

PERFORMANCE EVALUATION OF SUSTAINABLE SUPPLIERS IN A SUPPLY CHAIN USING FUZZY TOPSIS AND FUZZY VIKOR TECHNIQUES

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Abstract

The Green Supply Chain Management (GSCM) describes the integration of environmental factors into Supply Chain Management (SCM), with also formulation of appropriate architectural features, material sourcing and selection, production methods, shipping of the completed product to the customers, and end-of-life management of the product after its useful life. In light of emerging natural regulations and charged governmental problems of the companies about sustainable practices, companies need to strengthen their capacity for GSCM activities. Considering the aforementioned, Multi-Criteria Decision-Making (MCDM) approaches are a great way to examine the rankings of the providers in Supply Chain Management (SCM). This study introduces two effective fuzzy-based approaches, such as fuzzy TOPSIS and fuzzy VIKOR, for supplier selection in networks of green supply chains.

1. Introduction

The creation of a sophisticated network of interactions between firms for controlling the movement of goods, information, and cash is known as Supply Chain Network Design (SCND). Early in the 1990s, SCND's top priority was to maximise profits overall and/or cut costs by streamlining the movement of materials along the supply chain. Companies are concentrating increasingly on the design of their SC to make them sustainable as a result of shifting consumer preferences toward greener products, increasing regulatory pressure from governments and Non-Governmental Organizations, and other factors. To improve the efficiency of businesses as a whole, supply chain managers view sustainability as the most important idea when creating a sustainable model related to economical, environmental, and social norms. In other words, managers strive to achieve social and environmental standards while taking into account public opinion, regulatory requirements, and the necessity of economic elements for each manufacturing organization. The invention of the triple bottom

line concept, its application to business relationships and supply chains, and the theory of Sustainable Supply Chain Management (SSCM) are all outcomes of the simultaneous examination of economical, environmental, and social issues.

The success of a firm in terms of sustainability is greatly influenced by its suppliers, who make up the first level of the supply chain. Therefore, businesses must evaluate their suppliers for potential long-term relationships. One of the most important SSCM techniques is choosing the right suppliers based on sustainability. Managers can receive the ideal raw materials at the ideal timing, quantity, and quality by selecting the appropriate suppliers. It can be claimed that selecting and evaluating sustainable suppliers is a crucial process that influences SSCM across different industries. In SCM, choosing a supplier is crucial because businesses spend at least 60% of their sales on buying things like parts, components, and raw materials. Additionally, manufacturers spend up to 70% of the cost of a product on services and purchases. In order for SCM to be effective, supplier selection must be taken into account as a tactical factor.

Manufacturers tried to create strategic alliances in the 1990s to increase their management's preference and competitiveness. Decision-makers face challenging responsibilities when choosing and evaluating suppliers since they must take into account a variety of factors.

Despite extensive study on the assessment and selection of suppliers, these techniques nevertheless have some drawbacks because of the current state of fierce global competition. It is difficult to measure and quantify the supplier's qualitative indicators, and when there is a conflict between the supplier's various features, the quantitative indicators don't transform well, and it's hard to weigh the evaluating indicators. The TOPSIS ("Technique for Ordering Preference by Similarity to Ideal Solution"), VIKOR, AHP/DEA, and ELECTRE procedures are just a handful of the many solutions currently on the market to address the challenge of multiple-factor decisions created in supplier evaluation. Making choices from the available suppliers, rating, comparing and choosing among them all include some degree of uncertainty and faulty information processing like randomness, fuzzy, and roughness.

Today's market competition includes competition over supply chains as well as competition between individual businesses. In order to adjust to the expansion of the global economy, firms must learn how to cooperate instead of using the competitive approach of playing a single hand. SCM is a "cooperation-competition" strategy that helps to increase management and production rates while promoting normative, logical and scientific manufacturing management. In this study, each indicator's weight is determined by using the entropy technique and disputes between indicators are resolved using the VIKOR algorithm and fuzzy MADM TOPSIS with hazy sets. The choices are ranked using these methods as well. The compromise answer that develops when manufacturers employ the VIKOR algorithm to choose suppliers may be approved by the decision-makers since it offers the most advantages to the majority while inflicting the opponent with the least amount of personal grief. The ideal point approach, which forms the basis of the VIKOR algorithm, has simple logic and requires fewer considerations for calculation. VIKOR is a useful technique in multifactor decision-making when a decision maker lacks the ability or knowledge to communicate their choices during the first supplier selection stage. The decision-makers may agree to the proposed compromise because it increases the "majority's" "group utility" while lowering the "opponent's" personal regret. The compromise solutions may serve as the negotiation's starting point, containing the decision-makers weighted on the criteria. It is necessary to match techniques with classes of

pertinent problems in order to choose which way to use them. It is necessary to establish the validation processes and investigate the viability of the application. Before using an approach to address problems in the actual world, it must be conceptually and practically validated. Researchers must develop a manual for selecting a method that is both theoretically sound and practically practicable, and that can be applied to tackle real-world problems.

