Interval Valued Neutrosophic VIKOR Method for Assessment Green Suppliers in Supply Chain

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Abstract

In order to remain competitive, businesses must now invest in developing environmentally responsible green suppliers. The purpose of this article is to determine which vendors should be incorporated into green supplier growth programs in order to enhance their ecological sustainability, as well as the suppliers' current green/environmental efficiency. Factor evaluation was used to examine the reliability of the parameters used to assess green suppliers' efficiency and overall quality. To determine which provider offers the greatest ecological performance, the suggested technique uses a hybrid interval-valued neutrosophic set (IVNS) and VIKOR structure to assign relative importance to each criterion. To manage ambiguity while choosing choices, we combine the neutrosophic method with the VIKOR technique. We used 10 criteria and ten vendors in this research to demonstrate the usefulness and effectiveness of the suggested framework. The suggested methodology is applied in the application.

Keywords: Green Supplier; Supply Chain; VIKOR; Interval Valued Neutrosophic Set; MCDM0

1. Introduction

When building long-term connections in the supply chain (SC), selecting reliable suppliers is a crucial practical duty. The selection of a sustainable supplier that may improve SC efficiency requires attention to aspects of the economy, society, and the environment. A critical topic in the SC and manufacturing and operations literature on management is the assessment and choice of potential suppliers[1], [2].

Many businesses are paying attention to Green Supply Chain Management (GSCM) in an effort to enhance their sustainability-related practices. The objective of every business is to maintain its place in the competitive, highly changing marketplace through the use of various strategies, as ecological management systems, production methods that are lean, eco-design, recyclable materials, and dedication to green practices during its purchasing and production operations. The need for sustainable SC has recently come to the fore due to rising governmental pressure and customer demand. For this reason, it is important to consider how industrial business practices may be linked to sustainability in order to save prices in the supply chain while also making it more sustainable via the adoption of green practices[3]–[5].

Businesses must "green" their SC and partner with suppliers who have the skills to participate in green manufacturing and associated operations. Businesses now expect their vendors to define green apps and get the necessary ecological certifications. However, not all vendors can boast pristine ecological credentials right from the get. Without the help of the focal firm, suppliers will not be able to successfully enhance their contribution to the environment. Companies may improve their environmental and green initiatives by fostering cooperative, close, and interconnected connections with their suppliers, conducting supplier green performance evaluations, and providing suppliers with assistance

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related to green concerns. Focused businesses might build supplier development programmes to help with green challenges. Focused businesses need a green performance evaluation system to identify greening requirements among suppliers and map out green supplier development programmes[6]–[8]. Because of green supplier growth programs, key organizations may have a greener SC. The green SC has many criteria, so this problem can be solved by using MCDM concept[9]–[11].

When the decision maker's expression is ambiguous or when the choice's acceptability is in question, neither fuzzy sets (FSs) nor intuitionistic fuzzy sets (IFSs) can handle the problem well. Consequently, some novel ideas are needed to address the issue of doubt[12]–[14]. When faced with unreliable insufficient, and conflicting data, neutrosophic sets (NSs) are more efficient and desirable than FSs and IFSs because they take into account the truth value, the indeterminacy value, and the falsity value concurrently. Wang et al. developed NSs, and a natural extension of these is single-valued neutrosophic sets[15]–[17]. The innovative processes and aggregation algorithms of Peng et al. were established, and Ye provided simpler NS. Lastly, NSs may be extended in many ways, leading to constructs like interval NSs, bipolar NSs, and multi-valued NSs[18]–[20].

A significant area of study in the field of decision science is the MCDM issue. It has grown in significance in recent years if multiple factors must be taken into account in a single challenge. This leads to a situation requiring MCGDM, or multi-criteria group decision-making. In either a hazy or clear setting, MCGDM may be put to use in a variety of contexts.

This study developed a NS model for evaluation green supplier. The NS is hybrid with the MCDM due to contains many and various criteria. The VIKOR method is an MCDM method used to rank the alternatives. The neutrosophic VIKOR method is used in this paper to rank and evaluate the green suppliers.

