Entropy Weight Based Multi-Objective Optimization On The Basis Of Ratio Analysis (MOORA) Model For Supplier Selection In Supply Chain Management.

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Abstract: The effective supplier selection and evaluation processes are of vital importance in a manufacturing organization or business organizations, making the suppliers selection problem a fundamental key issue to their success. In this study, a supplier selection problem is solved in a manufacturing industry and the best supplier selection is the aimed among 10 suppliers. . Firstly, the criteria of supplier selection are mentioned with the help of literature survey. Then weights of the criteria's is solved by using entropy weight method and the suppliers are chosen by using multi-objective optimization on the basis of ratio analysis (MOORA).

Keywords *:* Entropy Weight, Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA), Supplier Selection, Supply Chain Management.

1. INTRODUCTION

In today's manufacturing scenario, the decision-making process is more difficult due to various interests and values of different decision makers. There is a need for simple, systematic and logical procedure to solve decision-making problems effectively. The MOORA method is one of the Multi-Criteria Decision-Making (MCDM) methods which use statistical procedure for the selection of the best alternative from the given alternatives. This method generates most suitable alternatives by considering both beneficial (maximization) and non-beneficial (minimization) alternatives and eliminates unsuitable alternatives for strengthening the existing selection procedure. The MOORA method involves lesser computations, comprehensiveness and robustness which can solve multiple numbers of criteria. simultaneously [1]. In the solution of multi-objective optimization, the relative importance of each criterion can be calculated using the entropy measurement concept. In information theory, entropy is a measure of how disorganized a system is. While applying the entropy concept for weight measurement, it is evident that an attribute having high entropy has a high diversity of output parameters. This attribute has a significant effect on the output parameter [2].

2. LITERATURE REVIEW

Supplier selection is an important step of the supply chain process in an industry or a business organization. A number of factors are to be considered while doing the supplier selection. Some of the important criteria under which the supplier selection is done are cost, delivery , business performance, quality, risk, and information technology [3].

DELIVERY : The material cost takes a large proportion in the manufacturing of a product. It comprises around 70% in common goods & reaches up to 80% in high-tech products[4].

Material cost is not the only concern for an enterprise but vendor selection also needs to be considered as one of the core competencies of an industry[5].

COST : It includes the cost per item and the fee associated with the cancellations and modifications after placement.

BUSINESS PERFORMANCE: It defines the financial performance and the compatibility of strategic plans of the suppliers with the buyer's long term plans.

QUALITY: It defines the rate of defective items among the shipped ones and the reaction time of the suppliers to correct the defects and other supply related issues.

RISK: It includes the risk due to the supply disruption.

INFORMATION TECHNOLOGY: Iit defines the availability of online ordering and online tracking.

3. METHODS FOR SUPPLIER SELECTION

The paper intents to provide a group decision making system to show the performance of MCDM tools. The algorithms for two methods can be presented here;

3.1 ENTROPY WEIGHT METHOD

The Entropy weight measurement method determines the weight of each individual response parameters without any consideration of the decision of the decision maker. The basic concept of entropy weight measurement is that higher weight index value is more useful than smaller index value. In this paper, the following steps are used to evaluate the weight index of each response [6].

Step-I: Construction of a decision matrix (X). A set of alternatives (A= {Ai, i = 1, 2…., n}) is to be compared to with respect to a set of criteria (C= {Cj, j =1, 2…., m}). Therefore, an n×m performance matrix (the decision matrix; X) can be obtained as:

$$X = \begin{bmatrix} x_{12} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \quad (1)$$

Where x_{ij} is a crisp value indicating the performance rating of each alternative A_i with regard to each criterion C_j.

