IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

DECISION MAKING FOR SUPPLIER SELECTION FOR CREATING A SUSTAINABLE SUPPLY CHAIN USING INTEGRATED ROV AND AHP METHODS

[1]Dharmendra Kumar, [2]Priti Kathoria, [3]Josy George

[1,2,3]Assistant Professor

[1,2]Department of Mechanical Engineering, Lakshmi Narain College of Technology & Science, Bhopal (M.P), India

[3]Department of Mechanical Engineering, Lakshmi Narain College of Technology, Bhopal (M.P), India

Abstract: In recent years, the procurement team operates the function of supplier selection and evaluation through various processes to improve supply chain activities. As we know that the decision-making for such problems is always a complicated task for the decision-maker and for solving these kinds of problems there are numbers of multiple criteria decisions making (MCDM) methods are available. For an effective supplier selection process, the decision-maker always has a set of criteria for selecting the best among the number of alternatives. In the chapter, the most suitable supplier will be selected using the Analytic Hierarchy Process based on the Range of Value (ROV) method. The objective weights of the criteria will be obtained by the AHP method and alternatives will be ranked by the ROV method. To understand the method an example is illustrated with ten different alternatives that are ranked concerning their performance by using these AHP and ROV methods.

***Index Terms* - Analytic Hierarchy Process (AHP), Multiple Criteria Decisions Making (MCDM) Range of Value (ROV), Supplier Selection, Supply Chain Management.**

I. INTRODUCTION

The supplier selection process is one of the most significant variables, which has a direct impact on the performance of an organization. As the organization becomes more and more dependent on their suppliers, the direct and indirect consequences of poor decision making will become more critical. The nature of this decision is usually complex and unstructured. In the present scenario of the pandemic period, supplier selection is a key strategic decision in the supply chain of any manufacturing firm as the limitation of resources. The decision-makers in earlier days primarily considered price as a major factor while selecting a supplier because their main priority was cost reduction. But in the present days, the firms need to direct their attention towards the simultaneous consideration of supplier' quality, price, customer service, capability, and other criteria to achieve a competitive advantage in the market. As the manufacturers have to purchase raw material from the suppliers, they are the customers and their satisfaction is the prime consideration. Therefore, the need for supplier selection stems from the need to increase customer satisfaction. [1] For supplier selection problem nowadays multi-criteria decision-making analysis is rapidly increasing, especially during the past several years, and therefore, many problems are being solved in the area of manufacturing, transportation, and logistics, electronic industry, etc. There is a great number of methods belonging to the area of multi-criteria decision making, and the most often used, at least when dealing with supplier selections, are the AHP and ROV methods, which are used in this paper for evaluation of supplier.

II. RESEARCH METHODOLOGY

As already mentioned, MCDM methods have been adopted by different researchers and applied in a wide variety of areas. In recent years, various MCDM tools find their applications in the manufacturing, transportation, and logistics, and electronic industry to evaluate the overall supplier performances. Lots of researchers also adopted and applied different MCDM techniques for the decision making and selection purposes of supplier for various field. In this paper an attempt has been made to investigate the applicability of an almost unexplored MCDM method, i.e., range of value (ROV) method for solving the supplier selection problems integrated with analytic hierarchy process (AHP).

2.1 ANALYTIC HIERARCHY PROCESS (AHP) METHOD

AHP is "a theory of measurement through pairwise comparisons and relies on the judgments of experts to derive priority scales". [2] It is one of the more popular methods of MCDM and has many advantages, as well as disadvantages. One of its advantages is its ease of use. Its use of pairwise comparisons can allow decision-makers to weight coefficients and compare alternatives with relative ease. It is scalable, and can easily adjust in size to accommodate decision-making problems due to its hierarchical structure. Analytic hierarchy process (AHP) was developed in the 1970s by Thomas Saaty is a highly outstanding management tool for complex multi-criteria decision problems. The approach can be used to help decision-makers for prioritizing alternatives and determining the optimal alternative using pair-wise comparison judgments. Weighting the criteria by multiple experts avoids bias decision making and provides impartiality. In this paper, we have used the following steps of AHP [2] to help us to measure the relative importance or the weighted values of several criteria. Then the importance of the second factor concerning the first is reciprocal. Ratio scale and the use of verbal comparisons are used for weighting of quantifiable and non-quantifiable elements.