2. Literature Review

TOPSIS is explained as “an approach to identify an alternative that is ideal solution and farthest to the negative ideal solution in a multi-dimensional computing space”. It offers a variety of benefits. It is programmable and simple to use. The fact that it does not take into account the connection of properties while using Euclidean Distance is a drawback. With more traits, it can be difficult to balance them while maintaining consistency in judgment.

The core idea behind TOPSIS is that both positively and negatively, the optimal option should be the one that is the furthest away from the ideal answer (Kuo et al., 2015). Since it allows for clear trade-offs between different attributes and contains an infinite number of parameters and performance indicators, the TOPSIS approach is a well-known approach for prioritizing concerns linked to supplier selection in the supply chain (Devika et al., 2013, Alireza Fallahpour, 2017). TOPSIS may occasionally be used in combination with other MCDM strategies like AHP (Hsiu Mei Wang 2016, Yazdani, 2014, Li, 2015) or ANP (Uygun & Dede, 2016, ifçi, 2012a, Kuo et al., 2015). TOPSIS has also been extensively used to tackle GSCM issues in the fuzzy environment (Huseylin Selcuk Kilic et al.2020, Ahmed Mohammed, 2019, Li &Wu, 2015, Sousa et al., 2014, Shen et al. 2013). The primary application areas of TOPSIS in GSCM processes, like AHP and ANP, are supplier selection and assessment. It is also utilized for performance analysis and deployment.

When Opricovic (2004) first created VIKOR, it was with the goals of helping decision-makers reach a final choice, coming up with compromise solutions for problems with conflicting circumstances, and rating and selecting from a collection of choices (Hsu et al., 2013). In contrast to other widely used MCDM techniques, VIKOR is a relatively new technology. Fuzzy best worst best and the VIKOR approach were used to choose suppliers (Devika Kannan, 2020; Qun Wu 2019). Furthermore, VIKOR worked in conjunction with other MCDM methodologies, including Analytical Network Process (ANP), to make it possible to choose environmentally friendly suppliers (Sahaj Valipour, 2017; Akman, 2015)

Compared to other MCDM strategies, VIKOR has a few benefits. When compared to the TOPSIS ,VIKOR takes into account both individual regret minimization and collective utility maximisation, and it can accurately reflect the decision makers' personal preferences. Supplier evaluation and selection difficulties are where VIKOR is most commonly used. It is also utilized to evaluate the success of initiatives aimed at creating a green supply chain and green suppliers.

3. Research problem and Objectives

The sustainable suppliers are examined in the current work utilizing GSCM criteria in addition to the conventional economical measures. The primary objective is to propose many multicriteria decision-making procedures for choosing the best supplier in the manufacturing industry. The first step in locating and choosing the best-manufactured supplier is to do a literature review to determine the key requirements and enabling variables. The suppliers are assessed by purchasing specialists using the criterion and subcriteria in the second stage. Then,

using two fuzzy-based approaches like fuzzy TOPSIS and fuzzy VIKOR, providers are ranked and appraised.

4. Research Methodology

4.1. Fuzzy TOPSIS

Chen and Hwang first presented TOPSIS, a multi-criteria technique, in 1992 to select solutions from a constrained set of options (Yazdani, 2014). The following is the method for employing the fuzzy TOPSIS algorithm in this investigation:

Step 1: Create decision matrix

Within that research, 5 factors and five alternatives are ranked using the fuzzy TOPSIS method. Every criterion's type and weight are displayed in the table below.

Step 2: Creating the Normalized Decision Matrix (NDM)

Using the Positive and Negative Ideal Solution (PIS and NIS) as a base, link the following to create a normalized choice matrix:

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*} \right) \quad ; \quad c_j^* = \max_i c_{ij} ; \text{PIS}$$

$$\tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}} \right) \quad ; \quad a_j^- = \min_i a_{ij} ; \text{NIS}$$

Step 3: Creating the Weighted Normalized Decision Matrix (WNDM)

The WNDM, which took the changing weights of each criterion into account, is produced by multiplying each criterion's weight in the fuzzy NDM.

$$\tilde{v}_{ij} = \tilde{r}_{ij} \cdot \tilde{w}_{ij}$$

here \tilde{w}_{ij} denotes the weight of the criterion c_j .

