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Application of multi-attribute decision-making method based on fuzzy influence diagram in green supplier selection

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Abstract

The external business environment exhibits many uncertainties with the continuing changes in technological progress, political environment, and consumption behavior. This has made companies recognize the significance of addressing environmental issues to remain competitive in the modern global market. Thus, much attention is given to the supply chain to ensure environmental factors are considered during supplier selection. However, the process of selecting the right suppliers to enable green supply chain management is proving difficult. This paper presents a novel approach using fuzzy influence diagrams to identify key green supplier selection criteria, combined with multi-criteria decision making to evaluate alternatives. The fuzzy influence diagram derives priority supplier capabilities by modeling interrelationships and uncertainties. The multi-criteria technique then ranks suppliers based on prospect values. A case study of furniture manufacturer supplier selection validates the proposed method. Compared to existing models, this integrated approach reduces subjective weight bias and improves handling of complex criteria dependencies and uncertainties. The results demonstrate state-of-the-art performance in identifying ideal green suppliers. This technique can enhance sustainability efforts across supply chains.

Keywords: Green supplier; Fuzzy influence diagram; Multi-attribute decision-making; Prospect theory.

1 Introduction

In the contemporary competitive world, local and global markets have experienced rapid changes in products and services across industries. Majorly, the changes in technological advancement, political environment, consumer behavior, and economic integration dynamics, alongside other external factors, continue to pose significant threats and uncertainties for enterprises [1]. This has not only disturbed the long-term business growth but also hindered the selection of suppliers, prompting a keen interest in the company's supply chain. The overwhelming deterioration of the global environment, increased demand and shift towards green consumption, and the growing attention on environmental pollution make it a top priority for organizations to become critical of their supply chain, particularly on supplier selection [2, 3].In the quest to attain a green supply chain, the green supply chain management concept is currently of great interest. A green supply chain is a supply chain management model that comprehensively considers environmental impact and resource efficiency[4, 5], requiring suppliers to be included in the enterprise's environmental strategy. Therefore, selecting the optimal green supplier is a key step to ensure the orderly operation of green supply chains [6, 7, 8]. Supplier selection is the process of finding the most suitable suppliers to deliver "the right quality of products and services, at the right time, price and quantities" [9].

As consumer awareness of environmental protection increases, much attention is given to the significance of environmental protection indicators in the supply chain evaluation. This has triggered the need to integrate these indicators into the supply chain- a concept termed a green supply chain. Scholars have proposed various evaluation methods for selecting the best suppliers over the years. For instance, the data-driven green supplier evaluation model is based on a random forest algorithm initially proposed by Liou et al.[10] evaluation based on fuzzy theory and standards of carbon management [11]; the random dual fuzzy language ranking green suppliers based on satisfaction or regret theory [12] has all been applied in supplier evaluation.

Of course, most scholars have tentatively made tremendous improvements in the said methods to solve the puzzle of green supplier selection. However, a candid, reliable solution is yet to be agreed upon. Interestingly, most of the mentioned models focused on the selection of evaluation methodologies and the creation of evaluation indicators but failed to match these models to actual situations. Circumstantially, the impacts of uncertainties attached to external suppliers are usually ignored. Owing to the criticality of environmental uncertainties and the adaptability of the evaluation methods in the evaluation process, the previous studies failed to depict the accuracy of evaluation results fully. In this respect, this paper proposes a multi-attribute decision-making method based on a fuzzy influence diagram. In an ideal decision-making process for green suppliers' selection, it is important to consider the comprehensive capabilities of suppliers and key attributes that affect comprehensive capabilities [13, 14, 15, 16]. In so doing, this paper fully considers the priority relationship between green supplier capability attributes. By using the multi-attribute decision-making method based on the fuzzy influence diagrams, supplier selection will be peculiar to the supplier key capability attributes to the green supply chain, as well as supplier ranking based on green supply chain standards. The applicability and effectiveness of this model were verified through an actual case study of furniture manufacturing enterprises.

2 Literature Review

2.1 The Green Supply Chain

In modern business operations, green supply chain management has become a concern for an environmentally sustainable supply chain [17, 18, 19, 20, 21]. Unlike the sustainable supply chain that encompasses the social, economic, and environmental dimensions, the green supply chain categorically emphasizes the environmental process flow, focusing mainly on reducing wastes and greenhouse gas emissions during production [22, 23]. Proponents allude that sustainability is crucial in the enterprise-supplier relationship, making corporate social responsibility a key factor in determining supplier sustainability during selection. Not long ago, the integration of sustainability into industrial set-up was demonstrated by, for instance, Blome et al. [24], who established the three-dimensional criteria of sustainable process design, sustainable product design, and sustainable collaboration on demand. Das [25] further expanded these dimensions by incorporating social inclusiveness, operation performance, environmental management, and supply chain integration into the green supply chain selection. All the same, evaluating the supplier's sustainability performance is centric on environmental parameters, including environmentally friendly materials and a green image [26, 27, 28]. In this perspective, most researchers have adopted wide conventional and sustainable criteria in supplier assessment and selection. Literature connotes that selecting the best supplier minimizes produce lead time and procurement costs and consequently improves profits, customer satisfaction, and competitiveness of an enterprise.

2.2 Supplier Selection Methods

Since there is no stipulated standard for green supplier selection, several selection methods have been developed and proposed by scholars over the years and were grouped into five categories: the statistical approach, linear weighting modes, mathematical programming models, cost-based models, and artificial intelligence-based models [6, 29]. Until 2012, Kannan et al. implied that the analytic hierarchy process (AHP), the linear programming (LP), the data envelopment analysis (DEA), and the analytic network process (ANP) were the most common techniques [14, 30]. Lee and colleagues [16] proposed the fuzzy AHP, taking into consideration technology capability, quality, total cost of the product life cycle, and green elements such as green products, green image, green competencies, environmental management, and pollution control. Scholars allude that the AHP and ANP methods require consistent user participation and judgment to complete the pairwise comparisons for the required accuracy levels [31, 32, 33]. The DEA approach was used by Wu and Blackhurst [36] to evaluate their green performance. Scholars also came up with the MCDM based on the fuzzy decision-making trial and evaluation laboratory (DEMATEL) [35], as well as the fuzzy TOPSIS and fuzzy ANP [36]. The bottom line is that green supplier selection is a strategically critical and important aspect of sustainable supply chain management.

Despite scholars identifying the many green supplier methods, literature identified some common limitations. The first is that the existing methods do not consider environmental impact and resource efficiency, which are important factors for an organization's growth. Besides, the existing methods relying on many evaluation indicators lead to unnecessary waste of time and the costs of collecting and analyzing the necessary data. Finally, existing methods do not consider the priority relationships between different evaluation indicators, leading to inefficient and error-prone decision-making.

3 Methodology

3.1 Fuzzy influence diagram

Howard et al. [37] created a good decision-modeling tool called the influence diagram, an intuitive and flexible tool that helps decision-makers solve complex nonlinear decision problems by constructing an impact structure revealing a relationship between the variables [38]. However, influence diagrams generally require high accuracy for marginal and conditional probabilities [39], which directly affects the evaluation effect of research objects. Real-world problems often come with various randomness and variability, coupled with cognitive biases that make it difficult to evaluate corresponding probability values accurately, and this is where the fuzzy set logic emanates. Fuzzy set theory provides a good idea for solving probability evaluation problems [40, 41]. Hence, combining fuzzy mathematics with influence diagrams into fuzzy influence diagrams provides a good evaluation modeling and calculation tool for evaluating and selecting green suppliers.