2. The Interval Valued Neutrosophic (IVN) VIKOR Method

This section presented the steps of the N-VIKOR method. Figure 1 shows the steps of the N-VIKOR method. The NS is used to overcome inconsistent information by using the indeterminacy value. The NS has three values truth, indeterminacy, and falsity values. This paper used the IVNS which is a type of NS[21], [22]. The IVN can be represented as $V = ([A_{vl}, A_{vu}], [B_{vl}, B_{vu}], [C_{vl}, C_{vu}])$, where $[A_{vl}, A_{vu}]$ refers to the truth value, $[B_{vl}, B_{vu}]$ refers to the indeterminacy value, and $[C_{vl}, C_{vu}]$ refers to the falsity value[23].

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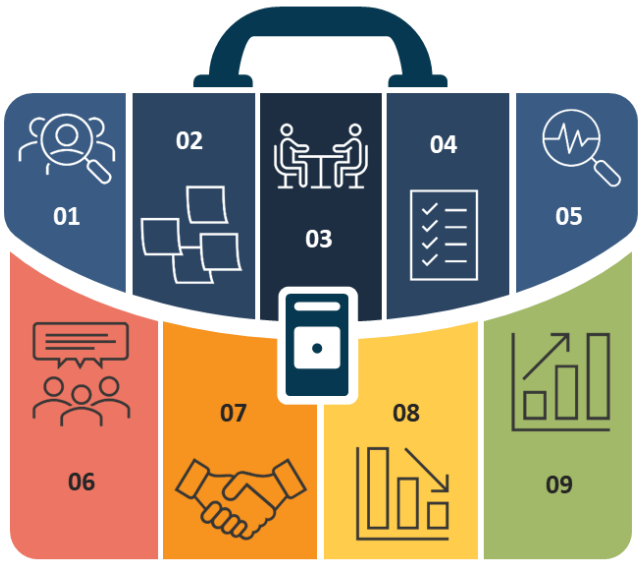

Figure 1: The steps of IVN-VIKOR method.

The steps of the IVN-VIKOR are discussed as:

Step 1: Build the matrix of decision $T = t_{ij}$

The values between criteria and alternatives are added in decision matrix by each decision makers.

Step 2: Determine the weights of features

This step computes the weights of features. The weights of features can be computed as:

$$w_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \quad (1)$$

Where the w_i refers to the weights of feature I, and n refers to the number of features.

Step 3: Establish the normalization decision matrix

This step builds the normalization matrix from the decision matrix as:

$$R = r_{ij} = \begin{cases} r_{ij}^{l} = \frac{t_{ij}^{l}}{\sum_{i=1}^{n}\left(t_{ij}^{u}\right)} \\ r_{ij}^{u} = \frac{t_{ij}^{u}}{\sum_{i=1}^{n}\left(t_{ij}^{l}\right)} \end{cases} \quad (2)$$

$$R = r_{ij} = \frac{t_{ij} - t_j^{min}}{t_j^{max} - t_j^{min}} \quad (3)$$

Step 4: Build the weighted normalized matrix

$$E_{ij} = (w^j r_{ij}) \quad (4)$$

Step 5: Compute the values of α_i and β_i by using distance of Manhattan and Chebyshev

$$\alpha_i = \sum_{j=1}^{m} E_{ij} \quad (5)$$

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$$\beta_i = \max(E_{ij}) \quad (6)$$

Step 6: Compute the value of priority

$$Y_i = \frac{\varphi(\alpha_i - \alpha_i^+)}{(\alpha_i^- - \alpha_i^+)} + (1-\varphi)\frac{(\beta_i - \beta_i^+)}{(\beta_i^- - \beta_i^+)} \quad (7)$$

$$\text{Where } \begin{cases} \alpha_i^+ = \min \alpha_i \\ \alpha_i^- = \max \alpha_i \\ \beta_i^+ = \min \beta_i \\ \beta_i^- = \max \beta_i \end{cases} \quad (8)$$

$\varphi = 0.5$

Step 7: Compute the crisp value

The crisp value can be computed by the score function S_i [23].

