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Research Article

Green Suppliers Performance Analysis in A Supply Chain Netwotk using Fuzzy Topsis and Fuzzy Vikor Techniques

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ABSTRACT

Green Supply Chain Management (GSCM) strives to decrease, if not eliminate, supply chain operations' negative environmental effects.Multi-criteria decision-making (MCDM) strategies should be utilized to evaluate suppliers' GSCM performance because GSCM includes multi-dimensional methods. In order to supply solutions to perplexing and demanding multi-attribute inquiries in a fuzzy environment, fuzzy group decision-making procedures must be produced. Based on integrated fuzzy MCDM methodologies, this research provides a methodology for assessing the GSCM performance of firms in terms of green design, green image, green transformation, green logistics, and green management system. The fuzzy DEMATEL technique is used to calculate the cause and effect relationships between GSCM dimensions. Based on this association, the fuzzy AHP approach is utilized to generate the weights of the relevant criterion.

Keywords: Supplier selection, Green, MCDM, supply chain, Fuzzy.

INTRODUCTION

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.

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

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:

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

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

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.

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

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:

$$A^* = \{\tilde{v}_1^*, \tilde{v}_2^*, \ldots, \tilde{v}_n^*\} = \left\{\left(\max_j v_{ij} \,|i \in B\right), \left(\min_j v_{ij} \,|i \in C\right)\right\}$$

$$A^- = \{\tilde{v}_1^-, \tilde{v}_2^-, \ldots, \tilde{v}_n^-\} = \left\{\left(\min_j v_{ij} \,|i \in B\right), \left(\max_j v_{ij} \,|i \in C\right)\right\}$$

here $\tilde{v}_i^*$ represents maximum value of i for all the alternatives and $\tilde{v}_1^-$ denotes minimum value of i for all the alternatives. B and C denote the PIS and NIS, resp.

The table below displays both the PIS & NIS.

Step 5: Analyze the distance between each alternative and the Fuzzy Positive Ideal Solutions(FPIS) $A^*$and the distance between each alternative and the Fuzzy Negative Ideal Solutions(FNIS) A^-

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

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

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

d is the distance between 2 fuzzy numbers when given 2 triangular fuzzy numbers (a_1, b_1, c_1) and (a_2, b_2, c_2), e distance between the 2 can be computed as follows:

$$d_v(\tilde{M}_1, \tilde{M}_2) = \sqrt{\frac{1}{3}[(a_1 - a_2)^2 + (b_1 - b_2)^2 + (c_1 - c_2)^2]}$$

Note that $d(\tilde{v}_{ij}, \tilde{v}_j^*)$ and $d(\tilde{v}_{ij}, \tilde{v}_j^-)$ are crisp 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 the positive ideal solution(PIS) and negative ideal solution(NIS)

There are both positive and negative ideal answers for each criterion, and they are as follows.

PIS (f ̃^*) and NIS ((f) ̃^°) can be found using the following relations if the criterion is positive:

$\tilde{f}_j^* = \underset{i}{Max}\, \tilde{f}_{ij}$ (here i ranges from 1 to n)

$\tilde{f}_j^\circ = \underset{i}{Min}\, \tilde{f}_{ij}$ (here i ranges from 1 to n)

If the criterion is negative, the relations given below can be used to get the PIS (f ̃^*) and NIS ((f) ̃^°):

$\tilde{f}_j^* = \underset{i}{Min}\, \tilde{f}_{ij}$ (here i ranges from 1 to n)

$\tilde{f}_j^\circ = \underset{i}{Max}\, \tilde{f}_{ij}$ (here i ranges 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:

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

$\tilde{d}_{ij} = (\tilde{f}_{ij} \ominus \tilde{f}_j^*)/(r_j^\circ - l_j^*)$ 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 S ̃i and R ̃i can be derived as follows once the matrix has been normalized to form the weighted normalized decision matrix:

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

$$\tilde{S}_i = \sum_{j=1}^{J} (\tilde{w}_j \otimes \tilde{d}_{ij})$$

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

Step 5: Compute the VIKOR index (Q)

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

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

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

Where,

$\tilde{s}^* = \underset{i}{min}\, \tilde{s}_i$

$s^{\circ r} = \underset{i}{max}\ s_i^r$

$\tilde{R}^* = \underset{i}{min}\, \tilde{R}_i$

$R^{\circ r} = \underset{i}{max}\ R_i^r$

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)

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

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 $A^{(1)}$ is the alternatives that are ranked Ist and $A^{(2)}$ is the alternative that is ranked 2nd in Q's ranking list. m is the 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 $A^{(1)}, A^{(2)}, \ldots, A^{(M)}$ if condition 1 is not satisfied; Alternative $A^{(M)}$ is determined by $Q(A^{(M)}) - Q(A^{(1)}) < 1/(m-1)$ for max M (the positions of these alternatives are in closeness).

2nd Solution. Alternatives $A^{(1)}$ and $A^{(2)}$ if only 2nd condition is not satisfied.

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)

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Table 5 Distance from PIS and NIS

Supplier	Distance from positive ideal (economic)	Distance from negative ideal (economic)	Distance from positive ideal (Green)	Distance from negative ideal (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	0.09

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	0.102	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.

References

[1] Zhihua Chen, Xinguo Ming, Tongtong Zhou, Yuan Chang, (2020), Sustainable supplier selection for smart supply chain considering internal and external uncertainty: An integrated rough-fuzzy approach, *Applied Soft Computing*, Volume 87, February 2020, 106004

[2] Huseyin SelcukKilic, Ahmet Selcuk Yalcin, (2020), Modified two-phase fuzzy goal programming integrated with IF-TOPSIS for green supplier selection, *Applied Soft Computing*, Volume 93, August 2020, 106371

[3] Ashkan Memari, Ahmad Dargi, Mohammad Reza, Akbari Jokar, Robiah Ahmad, (2019), Sustainable supplier selection: A multi-criteria intuitionistic fuzzy TOPSIS method, *Journal of Manufacturing Systems,* Volume 50, January 2019, Pages 9-24

[4] Jing Li, Hong Fang, WenyanSong,(2019), Sustainable supplier selection based on SSCM practices: A rough cloud TOPSIS approach, *Journal of Cleaner Production*, Volume 222, 10 June 2019, Pages 606-621

[5] Chunxia Yu, Yifan Shao, Kai Wang, Luping Zhang, (2019), A group decision-making sustainable supplier selection approach using extended TOPSIS under interval-valued Pythagorean fuzzy environment, *Expert Systems with Applications*, Volume 121, 1 May 2019, Pages 1-17

[6] Hadi Moheb Ali Zadeh, Robert Handfield, (2019), Sustainable supplier selection and order allocation: A novel multi-objective programming model with a hybrid solution approach, *Computers & Industrial Engineering*, Volume 129, March 2019, Pages 192-209

[7] Shubham Gupta, Umang Soni, Girish Kumar, (2019), Green supplier selection using multi-criterion decision making under fuzzy environment: A case study in the automotive industry, *Computers & Industrial Engineering*, Volume 136, October 2019, Pages 663-680

[8] MostafaZandieha, BabakAslanib, (2019), A hybrid MCDM approach for order distribution in a multiple-supplier supply chain: A case study, *Journal of Industrial Information Integration,* Volume 16, December 2019, 100-104

[9] M. Abdel-Baseta, Victor Changb, AbduallahGamala, FlorentinSmarandachec,(2019), An integrated neutrosophic ANP and VIKOR method for achieving sustainable supplier selection: A case study in importing field, *Computers in Industry,* 106 (2019) 94–110