Shachter [42, 43] refined the definition of influence diagrams and probability calculation methods. Thus, when combining fuzzy mathematics with influence diagrams, fuzzy influence diagrams are obtained, which serve as a powerful modeling and calculation tool for evaluating and selecting green suppliers. These diagrams can be understood as networks composed of non-cyclic directed graphs. Usually, the membership functions determine the degree of membership or element affiliation in the fuzzy set, and these take the affiliation degree value 1 for complete affiliation or membership, the value zero for non-affiliation, and the values between zero and 1 for partial affiliation. A triangular fuzzy probability diagram illustration is below, followed by its mathematical expression.

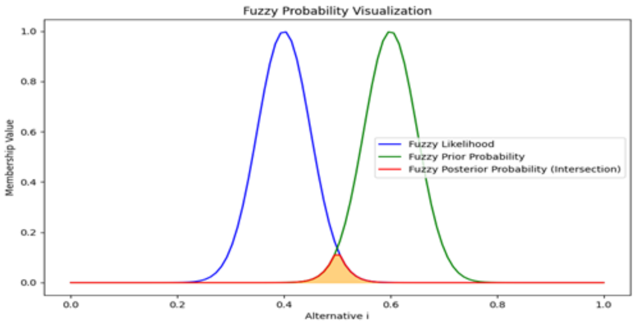

Figure 1: Illustration of fuzzy probability/number

The Figure 1 illustrates four types of fuzzy probabilities: crispy probability (a binary probability where an event either happens or does not); fuzzy probability or likelihood (allows for partial membership in a fuzzy set. This is a measure of how likely it is that an event will happen, given the evidence); prior probability (a measure of how likely it is that an event will happen before any evidence is considered). The graph shows that the fuzzy probability of an event is always greater than or equal to its crispy probability. This is because the fuzzy probability considers the possibility of partial membership in the fuzzy set. The graph also shows that the likelihood of an event is always greater than or equal to its prior probability. This is because the likelihood considers the evidence.

Suppose V=(G,α) represents a data graph $G = (A_m, E)$is a non-cyclic direct graph,

$A_m = \{x_1, x_2, ..., x_m\}$ is a node random variable, and α : A_m={$1, 2, ..., m$}corresponds to the node number of G; for arc(x_i, x_j)$\in E$, $\alpha(x_i)$< α (x_j).The immediate antecedent influence diagram of $A_m = \{x_1, x_2, ..., x_m\}$ based on $m - 1$ independent (G,α) under certain conditions.That is

$x_r \perp \{x_j \mid \alpha(x_j) < \alpha(x_r)\} \mid P(x_r)$,$\alpha(x_r) = 2, 3, ..., m$. Among them, $P(x_r) \subseteq \{x_j \mid \alpha(x_j) <\mid \alpha(x_r)\}$; $x_i \in p(x_r) \rightleftharpoons (x_i, x_r) \in E$;if $Q(x_j)$ represents the set of nodes x_j,there is no direct graph from x_i to x_j,then $x_i \perp Q(x_i) \mid P(x_i)$, $P(x_i)$ is the direct predecessor node of x_i.

3.2 Establishing the standard set

When solving influence diagrams, the most difficult part is constructing the marginal probability of each node and the conditional probability between different nodes. Generally, probability distribution is inferred based on previous experience or subjective judgment based on knowledge cognition. The estimation of marginal probability and conditional probability may have large errors. In addition, subjective probability estimation methods may also violate probability theory. Fuzzy influence diagrams combine influence diagram methods with fuzzy set theory, allowing cross-overlap between fuzzy sets, which can overcome these difficulties.

Given the fuzzy relationship (R) between two fuzzy subsets A and B in a fuzzy set, while $\mu_R(x_i, y_j) = \mu_{(A \times B)}(x_i, y_j) = [\mu_A(x_i), \mu_B(y_j)]$. Among them,$x \in U$, $y \in V$,$UandV$ respectively represent the domain of discourse. $R \cup S$ The sum of two fuzzy relations R and S has a feature value of $\mu_{(R \cup S)}(x_i, y_j) = [\mu_R(x_i, y_j), \mu_S(x_i, y_j)]$, and the feature value of their intersection $R \cap S$ is

$\mu_{(R \cap S)}(x_i, y_j) = [\mu_R(x_i, y_j), \mu_S(x_i, y_j)]$.

The quantification of linguistic variables is based on fuzzy sets to explain the relationship between nodes in the influence diagram theoretically. Therefore, two types of fuzzy sets need to be defined. One is used to describe independent node events and their occurrence frequencies; the other is used to represent the fuzzy relationship between predecessor and successor nodes.

In Figure 2 (influence relationship schematic), X represents an independent node with a clear frequency matrix (i.e., no immediate predecessor node), and X's vector can be represented as $P_x = (P_{x_1}, P_{x_2}, ..., P_{x_n})^T$. Among them, $P_{x_1}, P_{x_2}, ..., P_{x_n}$ represents an event fuzzy set obtained based on the linguistic variable definition.

We assume that the frequency vector of independent node X can be represented as:

$$f_x = (f_{x_1}, f_{x_2}, ..., f_{x_n})^T................(1)$$

$f_{x_1}, f_{x_2}, ..., f_{x_n}$ corresponds to a frequency fuzzy set for each possible state in X's frequency vector. The frequency matrix F_x (frequency matrix of independent node X) can be represented as:

$$F_x = (f_{x_1} \times P_{x_1}) \cup (f_{x_2} \times P_{x_2}) \cup ... \cup (f_{x_n} \times P_{x_n})................(2)$$

If Z's previous node is m random nodes $Y_1, Y_2, ..., Y_m$, then let F_{zp} represent the joint frequency matrix of all previous nodes of Z, then:

$$F_{zp} = F_{Y_1} \cup F_{Y_2} \cup F_{Y_3} \cup ... \cup F_{Y_m}................(3)$$

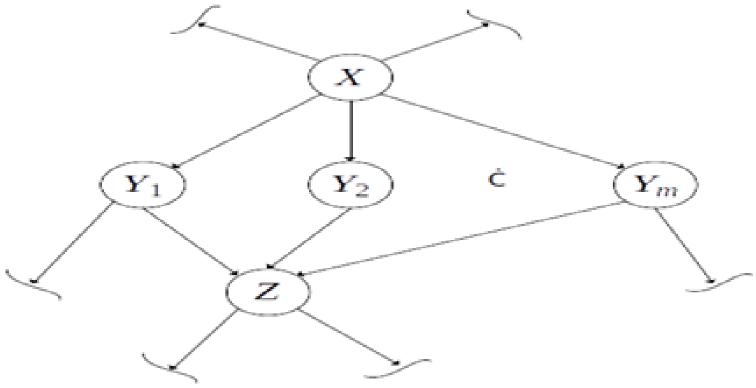

Figure 2: Influence relationship diagram

Let R_{Y_1Z} represent the fuzzy relationship from node Y_1 to node Z, then:

$$R_{Y_1Z} = (P_{Y_{11}} \times P_{Z_i}) \cup (P_{Y_{12}} \times P_{Z_i}) \cup ... \cup (P_{Y_{1n}} \times P_{Z_i})................(4)$$