Step 8: Compute the absolute distance

$$O_i = S_{max} - S_i \quad (9)$$

Step 9: Compute the relative weights, then rank the alternatives

$$F_i = \frac{O_i}{\sum_{i=1}^{n} O_i} \quad (10)$$

Then rank the alternatives by descending order of F_i

3. Results

This section presented application of IVN-VIKOR method. The application applied in green suppliers to select best suppliers in different criteria. This study collated ten criteria from previous study. The ten criteria are listed in the Figure 2. This study aims to select best supplier from ten suppliers are presented in this paper.

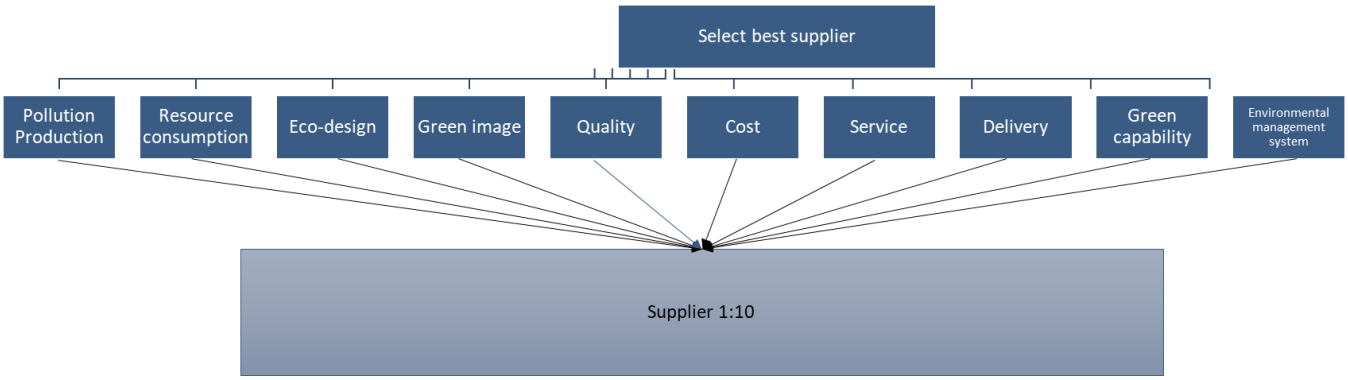

Figure 2: The ten green supplier's criteria.

Build the decision matrix by the decision makers and experts. This matrix contains the value of criteria and alternatives. The values are interval valued neutrosophic numbers[23]. Then compute the weights of criteria by using Eq. (1). Figure 3 shows the weights of criteria.

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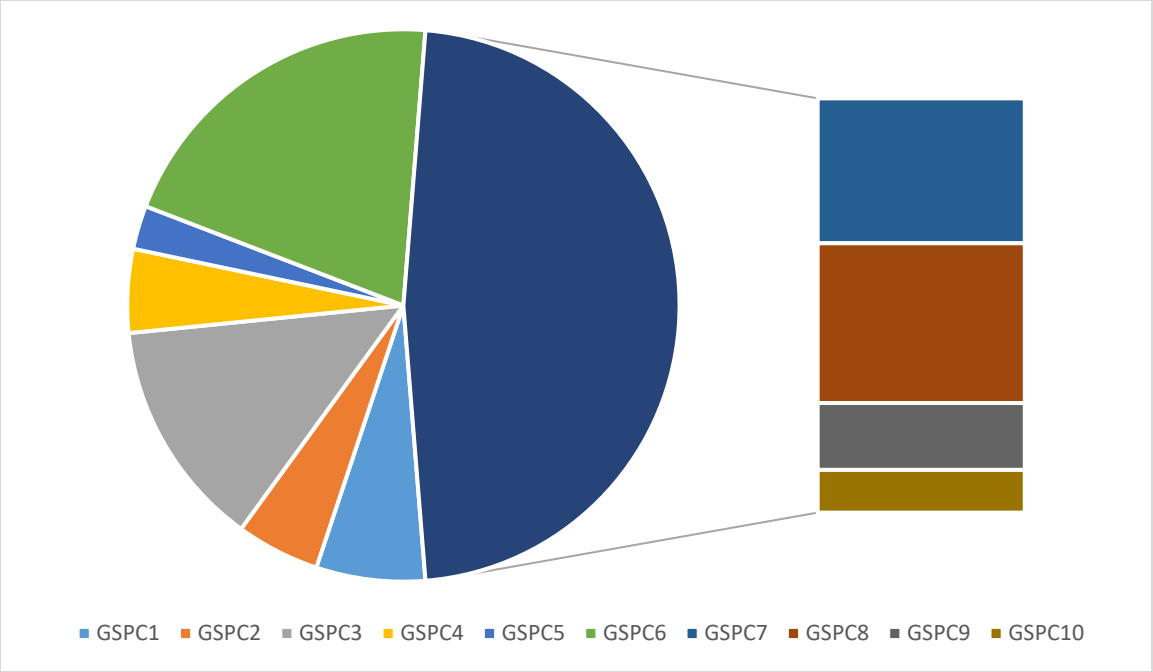