Step 4: Analyse the fuzzy positive ideal solutions (FPIS, A^*) and the fuzzy negative ideal solutions (FNIS, A^-)

The FPIS and FNIS of the alternatives are known according to the following criteria:

$$A^* = \{\tilde{v}_1^*, \tilde{v}_2^*, \dots, \tilde{v}_n^*\} = \{(i \in F), (i \in G)\}$$

$$A^- = \{\tilde{v}_1^-, \tilde{v}_2^-, \dots, \tilde{v}_n^-\} = \{(i \in F), (i \in G)\}$$

here \tilde{v}_i^* represents maximum value of i for all the alternatives and \tilde{v}_i^- denotes minimum value of i for all the alternatives. F and G represents the PIS and NIS. The table below displays both the PIS & NIS.

Step 5: Analyze the distance between each alternative and the FPIS, A^* and the distance between each alternative and FNIS, A^-

The following equations create the distances between each alternative and the FPIS and FNIS, respectively:

$$S_i^* = \sum_{j=1}^n d(\tilde{v}_{ij}, \tilde{v}_j^*) \quad (i \text{ range from } 1 \text{ to } m)$$

$$S_i^- = \sum_{j=1}^n d(\tilde{v}_{ij}, \tilde{v}_j^-) \quad (i \text{ range from } 1 \text{ to } m)$$

d is the distance between 2 fuzzy numbers when given 2 triangular fuzzy numbers (x_1, y_1, z_1) and (x_2, y_2, z_2) , d distance between the 2 can be computed as follows:

$$d_v(\tilde{M}_1, \tilde{M}_2) = \sqrt{\frac{1}{3} [(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2]}$$

Note that $d(\tilde{v}_{ij}, \tilde{v}_j^*)$ and $d(\tilde{v}_{ij}, \tilde{v}_j^-)$ are numbers.

Step 6: Compute the closeness coefficient and rank the alternatives

The following formula can be used to determine each alternative's proximity coefficient:

$$CC_i = \frac{S_i^-}{S_i^+ + S_i^-}$$

The greatest option is situated away from the FNIS and FPIS. The table below displays each alternative's proximity coefficient along with its ranking order.

4.2. Fuzzy VIKOR

The FUZZY VIKOR technique, created by Opricovic (2007), is used to rank choices in a fuzzy environment. The following is the method for employing the fuzzy VIKOR algorithm in this investigation:

Step 1: Create a decision matrix

The FUZZY VIKOR technique is used in this research to rank five factors and five alternatives. The tables shown below gives the category of each factor and the weight .

After the alternatives have been evaluated in light of several factors, the decision matrix's conclusions are generated. Take note if there are several specialists involved in the evaluation because the matrix below displays the arithmetic mean of all specialists.

Step 2: Determining PIS and NIS

There are both PIS AND NIS for each criterion, and they are as follows.

PIS (\tilde{f}^*) and NIS ($(\tilde{f})^\circ$) can be found using the following relations if the criterion is positive:

$$\tilde{f}_j^* = \text{Max}_i \tilde{f}_{ij}$$

$$\tilde{f}_j^\circ = \text{Min}_i \tilde{f}_{ij}$$

If the criterion is negative, the relations given below can be used to get the PIS (\tilde{f}^*) and NIS ($(\tilde{f})^\circ$):

$$\tilde{f}_j^* = \text{Min}_i \tilde{f}_{ij}$$

$$\tilde{f}_j^\circ = \text{Max}_i \tilde{f}_{ij}$$

here i is from 1 to n

Step 3: Generate the NDM

A normalizing choice matrix can be made by connecting the following, and using PIS and NIS as a base:

$$\tilde{d}_{ij} = (\tilde{f}_j^* \ominus \tilde{f}_{ij}) / (r_j^* - l_j^\circ) \quad \text{Positive ideal solution}$$

$$\tilde{d}_{ij} = (\tilde{f}_{ij} \ominus \tilde{f}_j^*) / (r_j^\circ - l_j^*) \quad \text{Negative ideal solution}$$

Where

$$\tilde{f}_j^* = (l_j^*, m_j^*, r_j^*)$$

$$\tilde{f}_j^\circ = (l_j^\circ, m_j^\circ, r_j^\circ)$$

The table below displays the assessment matrix's normalized values.

