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An Integrated MCDM Methodology for potential green supplier selection

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Abstract - In last decade, the market has become increasingly complex, uncertain, unpredictable, and presumable as results of turbulence demand of customize products. Decision-making upon vendor selection under multiple criteria have a significant role in industry. Supplier selection is a serious managerial verdict making problem, requires the considering of various qualitative and quantitative criteria. The present research work deals with the exploration of the multi criteria decision making-Fuzzy-Kano model, assist the authors to elect a few green vendor criteria under must be strategy in focusing on the fulfillment of customers desires. Next, in supporting the empirical case research, the SWARA technique, undertakes the weight vs criteria, is effectual implemented in a built framework under must be criteria strategy.

Key Words: Fuzzy Kano model, Green supplier, SWARA and ROV techniques.

1. Introduction :

MCDM (Multi Criteria Decision Making) has aim to find optimal choice under several (conflicting) criterion, which are to be achieved simultaneously. The characteristics of MCDM are a set of (conflicting) objectives, having non constraints. There are various benefits associated with an effective supplier evaluation process such as mitigation against poor supplier performance or performance failures. The benefits typically include sourcing from suppliers that provide high standards of product and service levels whilst offering sufficient capacity and business stability. . Supplier evaluation can help customers and suppliers identify and remove hidden cost drivers in the supply chain. The process of evaluating performance can motivate suppliers to improve their performance. In passing decades, Green supply chains (GSC) assisted business owners to increase their firm performances, get competitive advantages, obtain more profits, reduce production risks, and gain a great reputation and ethical image and cost reductions.The consideration of the following criteria such as Green service, Green recycling, Green technology, Hazardous waste elimination, Green policy, Eco-design, Green production and Green marketing amongst million criteria discussed with two rationales.In the proposed research method,the all mentioned objectives have been achived.An Mathematical model (Kano model) has been applied for categorizing the criteria as per the need of industry. The SWARA method has been applied for weight assessment of above mentioned criteria. Final supplier ranking has been done on the basis of ROV methods.

2. Literature Review :

Alptekin (2018), proposed aflexible manufacturing system which can be evaluated based on Entropy plus range of value (ROV) method. **Esra (2017)**, suggested a decision making approach based on two MCDM techniques. **Mehdi et al. (2017),** Provided a systemic review of applications of MCDM techniques for evaluation and selection of vendors in a vague environment.**Noci (1997),** Suggested a hypothetical approach to identify the measures for assessing the vendor's performance. **Krause et al. (1998),** Explored a feedback instrument based model and presented decision support system together to improve vendor performance. **Amida et al. (2006)** Built a fuzzy based multi-objective linear model to tackle the vagueness associated with the commitments of decision makers to supplier selection problem.

After conducting the various Systematic Literature Review (SLR) as depicted above. The authors focused solely on Journal comprehensive scientific literature in green supplier evaluation, where 67% literature survey dealt with evaluation of significant green supplier criteria and MCDM methods application in tackling green supplier problems. Remaining 33% focused on non-green supplier evaluation, specifically targeted to MCDM methods i.e. APH, DEA, SWARA, ROV and TOPSIS. It is found via all comprehensive Systematic Literature Review (SLR), the utility of SWARA with ROV is great as compare to other MCDM methods in last decade due to essay computation and understandability by researchers and effective results delivery.

3. Fuzzy Kano Method :

Fuzzy Kano is conceptually easy to understand. The mathematical concepts behind fuzzy reasoning are very simple. Customer satisfaction level has received the prime importance from each manufacturing sectors in present era. The investigation against the customer satisfaction is importance aspects for the professional of industry. From this perspective, Professor Noriaki Kano has proposed a KANO model in 1980s in order to classify or select the category of criteria based on the customer preferences. The KANO model chooses the criteria, considering categories have been discussed here Kersuliene and Turskis (2011).

$$\text{Kano}=\begin{bmatrix} Q & A & A & A & O \\ R & I & I & I & M \\ R & I & I & I & M \\ R & I & I & I & M \\ R & R & R & R & Q \end{bmatrix} \quad (1)$$

4. SWARA Method :

After passing through a few of relevant literature survey in the context of KANO and green supplier election, it is noted that the authors have recognized the supplier selection as a MCDM problem involving subjective and objective criteria. After identification of significant criteria weight assignment presents for Challenge to decision makers. The SWARA method has been found well for weight assignment because of the reason (i) SWARA involves less complex and fast mathematical calculation in comparison to other MCDM method. (ii) The results of SWARA methods are easy to interpret. Steps of SWARA methods are below:

Step1: Arrangement of criteria in descending order of their expected significances.