Where: $P_{Y_{11}}, P_{Y_{12}}, ..., P_{Y_{1n}} \in P_{Y_1}; P_{Z_i} \in \{P_{Z_1}, P_{Z_2}, ..., P_{Z_n}\} = P_Z$
The fuzzy relationship from node Y_m to node Z is:

$$R_{Y_mZ} = (P_{Y_{m_1}} \times P_{Z_i}) \cup (P_{Y_{m_2}} \times P_{Z_i}) \cup ... \cup (P_{Y_{m_n}} \times P_{Z_i})................(5)$$

The joint of fuzzy relation $R_{Y_1Z}, R_{Y_2Z}, ..., R_{Y_mZ}$ is:

$$R_{ZP} = R_{Y_1Z} \cup R_{Y_2Z} \cup ... \cup R_{Y_mZ}................(6)$$

The frequency matrix F_z of node Z is as follows:

$$F_z = F_{zp} \circ R_{zp}................(7)$$

Next, from the value node frequency matrix * calculated above, select the row whose sum and corresponding frequency product are the largest among all rows as the membership degree of the random result. Therefore, the probability function of each random result can be represented as

$$P(Z_i) = \frac{\mu_{Z_i}}{\sum_{\Omega_Z \mu_{Z_i}}}................(8)$$

Pseudocode is shown in Figure 3.

```
# Pseudo code for constructing a fuzzy influence diagram
For each node in the influence diagram:
   Determine the immediate predecessors of the node
   Define the relationship between the node and its predecessors (e.g., conditional probabilities)
   Determine the type of the node (e.g., random variable, linguistic variable)

# Incorporate fuzzy logic
For each linguistic variable in the diagram:
   Define the linguistic terms and membership functions

# Calculate fuzzy probabilities
For each node with conditional probabilities:
   Calculate the fuzzy conditional probability distribution

For each node with marginal probabilities:
   Calculate the fuzzy marginal probability distribution

# Solve for the fuzzy influence diagram
Apply fuzzy logic operations and reasoning methods to obtain answers based on uncertain information

# Perform evaluations and selections
Use the fuzzy influence diagram to evaluate and select options, such as green suppliers, considering uncertainty and
complex relationships.
```

Figure 3: Pseudocode for fuzzy influence diagram

3.3 Fuzzy Multi-Attribute Decision Design

Multi-criteria decision models (MCDM) rank alternatives based on multiple criteria during decision-making and can deploy various methods, such as the weighted average method, the simple additive weighting method, and the technique for order preference by similarity to ideal solution (TOPSIS) method.

In the design, the first consideration is the alternative plans; these involve different choices or actionable courses available for particular decision-making scenarios. Next is the concept of the attribute set; the attributes within a set are determined based on the evaluation results attained from the fuzzy influence diagram, and these crucially help in distinguishing and characterizing the various considerable alternatives. The final consideration is the introduction of the weight vector. The weight vector assigns specific importance or significance to each attribute within the set. These weights reflect the relative priority or contribution of each attribute to the decision process.

This proposed method also involves an expected vector related to attributes, which mainly encapsulates the anticipated values or characteristics associated with each attribute. This helps decision-makers understand the expected outcomes or properties of the attributes. This design also explores the concept of a decision matrix, typically a structured representation of how each alternative relates to each attribute. This matrix provides a comprehensive view of how the attributes are assessed in the context of each alternative. Furthermore, since the nodes within the fuzzy influence diagram model are linguistic variables, the expectations and attribute values are expressed as text numbers to represent the qualitative assessments and linguistic descriptions. To effectively analyze and manage the text number information, the subsets for decision expectations and attribute values are defined as 'L'. These subsets adhere to the principle of orderliness, implying a clear order of preferences or values. The symbol '>' denotes 'greater than or equal to,' indicating the comparative relationship between these values. An inverse operator, 'inv', is also introduced, which is useful for calculating the reciprocal of a value to allow a meaningful interpretation of relationships between values in a decision context.

Considering the multi-attribute decision-making problem $P = \{P_1, P_2, ..., P_m\}$ is the alternative plan; $A = \{A_1, A_2, ..., A_n\}$ is the attribute set (each attribute is determined from the evaluation results of the fuzzy influence diagram); $w = (w_1, w_2, ..., w_n)$ is the weight vector; $E = (e_1, e_2, ...e_n)$ is the expected vector about attributes, e_j is the expectation for attribute A_j; $D = [d_{ij}]_{(m\times n)}$ is the decision matrix, and d_{ij} is the attribute value of P_i to A_j. Since the nodes in the fuzzy influence diagram model are all linguistic variables, the types of expectations and attribute values are set to text numbers. Let $Z = \{1, 2, ..., z\}$ and A^P represent the subset of decision expectations or attribute values that are text number form information, e_j and d_{ij} are text numbers, L is a text number set, $L = \left\{l_g \mid g = 0, 1, ..., \frac{R}{2} - 1, \frac{R}{2}, \frac{R}{2} + 1, ..., R\right\}$. The property of L is orderliness. When $\geq gk$, there is $l_g \succ l_k$. The symbol "$>$" means "better than or equal to". There exists an inverse operator "inv": when $k = R - g$, there is $inv(l_g) = l_k$. Maximization operation and minimization operation: when $l_g \succ l_k$, there are $max\{l_g, l_k\} = l_g$ and $min\{l_g, l_k\} = l_k$. This paper converts text numbers into triangular fuzzy numbers μ_{tfn} calculation formula:

$$\mu^{tfn} = (\mu^1, \mu^2, \mu^3) = [max(\frac{(g-1)}{R}, 0), \frac{g}{R}, min(\frac{(g+1)}{R}, 1)]$$

(1)Information normalization processing. When property $A_j \in A^P$, the calculation formula is:

$$n_j \begin{cases} e_{ij}, j \in S_3 \cap E_P \\ inv(d_{ij}), j \in S_3 \cap E_C \end{cases}$$

$$y_{ij} = \begin{cases} d_{ij}, i \in Z, j \in S_3 \cap E_P \\ inv(d_{ij}), i \in Z, j \in S_3 \cap E_C \end{cases}$$

Text numbers can be converted into triangular fuzzy numbers, that is $n_j^{tfn} = (n_j^1, n_j^2, n_j^3), y_{ij}^{tfn} = (y_{ij}^1, y_{ij}^2, y_{ij}^3)$.

(2) Benefit matrix calculation. Determine the size relationship between attribute value y_{ij} and reference point n_j. Let y_{ij}^{tfn} correspond to text numbers for $L_g(g = 0, 1, 2, ..., R)$, and n_j^{tfn} correspond to text numbers for a reference point $L_k(k = 0, 1, ..., R)$, The comparison method is: (a) if $l_g \succ l_k$, then $y_{ij}^{tfn} > n_j^{tfn}$; (b) if $l_g = l_k$, then $y_{ij}^{tfn} = n_j^{tfn}$; (c): if $l_g \prec l_k$, then $y_{ij}^{tfn} < n_j^{tfn}$. Calculate the distance between attribute values and reference points:

$$J_{ij} = \begin{cases} \mid \tilde{y}_{ij} - \tilde{n}_j \mid & i \in Z, j \in S_1 \\ \sqrt{(\frac{1}{2}[(y_{ij}^{LL} - n_j^{LL})^2 + (y_{ij}^{UL} - n_j^{UL})^2])} & i \in Z, j \in S_2 \\ \sqrt{(\frac{1}{3}[(y_{ij}^1 - n_j^1)^2 + (y_{ij}^2 - n_j^2)^2 + (y_{ij}^3 - n_j^3)^2])} & i \in Z, j \in S_3 \end{cases}$$

Calculate profit and loss matrix $G = [G(y_{ij})]_{(m \times n)}$, where $G(y_{ij})$ is y_{ij} gain-loss value:

$$[G(y_{ij})] = \begin{cases} J_{ij} & y_{ij} \geq n_j \\ -J_{ij} & y_{ij} < n_j, i \in Z, j \in T \end{cases}$$

(3) Construction of value function matrix.