Table 1. Intensity of Importance

Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one element over another
5	Strong importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another, its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation
2,4,6 and 8 can be used to express the intermediate value		

The steps to follow in AHP Method:

- Define the problem and determine the objective.
- Structure the hierarchy from the top through the intermediate levels to the lowest level.
- Construct a set of pair-wise comparison matrices for each of the lower levels. The numerical value for the element depends on Saaty Nine Point Scale shown in Table 1. There is n (n-1) / 2 judgments required to develop the set of matrices.
- Having done all the pair-wise comparisons and entered the data, the consistency is determined using the Eigen value.
- To do so, normalize the column of numbers by dividing each entry by the sum of all entries. Then sum each row of the normalized values and take the average. This provides Principal Vector [PV].
- Find the consistency Index, CI, as follows:
- $CI = (\lambda_{max} - n)/(n-1)$ Where n is the matrix size

Judgment consistency can be checked by taking the consistency ratio (CR) of CI with the appropriate value in Table 2. The CR is acceptable, if it does not exceed 0.10. If it is more, the judgment matrix is inconsistent. To obtain a consistent matrix, judgments should be reviewed and improved.

Table No. 2 Random Index Table

N	1	2	3	4	5	6	7	8	9	10
RCI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.51

2.2 RANGE OF VALUE (ROV) METHOD

The range of value (ROV) method used for alternatives ranking. [3] This method requires only the ordinal specification of criteria importance from a decision-maker. Thus, in situations where decision-makers are facing problems in supplying quantitative weights, the application of the ROV method can be particularly useful. [4]

The application of any MCDM method for solving a decision-making problem usually involves the three main steps, i.e. i) determination of the relevant conflicting criteria and feasible alternatives, ii) measurement of the relative importance of the considered criteria and impact of the alternatives on those criteria, and iii) determination of the performance measures of the alternatives for ranking. [5] The procedure of the application of the MOORA method is simple and consists of the following steps:
Step 1: The ROV method starts with setting the goals and identification of the relevant criteria for evaluating available alternatives.
Step 2: In this step, based on the available information about the alternatives, a decision-making matrix or decision table is set. Each row refers to an alternative and each column to one criterion. The initial decision matrix, X, is:

$$X = [x_{ij}] = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ . & . & \dots & . \\ . & . & \dots & . \\ . & . & \dots & . \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix}$$

where x_{ij} is the performance measure of *i-th* alternative concerning *j-th* criterion, m is the number of alternatives and n is the number of criteria.

Step 3. In this step performance measures of alternatives are normalized – defining values $\bar{x}_{ij}$ of normalised decision-making matrix $\bar{X}$.

$$X = [\bar{x}_{ij}] = \begin{bmatrix} \bar{x}_{11} & \bar{x}_{12} & \dots & \bar{x}_{1n} \\ \bar{x}_{21} & \bar{x}_{21} & \dots & \bar{x}_{2n} \\ . & . & \dots & . \\ . & . & \dots & . \\ . & . & \dots & . \\ \bar{x}_{m1} & \bar{x}_{m1} & \dots & \bar{x}_{mn} \end{bmatrix}$$

For beneficial criteria, whose preferable values are maxima, normalization is done by using the linear transformation [4]:

$$\bar{x}_{ij} = \frac{x_{ij} - min_{i-1}^{m}(x_{ij})}{max_{i-1}^{m}(x_{ij}) - min_{i-1}^{m}(x_{ij})}$$

For non-beneficial criteria, whose preferable values are minima, normalization is done by:

$$\bar{x}_{ij} = \frac{max_{i-1}^{m}(x_{ij}) - x_{ij}}{max_{i-1}^{m}(x_{ij}) - min_{i-1}^{m}(x_{ij})}$$

Step 4. The application of the ROV method involves the calculation of the best and worst utility for each alternative. This is achieved by maximizing and minimizing a utility function. For a linear additive model, the best utility (u_i^+) and the worst utility (u_i^-) of *i-th* alternative are obtained using the following equations [4] [6]:

Maximize: $u_i^+ = \sum_{j=1}^{n} \bar{x}_{ij}.w_j$

Minimize: $u_i^- = \sum_{j=1}^{n} \bar{x}_{ij}.w_j$

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

If $u_i^- > u_i^+$ then alternative *i* outperforms alternative *i'* regardless of the actual quantitative weights. If it is not possible to differentiate the options on this basis then a scoring (enabling subsequent ranking) can be attained from the midpoint, which can be calculated as [4] [6]:

$$u_i = \frac{u_i^- + u_i^+}{2}$$

Step 5. In this final step, the complete ordinal ranking of the alternatives is obtained based on u_i values. Thus, the best alternative has the highest u_i value and the worst alternative has the lowest u_i value.

