multi-criteria decision-making (MCDM) methods to evaluate and select green suppliers in the textile dyeing industry, addressing multiple criteria like cost, quality, and environmental impact.
5) Luthra & Mangla (2018) reviewed hybrid models combining FAHP with TOPSIS and VIKOR for supplier selection, offering more robust decision-making frameworks.
6) Wang & Lee (2009) presented an influential hybrid FAHP approach that integrates fuzzy logic with traditional AHP, relevant for contemporary supplier selection applications.
7) Govindan & Chaudhuri (2019) explored integrating FAHP with goal programming to select suppliers that meet specific sustainability and performance goals.
8) Yazdani & Hashemkhani Zolfani (2017) applied FAHP in a case study of the Iranian textile industry, focusing on selecting suppliers that meet both local and international standards.
9) Ho & Xu (2019) demonstrated the use of FAHP for selecting suppliers for a multinational textile company, emphasizing the need to meet diverse regulatory requirements.
10) Kumar & Sharma (2020) conducted a case study in the Indian textile sector using FAHP to prioritize suppliers based on quality, delivery performance, and cost.
11) Govindan, Khodaverdi, & Jafarian (2016) explored FAHP for evaluating suppliers on sustainability criteria, highlighting its effectiveness in handling qualitative and quantitative factors.
12) Kumar & Vrat (2018) focused on selecting green suppliers in the textile dyeing industry using FAHP, considering factors like energy consumption and waste management.
13) Chan & Kumar (2007) laid the foundation for sustainability-focused supplier selection models using FAHP.
14) Bag & Pretorius (2019) examined integrating digital technologies with FAHP for supplier selection, focusing on how big data can enhance decision-making.
15) Mikhailov & Singh (1999) developed a fuzzy ranking method foundational for later FAHP applications in supplier selection, particularly for complex criteria.
16) Garg & Sharma (2021) discussed future directions in FAHP, including incorporating AI and machine learning to address increasingly complex supplier selection problems.

By leveraging FAHP, we aim to enhance decision-making in supplier selection by balancing conflicting criteria and integrating qualitative factors like environmental impact, which are increasingly important in the textile industry.

III. FUZZY ANALYTIC HIERARCHY PROCESS (FUZZY AHP)

The Analytic Hierarchy Process (AHP), developed by Thomas L. Saaty in 1980, organizes complex decisions into a hierarchical structure and uses pairwise comparisons to derive priority scales. Incorporating fuzziness, the method is extended with Triangular Fuzzy Numbers (TFN) to model uncertainty in judgments.

1) Developing a fuzzy comparison matrix

First the scale of linguistics is determined. The scale used is the TFN scale from one to nine are shows in Table 1.

Table 1. Scale of Interest

Scale of Interest	Linguistic Variable	Membership Function
1	Equally important	(1,1,1)
3	Weakly important	(2,3,4)
5	Strongly more important	(4,5,6)
7	Very strongly important	(6,7,8)
9	Extremely important	(8,9,10)

Then, using the TFN to make pair-wise comparison matrix for the main criteria and sub-criteria.

Equation (1) shows the form of fuzzy comparison matrix.

$$\mathcal{A} = \begin{bmatrix} 1 & \cdots & \overline{a_{1n}} \\ \vdots & \ddots & \vdots \\ \overline{a_{n1}} & \cdots & 1 \end{bmatrix} \quad (1)$$

2) Define Fuzzy Geometric Mean

The fuzzy geometric mean is then calculated using Equation (2)[13]:

$$\tilde{x_i} = \left(\bar{a}_{(i1)} \otimes \bar{a}_{(i2)} \otimes \ldots \otimes \bar{a}_{(in)}\right)^{\frac{1}{n}} \quad (2)$$

Where $\tilde{a}_{in}$ is a value of fuzzy comparison matrix from criteria I to n. Result from the fuzzy geometric mean will be referred to later as local fuzzy number.

3) Calculate the weight of fuzzy of each dimension

The next step is to calculate the global fuzzy number for each evaluation dimension with Equation (3).

$$\widetilde{w}_i = \tilde{x}_1 \otimes (\tilde{x}_1 \oplus \tilde{x}_1 \oplus \ldots \oplus \tilde{x}_1)^{-1} \quad (3)$$

4) Define the best non fuzzy performance (BNP)

The global fuzzy number is then converted to crisp weight value using the Centre of Area (COA) method to find the value of best BNP from the fuzzy weight in each dimension, calculated using Equation (4).

$$BNP_{wi} = \frac{[(u_{wi} - l_{wi}) + (m_{wi} - l_{wi})]}{3} + l_{wi} \quad (4)$$

A. Case Study

The numerical experimental data was collected from one place such that tirupur. After that, the questionnaire was reviewed by the Experts more than 30 years' textile industries experience and to make the pairwise comparison of the matrix. This study considered the various types of criteria such as cost (C1), quality (C2), time delivery (C3), and customer delivery (C4). The above criteria we considered to determine the weight of the criteria by using Fuzzy AHP. The FAHP value are shows in Table 1.