Step 4: Compute the values \tilde{S}_i and \tilde{R}_i :

The values \tilde{S}_i and \tilde{R}_i can be derived as follows once the matrix has been normalized to form the weighted normalized decision matrix:

$$\text{If } \tilde{R}_i = (R_i^l, R_i^m, R_i^r) \text{ and } \tilde{s}_i = (s_i^l, s_i^m, s_i^r)$$

$$\tilde{S}_i = (\tilde{w}_j \otimes \tilde{d}_{ij})$$

$$\tilde{R}_i = (\tilde{w}_j \otimes \tilde{d}_{ij})$$

Step 5: Compute the VIKOR index (Q)

The formula below can be used to determine Q's value.

$$\text{If } \tilde{Q}_i = (Q_i^l, Q_i^m, Q_i^r)$$

$$\tilde{Q}_i = v \frac{(s_i^\circ \ominus s_i^*)}{s_i^r - s_i^l} \oplus (1 - v) \frac{(\tilde{R}_i \ominus \tilde{R}^*)}{R_i^r - R_i^l}$$

Where,

$$\tilde{s}^* = \tilde{s}_i$$

$$s_i^{\circ r} = s_i^r$$

$$\tilde{R}^* = \tilde{R}_i$$

$$R_i^{\circ r} = R_i^r$$

The variable v (indicating the highest group utility) will be assigned as 0.5 in this research. The following formula can be used to convert the hazy numbers S , R , and Q into distinct numbers.

If $\tilde{A} = (l, m, r)$ (\tilde{A} is expressed as a fuzzy number)

$$\text{Crisp}(\tilde{A}) = \frac{2m+l+r}{4}$$

Step 6: Offering a compromise solution

Therefore, a choice is determined by the values of R , S , and Q , which are stated in descending order, for the alternatives. A selection of compromise answers can be suggested after the two choices that need to be made.

1st Condition. Acceptable advantage: $Q(A^{(2)}) - Q(A^{(1)}) \geq 1/(m - 1)$ where $A^{(1)}$ intimates alternatives that are ranked 1st and $A^{(2)}$ is the alternative that is ranked 2nd in Q 's ranking list. m denotes no. of alternatives.

2nd Condition. Acceptable stability in decision making: Additionally, S or/and R must rank the alternative $A^{(1)}$ as the highest.

The following list of compromise solutions is suggested if any of the conditions are not encountered:

1st Solution. Alternatives $A^{(1)}, A^{(2)}, \dots, A^{(M)}$ if condition 1 is dissatisfied; Alternative $A^{(M)}$ is determined by $Q(A^{(M)}) - Q(A^{(1)}) < 1/(m - 1)$ for max M .

2nd Solution. Alternatives $A^{(1)}$ and $A^{(2)}$ if only 2nd condition is dissatisfied.

3rd Solution. The alternative with the lowest Q value will be picked as the best one if all requirements are satisfied.

The findings of the survey on conditions are shown below.

Result of conditions survey

Condition 1	non acceptance
Condition 2	-
Selected solution	Solution 1

5. Case study and illustration

In a case study, five different suppliers are assessed based on predetermined green dimensions and associated criteria to test the suggested performance evaluation method for GSCM. Fuzzy TOPSIS and fuzzy VIKOR approaches are combined in the recommended model to analyze and rank the alternative businesses. To choose a supplier from a group of five equally qualified candidates (S1, S2, S3, S4, S5), a decision-making committee made up of 3 experts (DM-decision makers), DM1, DM2, and DM3 have been constituted.

Table 1 lists the economic and environmental criteria, together with the weights assigned to each, that should be considered when assessing suppliers. Tables 2 and 7 provide a list of the fuzzy scales used for this study's TOPSIS and VIKOR algorithms. Table 5 denotes the separation between the optimal solution's positive and negative effects on the economy and the environment. TopSIS fuzzy Table 6 displays the ranking of each provider and the closeness coefficient. Taking into account both economic and environmental factors, Supplier 3 is ranked highest. Using the fuzzy VIKOR approach, the crisp values S, R, Q, and alternatives ranking for both economic and environmental factors are provided in Tables 12 and 13. In the fuzzy VIKOR method, Supplier 1 has the highest ranking while considering economic factors whereas supplier 3 has the highest ranking in green factors.