Step2: Calculate Comparative importance of average value, S_j. starting from second criterion, for each criterion, the respondent expresses its relative importance with respect to previous criterion Zolfani et al. (2015), Kersuliene et al. (2017).

Step3: Establish coefficient K_j as

$$K_j = 1 \quad \text{if} \quad j = 1 \quad (2)$$

$$K_j = S_j + 1 \quad \text{if} \quad j > 1 \quad (3)$$

Step4:Establish recalculated weight Q_j as

$$Q_j = 1 \quad \text{if} \quad j = 1 \quad (4)$$

$$Q_j = \frac{K_{j-1}}{K_j} \quad \text{if} \quad j > 1 \quad (5)$$

Step5: Assign relative weights of the evaluation criteria W_j

$$W_j = \frac{Q_j}{\sum_{k=1}^{n} Q_k} \quad (6)$$

5. ROV Method :

Many multi criteria decision making have been developed by previous author to assist the expert panels in assessing the quality of suppliers against considered criteria. These techniques deal with a Range of Values (ROV) for assigning the preference orders agaisnt candidate green suppliers. This technique was proposed by M. M. C and M. R. C (2015). The procedure of the application of this method is simple and steps involved:

Step1: Establish criteria for evaluating alternatives.

Step2: Establish a decision matrix.

$$\text{D matrix}= [X_{ij}] = \begin{array}{c|cccccc} & C_1 & C_2 & - & - & C_n \\ \hline A_1 & x_{11} & x_{12} & - & - & x_{1n} \\ A_2 & x_{21} & x_{22} & - & - & x_{2n} \\ - & - & - & - & - & - \\ A_n & x_{m1} & x_{m2} & - & - & x_{mn} \end{array} \quad (7)$$

Where

S_i denotes the alternatives i, i=1…..m.

C_j denotes the j[th] criterion, j=1…….n related to i[th] alternative. X_{ij} is the numerical value indicating the performance rating of each criterion A_i with respect to each criterion C_j.

Step3: Establish a Normalized decision matrix. In this step performance measure of alternatives are normalized (Xij) and normalized decision matrix is established.

$$[\overline{X_{IJ}}] = \begin{bmatrix} \overline{X_{11}} & \overline{X_{12}} & - & - & \overline{X_{1n}} \\ \overline{X_{21}} & \overline{X_{22}} & - & - & \overline{X_{2n}} \\ - & - & - & - & - \\ - & - & - & - & - \\ \overline{X_{m1}} & \overline{X_{m2}} & - & - & \overline{X_{mn}} \end{bmatrix} \quad (8)$$

Normalization of performance measure (criteria) depends whether it's a beneficial criteria or non-beneficial criteria. For beneficial criteria, maximum values are preferred and for non-beneficial criteria minimum values are preferred.

(i) For beneficial criteria maximum values are preferred and normalization is done by applying linear transformation.

$$x_{ij} = \frac{x_{ij} - max_{i=1}^{m}(x_{ij})}{max_{i=1}^{m}(x_{ij}) - min_{i=1}^{m}(x_{ij})} \quad (9)$$

(ii) For non-beneficial criteria minimum values are preferred and normalization is done by applying linear transformation

$$x_{ij} = \frac{max_{i=1}^{m}(x_{ij}) - x_{ij}}{max_{i=1}^{m}(x_{ij}) - min_{i=1}^{m}(x_{ij})} \quad (10)$$

Step4: Performed for each alternative. It is achieved by maximization or minimization of a utility function. For linear additive model, for each alternative best utility (ui+) and worst utility (u_i^-) are calculated with help of following equations

Maximize:

$$U_i^+ = \sum_{j=1}^{n} \overline{X_{ij}} \quad W_j \qquad (11)$$

Minimize:

$$U_i^+ = \sum_{j=1}^{n} \overline{X_{ij}} \quad W_j \qquad (12)$$

Where W_j (j=1,.....,n) are weights of criteria which satisfy $\sum_{j=1}^{n} W_j = 1$ and $W_j \geq 0$

If $U_i^+ < U_i^-$ then alternative 'i' outperforms alternatives 'i' regardless of the actual quantitative weights. If alternatives are not comparable using this rule then scoring can be attained from the midpoint.

$$U_i = \frac{U_i^+ + U_i^-}{2} \qquad (13)$$

Step5: In final step of method, on the basis of u_i complete ordinal ranking of alternatives are obtained. Alternative having highest u_i value is considered as best and awarded first rank and alternative having lowest u_i value is considered as worst choice and is ranked last.