Establish a value function matrix $Q = [Q(y_{ij})]_{(m \times n)}$, where $Q(y_{ij})$ is the evaluation value of each scheme for each attribute. The formula for calculating the value function is:

$$Q(y_{ij}) = \begin{cases} [G(y_{ij})]^{\alpha} & y_{ij} \geq n_j \\ -\lambda[-[G(y_{ij})]^{\beta}] & y_{ij} < n_j, i \in Z, j \in T \end{cases}$$

Where parameters α and β represent the convexity and concavity of function $Q(y_{ij})$, reflecting the decreasing speed of decision-makers sensitivity to benefits and losses,$0 < \alpha < 1, 0 < \beta < 1$; parameter λ represents the degree of loss aversion of decision-makers and $\lambda > 1$ expresses the characteristic that subjective utility is steeper in the loss region than in the gain region. Regarding the coefficient calibration of α, β, λ, this paper adopts the results calibrated by Kahneman and Tversky in 1992 survey research, taking $\alpha = \beta = 0.88, \lambda = 2.25$.

(4) Determination of attribute weights. Use the square root method to calculate the attribute weights to construct a judgment matrix:

$$U = (u_{ij})_{(p \times p)}$$

The maximum characteristic root λ_{max} of the judgment matrix U and the calculation formula for consistency check are:

$$\lambda_{max} = \frac{1}{p} \sum_{i=1}^{p} \frac{(AW)_i}{W_i}$$

$$C.I. = \frac{\lambda_{max} - p}{p - 1}$$

$$C.R. = \frac{C.I.}{R.I.}$$

Where according to the consistency check result $C.I.$, query the average random consistency index $R.I.$, then calculate the consistency ratio $C.R.$. When the random consistency ratio $CR < 0.10$ is reached, it can be considered that the judgment matrix has satisfactory consistency; otherwise, it needs to be adjusted to have satisfactory consistency.

(5)Calculation and ranking of comprehensive prospect values. Finally calculate the comprehensive prospect value:

$$CV(p_i) = \sum_{j=1}^{n} W_j Q(y_{ij}), i \in Z$$

Therefore, it can be seen that the larger $CV(p_i)$ is, the better scheme P_i is. That is to say, sort alternative schemes according to $CV(p_i)$ size.

Example

The model and the fuzzy membership functions could then be used to calculate the fuzzy posterior probabilities of the green supplier selection alternatives. The fuzzy posterior probabilities could then be used to rank the alternatives.

1. Input:
   - Set of alternative plans (A)
   - Attribute set (B)
   - Weight vector (W)
   - Expected vector (E)
   - Decision matrix (D)
   - Attribute values from A to Bi Dai
   - Reference points (Rj)
2. Initialize an empty benefit matrix (M).
3. For each attribute Bi in B:
   a. For each reference point Rj:
      i. Calculate the benefit relationship between Dai and Rj using a benefit calculation method.
      ii. Store the result in M[i,j].
4. Initialize an empty distance matrix (D).
5. For each attribute Bi in B:
   a. For each reference point Rj:
      i. Calculate the distance between Dai and Rj using a distance calculation formula.
      ii. Store the result in D[i,j].
6. Initialize an empty profit and loss matrix (G).
7. For each attribute Bi in B:
   a. For each reference point Rj:
      i. Calculate the profit-loss value using a profit-and-loss matrix formula.
      ii. Store the result in G[i,j].
8. Initialize an empty value function matrix (V).
9. For each attribute Bi in B:
   a. For each alternative plan A:

i. Calculate the value function using a value function formula.

ii. Store the result in V[i,j].

10. Determine attribute weights using a method such as the Analytic Hierarchy Process (AHP).
11. Calculate the overall evaluation value of each alternative plan using a weighted sum method.
12. Rank the alternative plans based on their comprehensive evaluation values.
13. Output: The final ranking of alternative green suppliers.

The specific MCDM method used in the fuzzy influence diagram approach to green supplier selection depends on the specific preferences of the decision-maker. However, the following general steps are common to most MCDM methods:

- Normalization of the evaluation criteria: This involves converting the values of the evaluation criteria to a common scale to be compared fairly.
- Weighting of the evaluation criteria: This involves assigning weights to the evaluation criteria based on their relative importance.
- Calculating the overall score for each alternative: This is done by combining the normalized values of the evaluation criteria and the weights of the evaluation criteria using a specific MCDM formula.
- Ranking of the alternatives: The alternatives are then ranked based on their overall scores.

4 Results & Discussion

4.1 Furniture Manufacture Cases Study

To meet environmental regulations, market demand, and corporate profits, traditional furniture manufacturers must improve their high-polluting and high-consumption production methods, establish a green and environmentally friendly supply chain, and respond to the pressure of rapidly rising raw material and labor costs. Choosing high-quality green suppliers can help furniture manufacturers purchase raw materials based on comprehensive benefits and environmental protection requirements, ensure that their products meet the requirements and maximize corporate profits, promote green development, and transform the traditional furniture manufacturing industry. This article selects furniture manufacturing enterprises as a case study and uses the fuzzy influence diagram multi-attribute decision-making method to analyze the selection problem of their green suppliers. It also illustrates the application process and practical value of this method.

4.1.1 Developing a comprehensive green supplier capability model

To accurately assess the dynamic changes in green supplier comprehensive ability, an influence topology structure for green supplier comprehensive ability in furniture manufacturing enterprises was constructed based on three dimensions: development ability, innovation ability, and environmental protection ability (Figure 4). Considerations were also given to connotations from previous literature [44, 45, 46], and the characteristics of green supply chains in the furniture manufacturing industry, as well as the principles of scientificity, hierarchy, objectivity, and data availability for indicator selection.

4.1.2 Supplier Green Comprehensive Ability Analysis

Fuzzy Set Definition

Based on experts' opinions, the fuzzy relationship between each node was determined. For independent nodes (including nodes 1-12), the random events and frequency estimates are described, as well as the fuzzy relationship between each node and its previous and next nodes, as shown in Table 1).

This analysis provides quantifiable insights into the probability distribution of furniture manufacturing enterprises' comprehensive ability for green suppliers. It is evident that 30.77% of these enterprises fall within the 0% to 30% range, while a substantial 40.00% are in the 30% to 60% range.