Figure 3: The importance of factors.

Then build the normalization decision matrix by using Eqs. (2 and 3). Table 1 shows the normalization decision matrix. Then build the weighted normalized decision matrix by using Eq. (4). Table 2 shows the weighted normalized decision matrix.

Table 1: The normalization decision matrix

	$GSPC_1$	$GSPC_2$	$GSPC_3$	$GSPC_4$	$GSPC_5$	$GSPC_6$	$GSPC_7$	$GSPC_8$	$GSPC_9$	$GSPC_{10}$
$GSPA_1$	0.3	0.23	0.63	0.23	0.12	0.96	0.78	0.86	0.36	0.23
$GSPA_2$	0.96	0.36	0.92	0.93	0.36	0.32	0.25	0.362	0.36	0.32
$GSPA_3$	0.123	0.23	0.12	0.116	0.23	0.11	0.36	0.12	0.32	0.236
$GSPA_4$	0.236	0.96	0.36	0.15	0.236	0.63	0.369	0.15	0.55	0.236
$GSPA_5$	0.36	0.36	0.89	0.95	0.63	0.236	0.69	0.96	0.56	0.25
$GSPA_6$	0.52	0.74	0.23	0.153	0.36	0.396	0.98	0.36	0.85	0.29
$GSPA_7$	0.63	0.85	0.96	0.236	0.36	0.123	0.963	0.32	0.96	0.21
$GSPA_8$	0.752	0.236	0.45	0.56	0.96	0.26	0.23	0.56	0.75	0.69
$GSPA_9$	0.823	0.36	0.89	0.23	0.26	0.26	0.39	0.36	0.74	0.87
$GSPA_{10}$	0.823	0.82	0.18	0.15	0.12	0.26	0.29	0.36	0.26	0.56

Table 2: The weighted normalization decision matrix

	$GSPC_1$	$GSPC_2$	$GSPC_3$	$GSPC_4$	$GSPC_5$	$GSPC_6$	$GSPC_7$	$GSPC_8$	$GSPC_9$	$GSPC_{10}$
$GSPA_1$	0.050332	0.048936	0.05266	0.042247	0.025532	0.204255	0.044255	0.021783	0.065653	0.001483
$GSPA_2$	0	0.040222	0.006383	0.001174	0.018237	0.050463	0.161532	0.130263	0.065653	0.008156
$GSPA_3$	0.06383	0.048936	0.134043	0.048936	0.022188	0	0.137191	0.182979	0.07003	0.001928
$GSPA_4$	0.055212	0	0.095745	0.046941	0.022006	0.124956	0.1352	0.176444	0.044863	0.001928
$GSPA_5$	0.045756	0.040222	0.01117	0	0.010003	0.030278	0.06417	0	0.043769	0.002966