III. NUMERICAL ILLUSTRATION

A numerical example is illustrated in this section, a manufacturing company that wants to select a suitable supplier for raw material supply. In the given problem, there are ten suppliers (S1 to S10) and six criteria (C1 to C6) in which C2, C4, and C6 are non-beneficial attributes. Based on the given criteria, the application of integrated AHP and ROV methods carried out for demonstrating the methods. The Initial information about the supplier and criteria is given in table 3.

Table 3. Initial Decision Matrix

Suppliers/Criteria	Product Cost	Product Quality	Delivery Time	Service	Plant Location	Production Capacity
Supplier 1	120	75	5	80	19	19
Supplier 2	212	88	4	74	16	18
Supplier 3	225	68	6	84	20	12
Supplier 4	180	56	5	66	20	15
Supplier 5	230	66	7	58	18	16
Supplier 6	130	81	3	94	20	13
Supplier 7	275	94	2	54	20	17
Supplier 8	195	86	3	62	19	10
Supplier 9	315	71	5	43	16	11
Supplier 10	380	79	9	87	15	12

3.1 Weight Calculation: Implementation of AHP

Table 4. AHP Rating for Criterion

	C1	C2	C3	C4	C5	C6
C1	1	5	3	1/3	9	7
C2	1/5	1	1/5	1/7	1	1/3
C3	1/3	5	1	1/3	7	3
C4	3	7	3	1	5	7
C5	1/9	1	1/7	1/5	1	3
C6	1/7	3	1/3	1/7	1/3	1

Table 5. AHP Weightage for Criterion

	C1	C2	C3	C4	C5	C6	Sum	Weight
C1	0.21	0.23	0.39	0.15	0.55	0.33	1.86	0.3094
C2	0.04	0.05	0.03	0.07	0.06	0.02	0.26	0.0427
C3	0.07	0.23	0.13	0.15	0.01	0.14	0.73	0.1219
C4	0.63	0.32	0.39	0.46	0.30	0.33	2.43	0.4053
C5	0.02	0.05	0.02	0.09	0.06	0.14	0.38	0.0636
C6	0.03	0.14	0.04	0.07	0.02	0.05	0.34	0.0572

Table 6. Consistency Check

M1						M2	M3	M4	λmax	CI	CR	
1.00	5.00	3.00	0.33	9.00	7.00	0.3094	1.9960	6.4519	6.3697	0.0739	0.0596	< 0.1
0.20	1.00	0.20	0.14	1.00	0.33	0.0427	0.2695	6.3161				
0.33	5.00	1.00	0.33	0.14	3.00	0.1219	0.7541	6.1865				
3.00	7.00	3.00	1.00	5.00	7.00	0.4053	2.7159	6.7009				
0.11	1.00	0.14	0.20	1.00	3.00	0.0636	0.4107	6.4582				
0.14	3.00	0.33	0.14	0.33	1.00	0.0572	0.3491	6.1047				

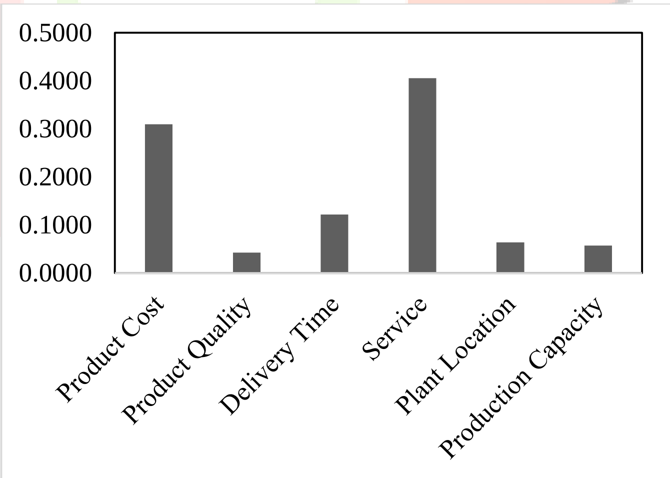

Figure 1. Weightage of Criteria

3.2 Rank Calculation: Implementation of ROV

Table 7. Normalize Matrix

	Product Cost	Product Quality	Delivery Time	Service	Plant Location	Production Capacity
Supplier 1	0.0000	0.5000	0.4286	0.2745	0.8000	0.0000
Supplier 2	0.3538	0.1579	0.2857	0.3922	0.2000	0.1111
Supplier 3	0.4038	0.6842	0.5714	0.1961	1.0000	0.7778
Supplier 4	0.2308	1.0000	0.4286	0.5490	1.0000	0.4444
Supplier 5	0.4231	0.7368	0.7143	0.7059	0.6000	0.3333
Supplier 6	0.0385	0.3421	0.1429	0.0000	1.0000	0.6667
Supplier 7	0.5962	0.0000	0.0000	0.7843	1.0000	0.2222
Supplier 8	0.2885	0.2105	0.1429	0.6275	0.8000	1.0000
Supplier 9	0.7500	0.6053	0.4286	1.0000	0.2000	0.8889
Supplier 10	1.0000	0.3947	1.0000	0.1373	0.0000	0.7778
Weightage	0.3094	0.0427	0.1219	0.4053	0.0636	0.0572