Table 1 Characteristics of Criteria

	Economic Factors	Green factors	weight
1	Quality	Green design	(0.200,0.250,0.300)

2	Lead time	Green image	(0.100,0.150,0.200)
3	Price	Green transformation	(0.250,0.300,0.350)
4	Productivity	Green logistics	(0.200,0.250,0.300)
5	Technology	Green Management System	(0.200,0.250,0.300)

Table 2 Fuzzy Scale for TOPSIS

Code	Linguistic terms	L	M	U
1	Very low	1	1	3
2	Low	1	3	5
3	Medium	3	5	7
4	High	5	7	9
5	Very high	7	9	9

Table 3 Normalised Decision Matrix (Economic criteria)

supplier	Quality	Lead time	Price	Productivity	Technology
1	(0.556,0.778,1.000)	(0.429,0.600,1.000)	(0.429,0.600,1.000)	(0.556,0.778,1.000)	(0.556,0.778,1.000)
2	(0.333,0.556,0.778)	(0.333,0.429,0.600)	(0.333,0.429,0.600)	(0.333,0.556,0.778)	(0.556,0.778,1.000)
3	(0.778,1.000,1.000)	(0.429,0.600,1.000)	(0.333,0.429,0.600)	(0.778,1.000,1.000)	(0.333,0.556,0.778)
4	(0.333,0.556,0.778)	(0.429,0.600,1.000)	(0.333,0.429,0.600)	(0.333,0.556,0.778)	(0.556,0.778,1.000)
5	(0.111,0.333,0.556)	(0.429,0.600,1.000)	(0.429,0.600,1.000)	(0.556,0.778,1.000)	(0.333,0.556,0.778)

Table 4 Normalised Decision Matrix (Green criteria)

supplier	Green design	Green image	Green transformation	Green logistics	Green Management System
1	(0.556,0.778,1.000)	(0.333,0.556,0.778)	(0.778,1.000,1.000)	(0.556,0.778,1.000)	(0.556,0.778,1.000)
2	(0.333,0.556,0.778)	(0.556,0.778,1.000)	(0.556,0.778,1.000)	(0.778,1.000,1.000)	(0.556,0.778,1.000)

3	(0.556,0.778,1.000)	(0.333,0.556,0.778)	(0.556,0.778,1.000)	(0.778,1.000,1.000)	(0.556,0.778,1.000)
4	(0.333,0.556,0.778)	(0.333,0.556,0.778)	(0.556,0.778,1.000)	(0.556,0.778,1.000)	(0.556,0.778,1.000)
5	(0.333,0.556,0.778)	(0.333,0.556,0.778)	(0.333,0.556,0.778)	(0.556,0.778,1.000)	(0.333,0.556,0.778)

Table 5 Distance from PIS and NIS

Supplier	Distance from PIS (economic)	Distance from NIS (economic)	Distance from PIS (Green)	Distance from NIS (Green)
1	0.218	0.225	0.085	0.222
2	0.181	0.249	0.106	0.208
3	0.105	0.323	0.085	0.23
4	0.23	0.2	0.191	0.124
5	0.379	0.056	0.307	0

Table 6 Closeness coefficient

Supplier	Ci (economic)	Rank (economic)	Ci (Green)	Rank (Green)
1	0.508	3	0.724	2
2	0.578	2	0.662	3
3	0.755	1	0.731	1
4	0.465	4	0.393	4
5	0.129	5	0	5

Table 7 Fuzzy scale for VIKOR

Code	Linguistic terms	L	M	U
1	Very Low	0	0	0.25
2	Low	0	0.25	0.5
3	Medium	0.25	0.5	0.75
4	High	0.5	0.75	1
5	Very High	0.75	1	1

Table 8 Normalised decision matrix (Economic criteria)

	Quality	Lead time	Price	Productivity	Technology
supplier 1	(-0.250,0.250,0.500)	(-0.667,0.000,0.667)	(-0.667,0.000,0.667)	(-0.333,0.333,0.667)	(-0.667,0.000,0.667)

supplier 2	(0.000,0.500,0.750)	(-0.333,0.333,1.000)	(-0.333,0.333,1.000)	(0.000,0.667,1.000)	(-0.667,0.000,0.667)
supplier 3	(-0.250,0.000,0.250)	(-0.667,0.000,0.667)	(-0.333,0.333,1.000)	(-0.333,0.000,0.333)	(-0.333,0.333,1.000)
supplier 4	(0.000,0.500,0.750)	(-0.667,0.000,0.667)	(-0.333,0.333,1.000)	(0.000,0.667,1.000)	(-0.667,0.000,0.667)
supplier 5	(0.250,0.750,1.000)	(-0.667,0.000,0.667)	(-0.667,0.000,0.667)	(-0.333,0.333,0.667)	(-0.333,0.333,1.000)

