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RANKING OF SUPPLIER ALTERNATIVES USING GREY RELATIONAL ANALYSIS METHOD

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Abstract:

In recent years, a number of firms have realized the potential of supply chain management (SCM). Supplier selection is an important strategic decision in SCM. In order to evaluate the overall performance of the supplier alternatives and to select the best supplier, Multiple Criteria Decision Making (MCDM) technique can be used effectively. In this paper, various supplier alternatives are considered for evaluation on the basis of conflicting criteria. The weight for each attribute is calculated by Analytical Hierarchy Process (AHP) and the same weights are then used in MADM method presented in this paper. These supplier alternatives are evaluated on the basis of criteria using Grey Relational Analysis Method (GRA).

Keywords: Supplier Selection, MCDM, AHP, GRA

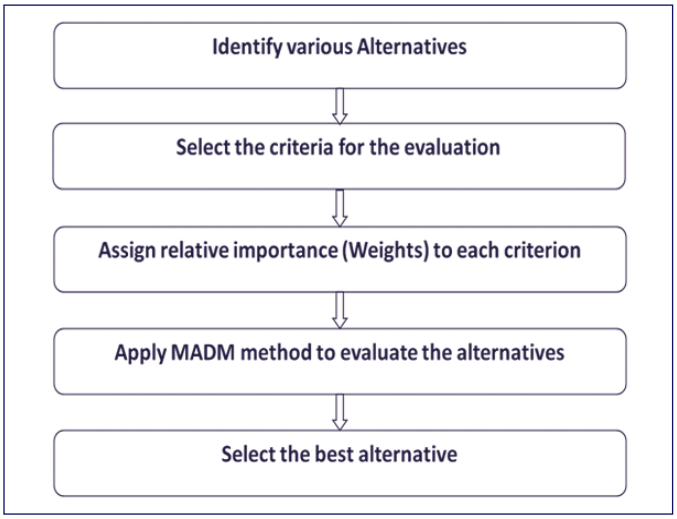
1. INTRODUCTION

In recent years, a number of firms have realised the potential of supply chain management (SCM) in day-to-day operations management. The manufacturing enterprise focuses on core business activities, and out-sources non-core business activities to outside suppliers and other service providers. It encourages both the manufacturers and suppliers' competitive ability, and enhances their mutual dependency in order to achieve mutual success. Many manufacturing and service organisations have used performance measures and measurement systems to evaluate the performance of the supplier performance. Supplier selection is an important strategic decision in SCM. Many criteria, either quantitative or qualitative, have been proposed, such as quality, productive capability, price, delivery, industry position, financial stability, performance history, reputation, location, reliability, responsiveness, safety, customer responsiveness, relationship closeness, etc to evaluate the supplier's performance. Nevertheless, the studies presented by Shipley [1]; Ellram [2]; Pi and Low [3] suggested that product quality, price and delivery time are the most important ones. In order to evaluate the overall performance of the supplier alternatives and to select the best supplier, MADM technique is to be used. MADM is the technique of finding the best option from all of the feasible alternatives. The supplier selection can be considered as a complex multi-attribute decision problem. In this paper, various supplier alternatives are considered for evaluation on the basis of conflicting criteria. The weight for each attribute is calculated by Analytical Hierarchy Process (AHP) and the same weights are then used in MCDM method presented in this paper. These supplier alternatives are evaluated on the basis of criteria using Grey Relational Analysis Method (GRA).

2. METHODOLOGY

The methodology [Fig. 1] used in this paper is discussed in this section. Firstly the different suppliers for tool inserts are identified for cutting tool for particular application. After identification of suppliers, different criteria affecting the selection of suppliers of inserts are identified. The weights of each criterion are determined by AHP method. By using the weights, a decision matrix is formed. This decision matrix [Table1] is then used for selection of appropriate selection of supplier.

Fig.1. Methodology



In Multiple Criteria Decision Making (MCDM) method, the decision table (also called decision matrix) has four main parts, namely: (a) alternatives (b) attributes (c) weight or relative importance of each attribute, and (d) measures of performance of alternatives with respect to the attributes. The decision matrix is shown in Table 1. It shows alternatives, Ai (for i = 1, 2,….., n), attributes, Bj (for j = 1, 2,….., m), weights of attributes, wj (for j=1, 2,….., m) and the measures of performance of alternatives, yij (for i= 1, 2,….., n; j=1, 2,….., m). It may be added here that all the elements in the decision table must be normalized to the same units so that all the possible attributes in the decision problem can be considered.