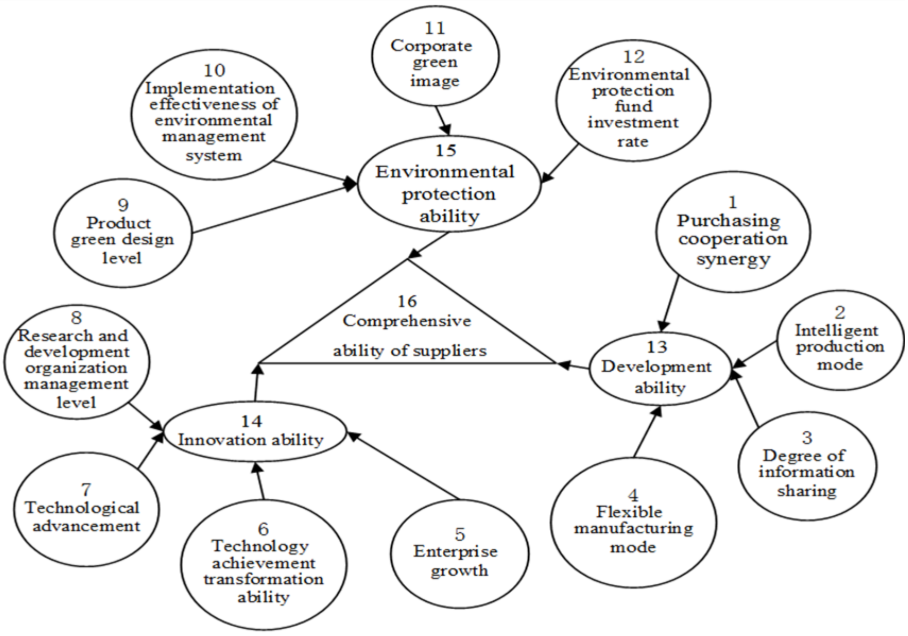

Figure 4: Influence topology of the comprehensive ability of green suppliers for furniture manufacturing enterprises

Moreover, 29.23% of these enterprises have comprehensive ability within the 60% to 80% range. Importantly, there is no representation above 80%, signifying that none of the enterprises have achieved a comprehensive ability score in that upper range.

Fuzzy Influence Diagram Calculation

The calculation process based on the fuzzy influence diagram can be summarized as follows:

- Independent node frequency matrix: Calculate the frequency matrix of independent nodes F(1)-F (12) using formula (2) and releasing each node one by one.
- Non-independent node frequency matrix: First, calculate the joint frequency matrix of all previous node frequency matrices and the fuzzy relationship with all previous nodes. Then, using formula (3), calculate the joint frequency matrix of nodes F13, F14, F15, and F16 immediately before the node frequency matrix.
- Fuzzy relationship: Calculate the corresponding fuzzy relationship between nodes using the formula (5).
- Calculate the node frequency matrix containing the immediate previous node: Using the fuzzy relationship calculated in step 3, calculate the node frequency matrix containing the immediate previous node.
- Calculate the value node frequency matrix: After obtaining the frequency matrix of nodes 13-15, which indicates that the nodes have been released, calculate the frequency matrix of value node 16. Before that, it is necessary to calculate the joint frequency matrix of all previous node frequency matrices and all previous node fuzzy relationships.

  Once the frequency matrix of value node 16 is calculated, it can be used to determine the probability distribution of changes in node 16. Using the formula (8), select all rows in matrix F (16) whose product of that row and its corresponding frequency is maximum. Then, calculate the probability distribution and cumulative probability based on this (Table 2).

4.1.3 Green Supplier Evaluation and Attribute Recognition

Quantitative Analysis

Table 1: Frequency of each node and different node fuzzy relationship

Node	Node status								Relationship node	Fuzzy relationship
	NO	LA	MA	HA	GA	G	M	B		
1	L	M		VH	H				13	NO→LA; LA→MA; HA→GA; GA→GA
2						H	L	VL	13	G→GA; M→MA; B→NO
3		H	M	L	VL				13	LA→MA; MA→HA; HA→GA; GA→GA
4						L	M	H	13	G→GA; M→MA; B→NO
5						M	H	L	14	G→GA; M→MA; B→NO
6	M		H	L	VL				14	NO→LA; MA→HA; HA→GA; GA→GA
7						M	H	L	14	G→GA; M→MA; B→NO
8		L	M	H	M				14	LA→MA; MA→HA; HA→GA; GA→GA
9	VL	M		VH	H				15	NO→LA; LA→MA; HA→GA; GA→GA
10	VL		M	H	VH				15	NO→LA; MA→HA; HA→GA; GA→GA
11						L	M	H	15	G→GA; M→MA; B→NO
12		L	M	H	M				15	LA→MA; MA→HA; HA→GA; GA→GA
13	——								16	LA→MA; MA→HA;
14	——								16	MA→LA; HA→MA
15	——								16	NO→NO; LA→MA; MA→HA

Table 2: Probability distribution of value nodes

Percentage	Membership degree	Probability	Cumulative probability
0%	0	0	0
10%	1.0	0.1538462	0.1538462
20%	0.4	0.0615385	0.2153846
30%	0.6	0.0923077	0.3076923
40%	1.0	0.1538462	0.4615385
50%	0.8	0.1230769	0.5846154
60%	0.8	0.1230769	0.7076923
70%	1.0	0.1538462	0.8615385
80%	0.9	0.1384615	1
90%	0	0	1
100%	0	0	1

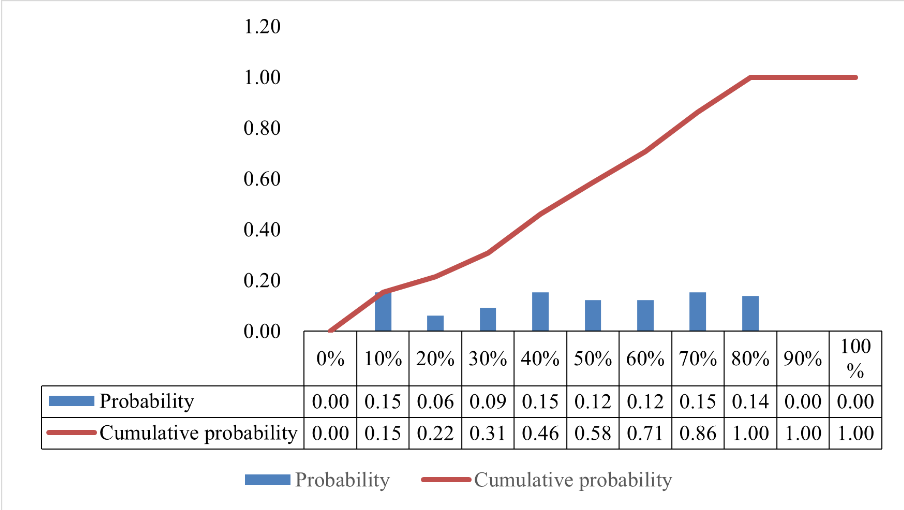

Figure 5: Probability distribution of green supplier comprehensive ability nodes

Table 3: Decision-making matrix with multiple information attributes

	A1	A2	A3	A4
P1	MG	G	M	MG
P2	P	MG	G	M
P3	G	M	MG	MP
P4	MG	P	VG	MG
P5	M	MP	MG	G

The probability distribution for the comprehensive ability of furniture manufacturing enterprises in the context of green suppliers predominantly falls within the 30% to 60% range. This concentration suggests a significant potential for further enhancement. Consequently, leveraging the insights from Table 1, this study undertakes in-depth analysis and deduction to uncover the primary drivers behind the advancement of furniture manufacturing enterprises' comprehensive ability concerning green suppliers (Figure 6).