Table 9 Normalised decision matrix (Green criteria)

Supplier	Green design	Green image	Green transformation	Green logistics	Green Management System
1	(-0.667,0.000,0.667)	(-0.333,0.333,1.000)	(-0.333,0.000,0.333)	(-0.500,0.500,1.000)	(-0.667,0.000,0.667)
2	(-0.333,0.333,1.000)	(-0.667,0.000,0.667)	(-0.333,0.333,0.667)	(-0.500,0.000,0.500)	(-0.667,0.000,0.667)
3	(-0.667,0.000,0.667)	(-0.333,0.333,1.000)	(-0.333,0.333,0.667)	(-0.500,0.000,0.500)	(-0.667,0.000,0.667)
4	(-0.333,0.333,1.000)	(-0.333,0.333,1.000)	(-0.333,0.333,0.667)	(-0.500,0.500,1.000)	(-0.667,0.000,0.667)
5	(-0.333,0.333,1.000)	(-0.333,0.333,1.000)	(0.000,0.667,1.000)	(-0.500,0.500,1.000)	(-0.333,0.333,1.000)

Table 10 Fuzzy values of R, S and Q

Economic	Fuzzy R	Fuzzy S	Fuzzy Q
Supplier-1	(0.050,0.083,0.233)	(-0.483,0.146,0.917)	(0.752,0.000,0.752)
Supplier- 2	(0.000,0.167,0.350)	(-0.250,0.442,1.275)	(0.623,0.188,1.000)
Supplier- 3	(0.050,0.100,0.350)	(-0.333,0.183,0.958)	(0.710,0.031,0.910)
supplier -4	(0.000,0.167,0.350)	(-0.283,0.392,1.208)	(0.633,0.174,0.981)
Supplier -5	(0.050,0.188,0.300)	(-0.317,0.354,1.167)	(0.580,0.189,0.907)

Table 11 Fuzzy values of R, S and Q

green	Fuzzy R	Fuzzy S	Fuzzy Q
Supplier- 1	(0.033,0.150,0.350)	(0.508,0.200,1.067)	(0.698,0.072,0.892)
Supplier- 2	(0.067,0.100,0.300)	(0.475,0.183,1.042)	(0.729,0.008,0.826)
supplier -3	(0.033,0.100,0.233)	(0.508,0.150,1.008)	(0.698,0.000,0.738)
supplier -4	(0.033,0.150,0.350)	(0.442,0.383,1.283)	(0.681,0.118,0.946)
Supplier -5	(0.000,0.200,0.350)	(0.292,0.567,1.500)	(0.604,0.224,1.000)

Table 12 The crisp values S, R, Q and alternatives ranking (Economic)

Supplier	Crisp value of R	Rank in R	Crisp value of S	Rank in S	Crisp value of Q	Rank in Q
1	0.088	1	0.181	1	0	1
2	0.171	3	0.477	5	0.188	5
3	0.125	2	0.248	2	0.066	2
4	0.171	3	0.427	4	0.174	3
5	0.181	4	0.39	3	0.176	4

Table 13 The crisp values S, R, Q and alternatives ranking (Green)

Supplier	Crisp value of R	Rank in R	Crisp value of S	Rank in S	Crisp value of Q	Rank in Q
1	0.154	3	0.24	3	0.085	3
2	0.108	2	0.233	2	0.028	2
3	0.1	1	0.2	1	0.01	1
4	0.154	3	0.402	4	0.125	4
5	0.188	4	0.585	5	0.211	5

6. Conclusion

Organizational decision-making processes are crucial and supplier selection is necessary to generate competitive advantages. To achieve this, management should choose suitable supplier selection criteria and implement a successful approach. Because they create performance values that cannot be quantified, linguistic aspects are essential in the decision-making processes. By using linguistic terms to assess each factor concerning each multiplier, fuzzy set theory allows DMs' choices and experiences to be translated into positive outcomes. The evaluation and supplier selection processes are frequently vague and imprecise. First of all, it informs the reader of the different difficulties the company encounters while selecting the finest supplier in a factory that produces high-quality goods. Second, it identifies the area needed for performance implementation and provides a clearer understanding of choosing a supplier in uncertain circumstances.

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