Step II: To ascertain objective weights by the entropy measure, the decision matrix in Eq. (1) needs to be normalized for each criterion Cj (j= 1,2….m)

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (2)$$

The Normalized decision matrix is obtained as a result of the process.

$$P = \begin{bmatrix} p_{12} & p_{12} & \dots & p_{1n} \\ p_{21} & p_{22} & \dots & p_{2n} \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots \\ p_{m1} & p_{m2} & \dots & p_{mn} \end{bmatrix} \quad (3)$$

Step III: Calculate the entropy measure of every index using the following equation:

$$e_j = -k \sum_{i=1}^{m} p_{ij} . \ln p_{ij} \quad (4)$$

where $k = \frac{1}{\ln(n)}$ is a constant which guarantees 0 < ej < 1.

Step IV: The degree of divergence (dj) of the average intrinsic information contained by each criterion Cj (j = 1, 2…., m) can be calculated as:

$$d_j = 1 - e_j \quad (5)$$

Step V: The objective weight for each criterion Cj (j = 1, 2…., m) is thus given by:

$$w_j = \frac{1 - e_j}{\sum_{j=1}^{n} 1 - e_j} \quad (6)$$

3.2 MOORA Method

MOORA, developed by, is a MCDM method consisting of two phases, namely, the reference point approach and the ratio system approach, and allows measuring both beneficial and non-beneficial criteria in a process of selecting an alternative from a set of alternatives.

The MOORA method, first used by Brauers, is relatively new multi-criteria decision making method. The method based on ratio system and dimensionless measurement [7].

MOORA method is composed of five major steps:
Step I: Creating the decision matrix.

$$X = \begin{bmatrix} x_{12} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \quad (1)$$

where xij is the performance measure of ith alternative on jth criteria, m is the number of alternatives, and n is the number of criteria.

Step II: Normalization procedure

MOORA refers to a ratio system in which each response of an alternative on criteria is compared to a denominator, which is representative for all alternatives concerning that objective. This ratio can be expressed as below:

$$x_{ij}^* = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad (7)$$

where x_{ij}^* is a dimensionless number which belongs to the interval [0, 1] representing the normalized performance of ith alternative on jth criteria.

Step III: For multi-objective optimization

These normalized performances are added in case of maximization (for beneficial attributes) and subtracted in case of minimization (for non-beneficial attributes). Then the optimization problem becomes:

$$y_i = \sum_{j=1}^{g} x_{ij}^* - \sum_{j=g+1}^{n} x_{ij}^* \quad (8)$$

Where g is the number of attributes to be maximized, (n−g) is the number of attributes to be minimized, and y_i is the normalized assessment value of i^{th} alternative with respect to all the attributes. In some cases, it is often observed that some attributes are more important than the others. In order to give more importance to an attribute, it could be multiplied with its corresponding weight.

Step IV: Determine the weighted assessmentlue

Generally, it is often observed that some decision criteria are more important than the others. In order to increase priority of criteria, it could be multiplied with its weight. When these criteria weights are taken into consideration, becomes as follows:

$$y_i = \sum_{j=1}^{g} w_j . x_{ij}^* - \sum_{j=g+1}^{n} w_j . x_{ij}^* \quad (9)$$

where wj is the priority of jth criteria, which can be assigned using different multi-criteria decision making method.

Step V: Ranking of alternatives.

Decision alternatives should be ranked the preference order according to decreasing values of yi*. Assessment value can be positive or negative depending of criteria situation and priority values.

4. ILLUSTRATIVE EXAMPLES

This paper examines a numerical example which is related to the selection of the best supplier for a manufacturing industry. The weights of decision criteria are calculated with the help of Entropy Weight Method. Among four criteria, C2 is a cost criteria and rest of three factors C1, C3 and C4 are as benefit indicators. Table 1 shows the data and details for supplier selection decision problem including alternative information. Then further the selection of supplier is performed by Multi-Objective Optimization on the Basis of Ratio Analysis (MOORA) method.