Table 8. Normalized Weights Matrix

	Product Cost	Product Quality	Delivery Time	Service	Plant Location	Production Capacity
Supplier 1	0.0000	0.0213	0.0522	0.1113	0.0509	0.0000
Supplier 2	0.1095	0.0067	0.0348	0.1589	0.0127	0.0064
Supplier 3	0.1249	0.0292	0.0697	0.0795	0.0636	0.0445
Supplier 4	0.0714	0.0427	0.0522	0.2225	0.0636	0.0254
Supplier 5	0.1309	0.0314	0.0871	0.2861	0.0382	0.0191
Supplier 6	0.0119	0.0146	0.0174	0.0000	0.0636	0.0381
Supplier 7	0.1844	0.0000	0.0000	0.3179	0.0636	0.0127
Supplier 8	0.0892	0.0090	0.0174	0.2543	0.0509	0.0572
Supplier 9	0.2320	0.0258	0.0522	0.4053	0.0127	0.0508
Supplier 10	0.3094	0.0168	0.1219	0.0556	0.0000	0.0445

Table 9. Computational Details with Ranking for ROV Method

	U+	*U-*	*Ui*	Rank
Supplier 1	0.1326	0.1031	0.1178	9
Supplier 2	0.1720	0.1570	0.1645	8
Supplier 3	0.1531	0.2582	0.2057	7
Supplier 4	0.2906	0.1872	0.2389	6
Supplier 5	0.3366	0.2561	0.2963	2
Supplier 6	0.0527	0.0929	0.0728	10
Supplier 7	0.3306	0.2480	0.2893	3
Supplier 8	0.3205	0.1575	0.2390	5
Supplier 9	0.4820	0.2970	0.3895	1
Supplier 10	0.1169	0.4313	0.2741	4

IV. RESULT AND DISCUSSION

In this paper, with the help of an illustrative example, the adopted methods were successfully implemented for supplier selection problem or we can say a multi-criteria decision model for evaluating alternatives for supplier selection problem was established. For this purpose, a two-step methodology is introduced, in which the AHP method determines the weight of criteria via the expertise of decision-making team members and then ROV method used to calculate the rank. On the basis of the obtained results, it is observed that supplier 9 is the most suitable choice and supplier 6 was worst choice for the manufacture, the result we can understand with the selection order of supplier from best to worst ranking i.e., S9>S5>S7>S10>S8>S4>S3>S2>S1>S6. To obtain the most suitable suppler the ROV method is integrated with AHP method. Both the methods are very simple to comprehend and easy to implement. In the present paper the calculations are carried out with the help of MS-Excel, so the mathematical operation become easier for calculation. Further the demonstrated AHP-ROV based MCDM method can be used for any type of selection problems with alternatives and criterions.

REFERENCES

1. Ghorbani, M., Mohammad Arabzad, S., and Shahin, A., 2013. A novel approach for supplier selection based on the Kano model and fuzzy MCDM. International Journal of Production Research, 51(18), pp.5469-5484.
2. Saaty, T. (2008). Decision making with the analytic hierarchy process. International Journal of Services Sciences, 1(1): 83-98.
3. Yakowitz, D. S., Lane, L. J., & Szidarovszky, F. (1993). Multi-attribute decision making: dominance with respect to an importance order of the attributes. Applied Mathematics and Computation, 54(2), 167-181.
4. Hajkowicz, S., & Higgins, A. (2008). A comparison of multiple criteria analysis techniques for water a resource management. European journal of operational research, 184(1), 255-265
5. Chakraborty, S., & Chatterjee, P. (2013). Selection of materials using multi-criteria decision-making methods with minimum data. Decision Science Letters, 2(3), 135-148.
6. Athawale, V. M., & Chakraborty, S. (2011). A comparative study on the ranking performance of some multi-criteria decision-making methods for industrial robot selection. International journal of industrial engineering computations, 2(4), 831-850.