The case study effectively illustrates the proposed technique. To enhance it, we will conduct additional quantitative analysis, including sensitivity analysis on criteria weights. In the above analysis (Figure 5), the comprehensive ability to influence the relationship of green suppliers reveals that the key drivers for improving furniture manufacturing enterprises' comprehensive ability primarily involve their suppliers' development ability, innovation ability, and environmental protection ability. Specifically, enhancing procurement cooperation bolsters development ability. Moreover, technology achievement transformation significantly impacts innovation ability, and the effectiveness of product green design and environmental management system implementation largely determines the improvement in environmental protection ability. Thus, when selecting green suppliers, furniture manufacturing enterprises should prioritize four critical supplier capability attributes: procurement cooperation synergy, technology achievement transformation capability, product green design level, and environmental management system implementation effectiveness. These attributes are pivotal in shaping the overall sustainability and comprehensive ability of the supplier network.

4.2 Green Supplier Selection in Practice

In green supplier selection based on capability attribute recognition, this study draws on a real-world case scenario of SY Company- a Chinese hotel furniture manufacturer. After its establishment, it relied on its subordinate companies for supply matching. However, it currently outsources non-core components. SY Company has consistently adhered to green development principles. Currently, it evaluates five alternative green suppliers: $(P_1, P_2, P_3, P_4, P_5)$, as shown in Table 3.

The selection process focuses on four essential capability attributes, which have been identified through fuzzy influence diagram analysis. These attributes are Procurement Cooperation Synergy

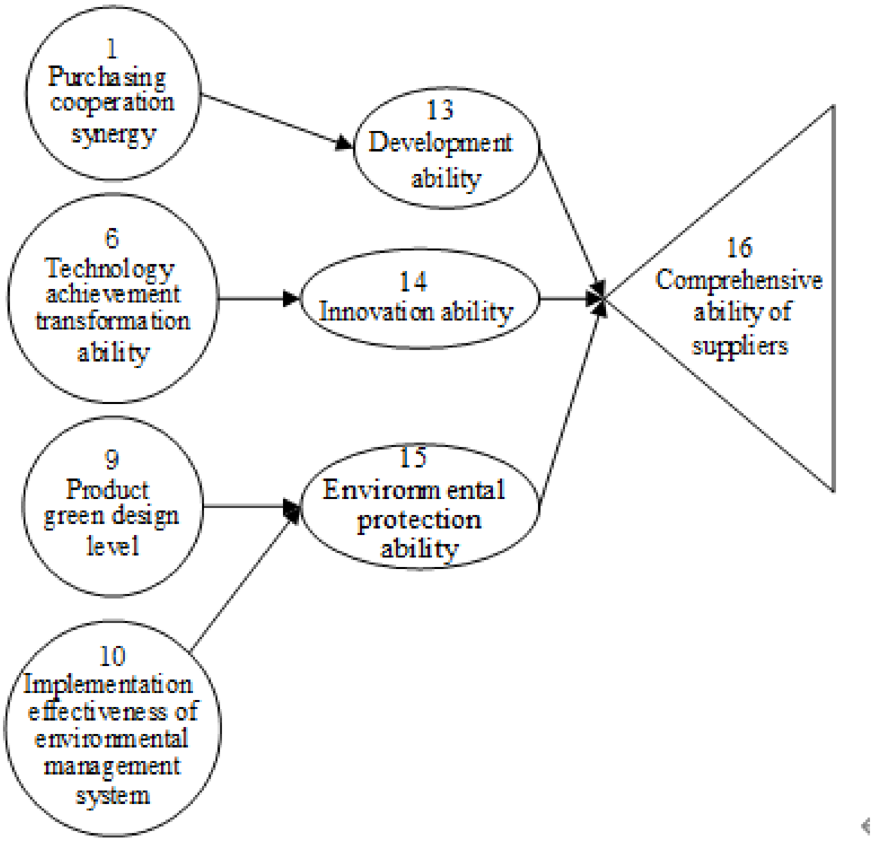

Figure 6: Relationship influence diagram with more improvement in green supplier comprehensive ability

Degree (A1), Technology Achievement Transformation Capability (A2), Product Green Design Level (A3), and Environmental Management System Implementation Effectiveness (A4). To facilitate this selection process, expected values for A1, A2, and A3 are represented in text form, forming an expected vector. Furthermore, a decision-making matrix, as depicted in Table 3, is employed to aid in the comprehensive evaluation and ranking of the green suppliers based on these critical capability attributes.

The task consists of the following steps:

(1) Normalize reference vector and decision-making matrix.

i. Normalize reference vector as:

$$N = [(0.33, 0.50, 0.67), (0.50, 0.67, 0.83), (0.67, 0.83, 1.00), (0.50, 0.67, 0.83)]$$

ii. Normalize decision-making matrix as:

$$Y = [y_{ij}]_{(m\times n)} = \begin{bmatrix} (0.50, 0.67, 0.83) & (0.67, 0.83, 1.00) & (0.33, 0.50, 0.67) & (0.50, 0.67, 0.83) \\ (0.00, 0.17, 0.33) & (0.50, 0.67, 0.83) & (0.67, 0.83, 1.00) & (0.33, 0.50, 0.67) \\ (0.67, 0.83, 1.00) & (0.33, 0.50, 0.67) & (0.50, 0.67, 0.83) & (0.17, 0.33, 0.50) \\ (0.50, 0.07, 0.83) & (0.00, 0.17, 0.33) & (0.83, 1.00, 1.00) & (0.50, 0.67, 0.83) \\ (0.33, 0.50, 0.67) & (0.17, 0.33, 0.50) & (0.50, 0.67, 0.83) & (0.67, 0.83, 1.00) \end{bmatrix}$$

(2) Profit and loss matrix calculation.

$$G = [G(y_{ij})]_{(m\times n)} = \begin{bmatrix} 0.17 & 0.17 & -0.17 & 0 \\ -0.33 & 0 & 0 & -0.17 \\ 0.33 & -0.17 & -0.17 & -0.33 \\ 0.17 & -0.50 & 0.17 & 0 \\ 0 & -0.33 & -0.33 & -0.17 \end{bmatrix}$$

Table 4: Key capability attribute weight

	A1	A2	A3	A4	Sensitivity
A1	1	0.33	0.2	0.5	52.32%
A2	3	1	0.33	2	23.98%
A3	5	3	1	3	15.19%
A4	2	0.5	0.33	1	8.51%

(3) Value function matrix calculation.

$$Q = [Q(y_{ij})]_{(m\times n)} = \begin{bmatrix} 0.21 & 0.21 & -0.85 & 0 \\ -0.85 & 0 & 0 & -0.47 \\ 0.38 & -0.47 & -0.47 & -0.85 \\ 0.21 & -1.22 & 0.21 & 0 \\ 0 & -0.85 & -0.47 & -0.47 \end{bmatrix}$$

(4) Attribute weight calculation and sensitivity analysis

Table 4 presents a pairwise comparison of capability attributes (A1, A2, A3, A4) and their respective sensitivity scores. These scores are an essential tool for assessing the relative importance of each attribute in the green supplier selection process. Notably, A1 holds the highest sensitivity score at 52.32%, signifying its substantial influence on the decision-making process. A2 follows closely with a sensitivity score of 23.98%, indicating its importance but to a lesser degree than A1. A3 and A4, with sensitivity scores of 15.19% and 8.51%, respectively, exhibit a comparatively lower impact on the decision-making process.