Table 1:Determining the weights of the criteria by FAHP Approach

Criteria	C_1	C_2	C_3	C_4
Fuzzy Weights	0.1804	0.1864	0.1740	0.1637
Rank	2	1	3	4

IV. CONCLUSION

The application of Fuzzy Analytic Hierarchy Process (FAHP) to supply chain management in the textile industry of Tirupur district has proven effective in addressing uncertainties and offering a nuanced evaluation of key criteria. By incorporating expert judgments and fuzzy logic, the study adeptly assessed the relative importance of cost, quality, time delivery, and management and organization. According to the FAHP model, quality criteria emerged as the top priority. This use of FAHP provides a robust decision-support tool for industry professionals, enhancing the precision of evaluations and facilitating more informed, reliable decision-making in supply chain management. It not only improves the accuracy of assessments but also accommodates the complexities inherent in the textile industry's operational environment.

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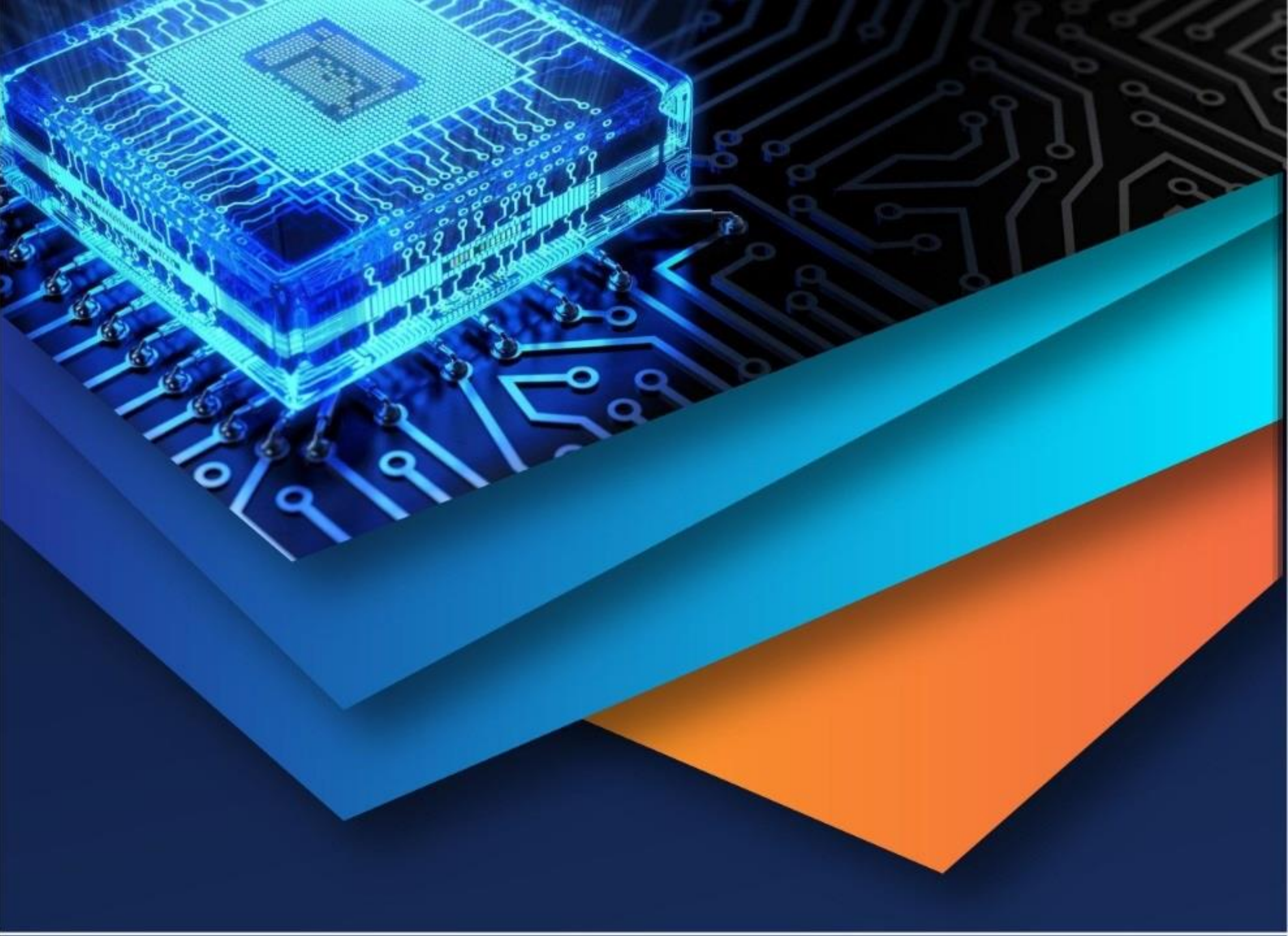

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