Table 1. Decision Matrix in MCDM methods [4]

Alternatives (A_i)	Criteria				
	B_1	B_2	B_3	---	B_m
	(w_1)	(w_2)	(w_3)	---	(w_m)
A_1	y_{11}	y_{12}	y_{13}	---	y_{1m}
A_2	y_{21}	y_{22}	y_{23}	---	y_{2m}
A_3	y_{31}	y_{32}	y_{33}	---	y_{3m}
-	-	-	-	---	-
A_n	y_{n1}	y_{n2}	y_{n3}	---	y_{nm}

3. GREY RELATIONAL ANALYSIS (GRA):

The grey system theory is proposed by Deng [5].GRA solves MCDM problems by combining the entire range of performance attribute values being considered for every alternative into one, single value. This reduces the original problem to a single attribute decision making problem. Therefore, alternatives with multiple attributes can be compared easily after the GRA process. The procedure of grey relational analysis is given below;

Step 1: Grey Relational Generating

When the units in which performance is measured are different for different attributes, the influence of some attributes may be neglected. Therefore, processing all performance values for every alternative into comparability sequence, in a process analogous to normalization, is necessary. This processing is called grey relational generating in GRA.

For MCDM problem, the i^{th} alternative can be expressed as $A_i = (y_{i1}, y_{i2}, y_{i3,...}, y_{ij,...} y_{im})$ where y_{ij} is the performance value of attribute j of alternative i. The term y_i can be translated into the comparability sequence $X_i = (x_{i1}, x_{i2}, x_{i3,...}, x_{ij,...}, x_{im.})$ by Eq. (1) and Eq. (2).

$$x_{ij} = \frac{y_{ij} - Min\{y_{ij}, i=1,2,...,n\}}{Max\{y_{ij}, i=1,2,...,n\} - Min\{y_{ij}, i=1,2,...,n\}} \quad (1)$$

$$x_{ij} = \frac{Max\{y_{ij}, i=1,2,....,n\} - y_{ij}}{Max\{y_{ij}, i=1,2,...,n\} - Min\{y_{ij}, i=1,2,...,n\}} \quad (2)$$

Eq. (1) is used for larger-the-better attributes and Eq. (2) for the smaller- the better attributes.

Step 2: Reference sequence definition

After the grey relational generating procedure, all the performance values are scaled into [0,1] An alternative will be the best choice if all of its performance values are closest to or equal to 1,however, such type of alternative may not exist. The reference sequence X_o is to be defined as $(x_{o1}, x_{o2}, x_{o3,...}, x_{oj,...}, x_{om.}) = (1, 1,\ldots,1,\ldots,1)$, and then aims to find the alternative whose comparability sequence is the closest to reference sequence.

Step 3: Grey relational coefficient calculation

Grey relational coefficient is used for determining how close x_{ij} and x_{oj}. The larger the grey relational coefficient, the closer x_{ij} and x_{oj} are. The grey relational coefficients can be calculated by Eq. (3).

$$\gamma(x_{0j}, x_{ij}) = \frac{\Delta_{min} + \zeta \Delta_{max}}{\Delta_{ij} + \zeta \Delta_{max}} \quad (3)$$

Where $\gamma(x_{oj}, x_{ij})$ *is the* grey relational coefficient between x_{oj} *and* x_{ij}, *and*

$$\Delta_{ij} = |x_{oj} - x_{ij}|$$

$\Delta_{min} = Min\{\Delta_{ij}, i = 1, 2,\ldots, n; j = 1,2,\ldots,m\}$,

$\Delta_{max} = Max\{\Delta_{ij}, i = 1, 2,\ldots, n; j = 1,2,\ldots,m\}$,

ζ is the distinguishing coefficient, $\zeta \in [0,1]$.

The distinguishing coefficient can be taken by the decision maker exercising judgment. The rank order of alternative remains always same though the different coefficients are adopted [6]. After grey relational generating, Δ_{max} will be equal to 1 and Δ_{min} will be equal to 0. In this paper, the distinguishing coefficient is set as 0.5.