Table 1. Initial Data

	C1	C2	C3	C4
A1	75	120	5	80
A2	88	212	4	74
A3	68	225	6	84
A4	56	180	5	66
A5	66	230	7	58
A6	81	130	3	94
A7	94	275	2	54
A8	86	195	3	62
A9	71	315	5	43
A10	79	380	9	87

Table 2. Normalized Matrix with Weight

	C1	C2	C3	C4
A1	0.0982	0.0531	0.1020	0.1140
A2	0.1152	0.0937	0.0816	0.1054
A3	0.0890	0.0995	0.1224	0.1197
A4	0.0733	0.0796	0.1020	0.0940
A5	0.0864	0.1017	0.1429	0.0826
A6	0.1060	0.0575	0.0612	0.1339
A7	0.1230	0.1216	0.0408	0.0769
A8	0.1126	0.0862	0.0612	0.0883
A9	0.0929	0.1393	0.1020	0.0613
A10	0.1034	0.1680	0.1837	0.1239
$\sum_{i=1}^{n}(p_{ij}.lnp_{ij})$	-2.292	-2.246	-2.222	-2.277
k	-0.4343	-0.4343	-0.4343	-0.4343
$\mathbf{e_j}$	0.9955	0.9758	0.9651	0.9892
$\mathbf{d_j = 1 - e_j}$	0.0045	0.0242	0.0349	0.0108
$w_j = \frac{1 - e_j}{\sum_{j=i}^{n} 1 - e_j}$	0.0605	0.3250	0.4694	0.1451

Implementation of MOORA Method for Supplier Selection

Table 3. Normalization Data

	C1	C2	C3	C4
A1	0.3073	0.1590	0.2993	0.3520
A2	0.3606	0.2809	0.2395	0.3256
A3	0.2786	0.2982	0.3592	0.3696
A4	0.2295	0.2385	0.2993	0.2904
A5	0.2704	0.3048	0.4191	0.2552
A6	0.3319	0.1723	0.1796	0.4135
A7	0.3852	0.3644	0.1197	0.2376
A8	0.3524	0.2584	0.1796	0.2728
A9	0.2909	0.4174	0.2993	0.1892
A10	0.3237	0.5036	0.5388	0.3828

Table 4. Weight Matrix

	C1	C2	C3	C4
A1	0.0186	0.0517	0.1405	0.0511
A2	0.0218	0.0913	0.1124	0.0472
A3	0.0169	0.0969	0.1686	0.0536
A4	0.0139	0.0775	0.1405	0.0421
A5	0.0164	0.0991	0.1967	0.0370
A6	0.0201	0.0560	0.0843	0.0600
A7	0.0233	0.1184	0.0562	0.0345
A8	0.0213	0.0840	0.0843	0.0396
A9	0.0176	0.1357	0.1405	0.0275
A10	0.0196	0.1637	0.2529	0.0556

Table 5. Max-Min Data with Ranking

	Maximum	Minimum	Y = (Max-Min)	Rank
A1	0.2102	0.0517	0.1585	2
A2	0.1815	0.0913	0.0902	7
A3	0.2391	0.0969	0.1422	4
A4	0.1965	0.0775	0.1190	5
A5	0.2501	0.0991	0.1510	3
A6	0.1644	0.0560	0.1084	6
A7	0.1140	0.1184	-0.0044	10
A8	0.1452	0.0840	0.0612	8
A9	0.1856	0.1357	0.0499	9
A10	0.3280	0.1637	0.1644	1

5. CONCLUSION

In the present work the application of MOORA method with entropy weight method is applied for solving multiple criteria (objective) optimization problem in supplier selection. The illustrative example is considered to demonstrate the application of this method. As this method is based on entropy weight and simple ratio analysis, it involves the least amount of mathematical calculations, which may be quite useful and helpful to the decision makers who may not have a strong background in mathematics. Also, the computation time of the MOORA method would obviously be less. In all the cases, it is observed that the top ranked alternatives exactly match with those derived by the past researchers which prove the applicability, potentiality, and flexibility of this method.

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