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GSPA6	0.033554	0.014748	0.116489	0.046765	0.018237	0.068726	0	0.130699	0.012036	0.005932
GSPA7	0.025166	0.007374	0	0.041895	0.018237	0.003124	0.003762	0.139412	0	0
GSPA8	0.015862	0.048534	0.081383	0.022884	0	0.036045	0.165957	0.087133	0.022979	0.03559
GSPA9	0.010448	0.040222	0.01117	0.042247	0.021277	0.036045	0.130553	0.130699	0.024073	0.048936
GSPA10	0.010448	0.009385	0.124468	0.046941	0.025532	0.036045	0.152681	0.130699	0.076596	0.025951

Then compute the distance of Manhattan and Chebyshev by using Eqs. (5 and 6). Then compute the priority value by using Eqs. (7 and 8). Then compute the absolute distance by using Eq. (9). Then compute the relative weight by using Eq. (10). Then rank the supplier as shown in Figure 4.

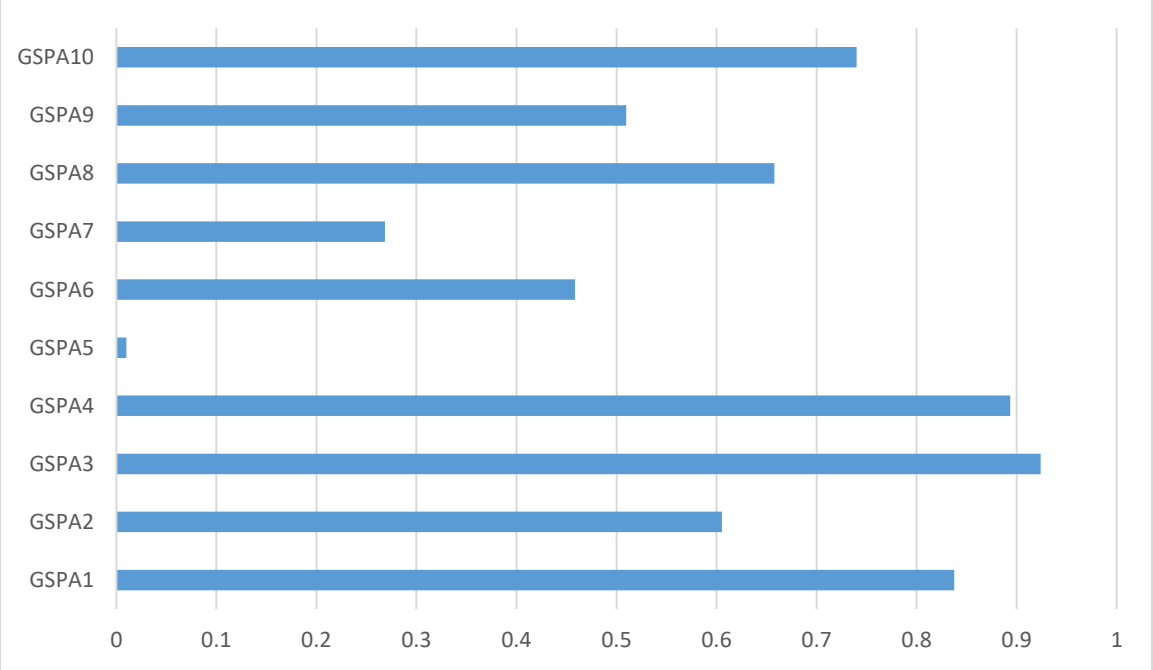

Figure 4: The ordering of ten suppliers.

4. Conclusion

In order to reap the benefits of becoming green, businesses must provide vendors with the knowledge and skills they need to adapt their operations to green manufacturing practices and take the initiative to implement sustainable practices across the supply chain. Thus, the purpose of this research is to begin implementing GSCM practices by including ecological variables in the choice of vendors. The current research helped determine which environmental factors should be prioritized in assessing and selecting eco-friendly vendors. This paper used ten criteria collected from previous studies and ten suppliers to select the best green supplier. The VIKOR method was used in this paper to compute the weights of 10 criteria, then rank the ten suppliers. The neutrosophic set was used to overcome the uncertain information in the evaluation process.

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