Step 4: Grey relational grade calculation

After calculating the entire grey relational coefficient $\gamma(x_{oj}, x_{ij})$, grey relational grade is calculated using Eq. (4).

$$\Gamma(X_O, X_i) = \sum_{j=1}^{m} w_j \gamma(x_{oj}, x_{ij}) \quad for\ i = 1,2,...,n \quad (4)$$

$\Gamma(X_o, X_i)$ is the grey relational grade between X_o and X_i. It represents the level of correlation between the reference sequence and the comparability sequence. The grey relational grade indicates the degree of similarity between the reference sequence and the comparability sequence. If the comparability sequence for an alternative gets the highest grey relational grade with the reference sequence, it means that the comparability sequence is most similar to the reference sequence, and that alternative would be the best choice.

4. CASE STUDY

Now to demonstrate the above mentioned decision-making approach an example of selection of supplier is presented. The example considered in this work is of the supplier of tool insert to the tool manufacturing company. In this work, four suppliers (S1, S2, S3 and S4) are evaluated on the criteria [B1: Cost: Non-beneficial attribute: Minimum desirable, B2: Delivery time: Non-beneficial attribute: Minimum desirable, B3: Payment terms: Beneficial attribute: Maximum desirable and B4: Quality: Beneficial attribute: Maximum desirable]. The decision matrix with the measures of performance of alternatives, y_{ij} values are shown in Table 2. In this study, four attributes/criteria for four supplier alternative are investigated and criteria for selection are described below:

- **Cost (Rs.)**: The net price per part offered by each supplier. It is quantitative criteria.
- **Delivery Time (Days)**: The ability of each supplier to meet

specified delivery of the product on time. It is quantitative criteria and express delivery scheduled in days.

- **Payment terms**: Financial Stability and Credit Strength: It is the financial stability of each supplier and credit offer by each supplier. It is qualitative criteria and express in terms of five point scale.
- **Product Quality**: The supplier's ability to provide quality product and to solve the quality problem detected by company audit. It is qualitative criteria and express in terms of five point scale.

Table 2. Decision Matrix

Alternative	Criteria			
	Cost (Rs)	Delivery time (Days)	Payment terms (Grade)	Quality (Grade)
	0.359	**0.099**	**0.059**	**0.483**
A1:Supplier1	800	2	4	3
A2:Supplier2	950	3	3	4
A3:Supplier3	1080	2	4	3
A4:Supplier4	1580	1	5	4

Grey Relational Analysis (GRA)

Step 1: Grey Relational Generating: The main purpose of grey relational generating is to transfer the original data into comparability sequence. The results of grey relational generating using Eq. (1) and Eq. (2) are shown in Table 3.

Table 3. The grey relational generating (Xij)

Alternative. no.	Criteria			
	Cost (Rs)	Delivery time (Days)	Payment terms (Grade)	Quality (Grade)
	0.359	**0.099**	**0.059**	**0.483**
A1	1	0.5	0.5	0
A2	0.808	0	0	1
A3	0.641	0.5	0.5	0
A4	0	1	1	1

Step 2: Reference sequence definition: After the grey relational generating procedure, all the performance values are scaled into [0, 1].

Step 3: Grey relational coefficient calculation: The grey relational coefficients between x_{oj} *and* x_{ij}, γ $(x_{oj,}\ x_{ij})$ are calculated using Eq.(3) are shown in Table 4.

Step 4: Grey relational grade calculation: The grey relational grade (Γ) between X_o and X_i, (X_o, X_i) using Eq. (4) is shown in Table 4.

Table 4. The grey relational coefficient[γ] and grey relational grade [Γ]

Alternative. no.	Criteria				Grey Relational Grade [Γ]	Rank
	Cost (Rs)	Delivery time (Days)	Payment terms (Grade)	Quality (Grade)		
	0.359	**0.099**	**0.059**	**0.483**		
	Grey relational coefficient[γ]					
A1	1.000	0.500	0.500	0.483	0.599	3
A2	0.722	0.333	0.333	0.333	0.795	1
A3	0.582	0.500	0.500	1.000	0.449	4
A4	0.333	1.000	1.000	0.333	0.760	2

5. RESULT AND CONCLUSION

The result of MCDM approach applied to the selection of supplier of tool inserts for cutting tool for a particular application is shown in Table 4. The ranking suggested by GRA method is A2 – A4 – A1 – A3. From the Table 4, it is understood that alternative 2 i.e. Supplier 2 is the most preferred choice among the four alternatives.

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