6. Proposed Methodology :

This section considers the real case of a Colony Developer Company **'Earth Work Construction.'** situated in the Satna,MP, India; desire to place an order of brick to green supplier firms, concerning the global green issues as per various rule and regulations imposed by the government.

The selection of best red brick supplier is subjected to the consideration of the green supply chain

Criteria (C_i)	Comparat -ve	Coefficiet	Recalculatd	Weights
Green service (C_1)	0	1.00	1.000	0.226
Green marketing (C_2)	0.123	1.123	0.890	0.201
Green recycling (C_3)	0.156	1.156	0.770	0.174
Hazardous waste elimination (C_4)	0.125	1.125	0.685	0.155
Green technology (C_5)	0.125	1.125	0.609	0.137
Eco design (C_6)	0.278	1.278	0.476	0.107

criteria against material procurement company **Earth Work Construction.** Preliminary **Earth Work Construction.** Conducted the brainstorming session and at last looked for five green supplier alternative

S_i	(C_1)	(C_2)	(C_3)	(C_4)	(C_5)	(C_6)
S_1	0.500	0.500	0.000	1.000	0.500	0.500
S_2	0.750	0.750	0.333	0.000	0.750	0.000
S_3	0.250	0.250	1.000	0.667	1.000	0.000
S_4	1.000	0.000	0.500	0.333	0.250	0.000
S_5	0.000	1.000	0.333	0.667	0.000	1.000

industries S_1, S_2, S_3, S_4 and S_5. The proposed methodology consists of:

Step 1: Gathering information.Step 2: Evaluation and ranking of criteria.

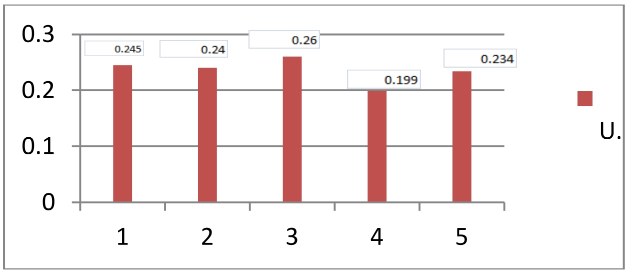
Step3: The list of research questions and computation of weights and ratings.

Step 4: Normalization of weights:.

Step 5: Benchmarking of brick green suppliers

7. RESULT & CONCLUSIONS :

In this Research we have determined the ranking of criterion by applying the fuzzy KANO model. The database in assigning the preference orders against criteria are determined by expert panel of a brick manufacturing company. Next, these criteria were ranked as per orders such as Green service (C_1), Green marketing (C_2),Green recycling (C_3), Hazardous waste elimination (C_4), Green technology (C_5), Eco design (C_6). We have applied KANO model in selecting the green supplier. KANO model accomplished the goal of supplier selection criteria for Brick Company. In this thesis we have applied SWARA method in order to compute the weight against the criterion. Next, a ROV method is applied fruitfully based on rating assign by experts to compute the preference orders of green suppliers. The ranking of brick green supplier by ROV is shown by bar charts Fig.



The result of SWARA Method calculation is shown in table1.

The Normalised matrix for Rov Method calculation is shown in table 2.

The final rank of supplier according to Rov method shown in table 3.

Table 1. The result of SWARA Method

Table 2. The Normalised matrix for Rov Method

Table 3. Final Result (Rank of supplier)

S_i	u^+	u^-	u_i	Preference orders
S_1	0.4905	0.000	0.245	2
S_2	0.4809	0.000	0.240	3
S_3	0.5211	0.000	0.260	1
S_4	0.3989	0.000	0.199	5
S_5	0.4693	0.000	0.234	4

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