(5) The comprehensive prospect value of each plan.

$$CV(P_i) = \begin{bmatrix} CV(P_1) \\ CV(P_2) \\ CV(P_3) \\ CV(P_4) \\ CV(P_5) \end{bmatrix} = \begin{bmatrix} -0.3765 \\ -01437 \\ -0.4554 \\ -0.1648 \\ -0.5211 \end{bmatrix}$$

Based on the comprehensive prospect value of each alternative green supplier, they can be ranked: $P_5 \succ P_3 \succ P_1 \succ P_4 \succ P_2$.

4.3 Discussion

Over the past few years, there has been a significant increase in the need for supply chain management due to shifting customer demands, technological advancement, market competition, and government regulations [47, 48]. Of main interest has been the consideration of environmental consciousness, implying that many factors have to be considered while selecting a supplier. True to the findings of previous literature, this study correlates with most principles. The method developed for green supplier selection, which integrates fuzzy influence diagrams and capability attribute recognition, resonates with prior research advocating for comprehensive and systematic supplier evaluation methods. Notably, this approach offers a structured framework for assessing supplier capabilities and enhances the decision-making process, consistent with the literature's emphasis on effective supplier selection techniques. For instance, fuzzy influence diagram has the ability to handle large numbers for evaluation indicators enabling the model complex relationships between many variables, including both quantitative and qualitative variables. They can also account for the complex relationships between different criteria by modeling complex relationships between different criteria. It also reduces subjective weight bias since the fuzzy influence diagram uses a more objective and systematic approach to prioritize different evaluation criteria. Finally, the fuzzy influence diagrams are more practical and easier to implement than the traditional methods, such as the analytic hierarchy process (AHP). Besides, fuzzy influence diagrams can also be used to model uncertainty in the decision-making process. This is important for green supplier selection, as there is often uncertainty about the performance of suppliers in terms of environmental, social, and economic criteria.

In evaluating the performance of our method to existing techniques, several advantages were observed. The utilization of fuzzy influence diagrams adds a layer of precision in handling uncertainty and imprecision, which distinguishes our approach from conventional methods. The integration of capability attribute recognition allows for a more nuanced evaluation, which is in line with recent advancements in supplier selection methodologies. The key contributions over existing methods encompass three critical aspects: Fuzzy Modeling; the study approach adeptly models the complex interrelationships and uncertainties associated with supplier selection criteria, allowing a more precise and comprehensive evaluation. Objective Criteria Identification; by objectively identifying and assessing capability criteria, the model provides a transparent and systematic means of evaluating green suppliers, overcoming the subjectivity that usually hinders traditional approaches. Reliable Supplier Ranking; it employs a reliable prospect value-based ranking system that enhances the accuracy of supplier assessments. This contributes to more effective and strategic supplier selection.

5 Conclusion

The practical implications of this research are substantial for organizations seeking to improve their sustainable supplier selection processes. The technique can empower enterprises to make well-informed decisions to advance development of green supply chains; mainly due to its ability to bolster supplier relationships, align with environmental goals, resulting to more responsible and sustainable supply chain practices. In contemplating the future, there is potential for further refinement and expansion of our methodology by developing more robust criteria evaluation and weight learning methods. Further empirical studies could also validate the approach's effectiveness in various industries and scenarios.

It is essential to acknowledge the limitations of this study. One notable constraint is the data requirements for this approach, which may be more extensive than some traditional methods. Additionally, the sensitivity of the method to the selection of weights and parameters necessitates a careful and informed selection process. The application of the approach may also require advanced expertise, which can be a barrier for smaller enterprises.

Choosing the optimal green supplier is a key link in green supply chain management. This article not only considers traditional evaluation indicators but also pays attention to environmental factors and social benefits. It constructs a comprehensive evaluation index system for selecting green suppliers based on development ability, innovation ability, and environmental protection ability. The index system meets the requirements for selecting green suppliers and also meets current requirements for enterprise development. By using a research method combining fuzzy influence diagrams with multi-attribute decision-making to identify key capability attributes of green suppliers and select optimal green suppliers, this method fully considers the priority relationship between the green supplier's ability attributes, determines the key ability attributes of the green supplier through a fuzzy influence diagram, and uses a multi-attribute decision-making method to rank the candidate green suppliers based on the key ability attributes, avoiding interference with decision results due to too many evaluation indicators. Finally, through an example analysis of furniture manufacturing enterprises, it can be seen that this method is feasible in the calculation process with strong practicality.

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Author contributions

The authors contributed equally to this work.

Conflict of interest

The authors declare no conflict of interest.

References

[1] RISTOVSKA K., RISTOVSKA A. The impact of globalization on the business, *Economic Analysis*, 2014, 47, 3-4, 83-89.

[2] Rodrigue J-P, Slack B., Comtois C. Green Logistics, In *Handbook of Logistics and Supply-Chain Management*,Bingley: Emerald Group Publishing Limited, 2017, 339–350.

[3] Mangla S.K., Govindan K., Luthra S. Prioritizing the barriers to achieve sustainable consumption and production trends in supply chains using fuzzy Analytical Hierarchy Process, *J Clean Prod*, 2017, 151, 509–525.

[4] Singh A, Trivedi A. Sustainable green supply chain management: trends and current practices, *Competitiveness Review*, 2016, 26(3),265-288.

[5] Shi P., Yan B., Shi S., et al. A decision support system to select suppliers for a sustainable supply chain based on a systematic DEA approach, *Information Technology and Management*, 2015, 16, 39–49.

[6] Zhang J., Li L., Zhang J., et al. Private-label sustainable supplier selection using a fuzzy entropy-VIKOR-based approach, *Complex and Intelligent Systems*, 2023, 9, 2361-2378. DOI: 10.1007/s40747-021-00317-w.

[7] Jafarzadeh Ghoushchi S., Khazaeili M., Amini A., et al. Multi-criteria sustainable supplier selection using piecewise linear value function and fuzzy best-worst method, *Journal of Intelligent and Fuzzy Systems*,2019,37(2), 2309-2325. DOI: 10.3233/JIFS-182609.

[8] Malviya R.K., Kant R. Green supply chain management (GSCM): a structured literature review and research implications, *Benchmarking: An International Journal*, 2015, 22(7), 1360-1394. DOI: 10.1108/BIJ-01-2014-0001.

[9] Chamodrakas I., Batis D., Martakos D. Supplier selection in electronic marketplaces using satisficing and fuzzy AHP, *Expert Syst Appl*, 2010, 37, 490–498.

[10] Liou J.J.H., Chuang Y-C, Zavadskas E.K., Tzeng G.H. Data-driven hybrid multiple attribute decision-making model for green supplier evaluation and performance improvement, *J Clean Prod*, 2019, 241: 118321.

[11] Fallahpour A., Wong K.Y., Rajoo S., et al. An Integrated Fuzzy Carbon Management-Based Model for Suppliers' Performance Evaluation and Selection in Green Supply Chain Management, *International Journal of Fuzzy Systems*, 2020, 22, 712–723.

[12] Qu G., Xue R., Li T., et al. A Stochastic Multi-Attribute Method for Measuring Sustainability Performance of a Supplier Based on a Triple Bottom Line Approach in a Dual Hesitant Fuzzy Linguistic Environment, *Int J Environ Res Public Health*, 2020, 17: 2138.

[13] Luthra S., Govindan K., Kannan D., et al. An integrated framework for sustainable supplier selection and evaluation in supply chains, *J Clean Prod*, 2017, 140, 1686–1698.

[14] Kannan D., Govindan K., Rajendran S. Fuzzy Axiomatic Design approach based green supplier selection: a case study from Singapore, *J Clean Prod*, 2015; 96, 194–208.

[15] Govindan K., Rajendran S., Sarkis J., et al. Multi criteria decision making approaches for green supplier evaluation and selection: a literature review, *J Clean Prod*, 2015, 98, 66–83.

[16] Lee A.H.I., Kang H.Y., Hsu C.F.,Hung H.C. A green supplier selection model for high-tech industry, *Expert Syst Appl*, 2009,36(4), 7917-7927, DOI: 10.1016/j.eswa.2008.11.052.

[17] Eltayeb T.K., Zailani S. Going Green through Green Supply Chain Initiatives Toward Environmental Sustainability, *Operations and Supply Chain Management: An International Journal*, 2014, 93–110.

[18] Rahim S.A., Fernando Y., Saad R. Sustainable Green Supply Chain Management and Impact on Organisations, *Journal of Emerging Trends in Economics and Management Sciences (JETEMS)*,7(3).

[19] Hashemzahi P., Azadnia A., Galankashi M.R., et al. Green supplier selection and order allocation: A nonlinear stochastic model, *International Journal of Value Chain Management*,2020,11(2),111-138, DOI: 10.1504/IJVCM.2020.106821.

[20] Wang Y.-L., Zeng X.-Y., Chen W. Supply Chain Decision-Making Considering Green Technology Effort: Effect on Random Output and Retail Price with Fairness Concerns. *Economic Computation and Economic Cybernetics Studies and Research*, 2023, 57(1), pp. 103-120, DOI: 10.24818/18423264/57.1.23.07.

[21] Wu C., Zhou L. Influence Mechanism of Smart City Innovation on Green Supply Chain Network Efficiency, *Tehnički vjesnik*, 2023, 30 (3), 945-950. DOI: 10.17559/TV-20221230114641.

[22] Iqbal M.W., Kang Y., Jeon H.W. Zero waste strategy for green supply chain management with minimization of energy consumption, *J Clean Prod*, 2020, 245: 118827.

[23] Rupa R.A., Saif A.N.M. Impact of Green Supply Chain Management (GSCM) on Business Performance and Environmental Sustainability: Case of a Developing Country, *Business Perspectives and Research* ,2022, 10, 140–163.

[24] Blome C., Hollos D., Paulraj A. Green procurement and green supplier development: Antecedents and effects on supplier performance, *Int J Prod Res*, 2014,52(1), 32-49, DOI: 10.1080/00207543.2013.825748.

[25] Das D. The impact of Sustainable Supply Chain Management practices on firm performance: Lessons from Indian organizations, *J Clean Prod*, 2018,203, 179-196, DOI: 10.1016/j.jclepro.2018.08.250.

[26] Humphreys P., McCloskey A., McIvor R., et al. Employing dynamic fuzzy membership functions to assess environmental performance in the supplier selection process, *Int J Prod Res*, 2006, 44, 2379–2419.

[27] Sarkis J., Dhavale D.G. Supplier selection for sustainable operations: A triple-bottom-line approach using a Bayesian framework, *Int J Prod Econ*, 2015, 166, 177–191.

[28] Dos Santos B.M., Godoy L.P., Campos L.M.S. Performance evaluation of green suppliers using entropy-TOPSIS-F, *J Clean Prod*, 2019, 207, 498–509.

[29] Zhang J., Yang D., Li Q., et al. Research on Sustainable Supplier Selection Based on the Rough DEMATEL and FVIKOR Methods, *Sustainability*, 2020, 13: 88.

[30] Kannan D., Jabbour A.B.L.de S., Jabbour C.J.C. Selecting green suppliers based on GSCM practices: Using fuzzy TOPSIS applied to a Brazilian electronics company, *Eur J Oper Res*, 2014, 233, 432–447.

[31] Handfield R., Walton S.V., Sroufe R., et al. Applying environmental criteria to supplier assessment: A study in the application of the Analytical Hierarchy Process, *Eur J Oper Res*, 2002, 141, 70–87.

[32] Hsu C.W., Hu A.H. Applying hazardous substance management to supplier selection using analytic network process, *J Clean Prod*, 2009, 17, 255–264.

[33] Kuo T.C., Hsu C.W., Li J.Y. Developing a green supplier selection model by using the DANP with VIKOR, *Sustainability*, 2015, 7(2), 1661-1689. DOI: 10.3390/su7021661.

[34] Wu T., Blackhurst J. Supplier evaluation and selection: an augmented DEA approach, *Int J Prod Res*,2009, 47, 4593–4608.

[35] Gharakhani D. The Evaluation of Supplier Selection Criteria by Fuzzy DEMATEL Method, *J Basic Appl Sci Res*, 2012,2(4),3215-3224.

[36] Uygun Ö., Dede A. Performance evaluation of green supply chain management using integrated fuzzy multi-criteria decision-making techniques, *Comput Ind Eng*, 2016, 102, 502–511.

[37] Howard R.A., Matheson J.E. Influence Diagrams, *Decision Analysis*, 2005, 2, 127–143.

[38] Baykasoğlu A., Gölcük İ. Development of a novel multiple-attribute decision making model via fuzzy cognitive maps and hierarchical fuzzy TOPSIS, *Information Sciences*, 2015, 301, 75–98.

[39] Carriger J.F., Newman M.C. Influence diagrams as decision-making tools for pesticide risk management, *Integr Environ Assess Manag*, 2012, 8, 339–350.

[40] Ducey M.J., Larson B.C. A fuzzy set approach to the problem of sustainability, *For Ecol Manage*, 1999, 115(1), 29–40.DOI: 10.1016/S0378-1127(98)00433-2.

[41] Zhang Y. M., Song Y. F., Meng X., Liu Z. G. Optimizing Supply Chain Efficiency with Fuzzy CRITIC-EDAS, *Int. Journal of Simulation Modelling*,2023, 22(4), p. 723-733

[42] Shachter R.D. Probabilistic inference and influence diagrams, *Operations Research*, 1988, 36(4), 589-604.DOI: 10.1287/opre.36.4.589.

[43] Shachter R.D. Evaluating Influence Diagrams, *Operations Research*, 1988, 34(6),871-882.DOI: 10.1287/opre.34.6.871.

[44] Chan S.W., Tiwari S.T.S., Ahmad M.F., et al. Green procurement practices and barriers in furniture manufacturing companies, *International Journal of Supply Chain Management*, 2018, 7(6),431-438.

[45] Huang K., Zhang Z.F., Tao Z.P., Liu H. Study on key technologies of the green furniture design, *Applied Mechanics and Materials*, 2012, 224,208-211.DOI: 10.4028/www.scientific.net/AMM.224.208.

[46] Xiong X.Q., Ma Q.R., Yuan Y.Y., et al. Current situation and key manufacturing considerations of green furniture in China: A review, *Journal of Cleaner Production*, 2020, 267,121957.DOI: 10.1016/j.jclepro.2020.121957.

[47] Lee H.L. Aligning Supply Chain Strategies with Product Uncertainties, *Calif Manage Revn*, 2002, 44, 105–119.

[48] Zhu Q., Sarkis J., Lai K. Green supply chain management implications for "closing the loop", *Transp Res E Logist Transp Rev*, 2008, 44, 1–18.

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