Application of Multiple Criteria Decision Making Mathematical Model for Selecting Best Automobile

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Abstract— This paper illustrates the application of Multiple-Criteria Decision-Making (MCDM) mathematical model to the problem of the selection of a new automobile from the variety of automobiles available in the market. Buying of automobiles, now a days in the marketplace is very hard job to the customers due to day to day changes in numerous technical and operational parameter specifications like style, life span, fuel economy, suspension and cost etc. Therefore, to overcome from this confusion state some selection procedure techniques are required TOPSIS is one the selection procedure technique is adopted for this problem. This paper shows the basic steps involved in the technique TOPSIS (Technique for Ordered Preference by Similarity to Ideal Solution), for choosing the most suitable alternative from among the varied options under consideration. This technique provides a base for decision-making processes where there are limited numbers of choices but each has large number of attributes. In this work, some cars are considered with different attributes and select the best car using TOPSIS technique.

Key words: MCDM, Automobile selection, TOPSIS

I. INTRODUCTION

Multi-Attribute Decision Making is the most well-known branch of decision making. It is a branch of a general class of Operations Research (or OR) models which deal with decision problems under the presence of a number of decision criteria. The Multi criterion Decision-Making (MCDM) are gaining importance as potential tools for analysing complex real problems due to their inherent ability to judge different alternatives (Choice, strategy, policy, scenario can also be used synonymously) on various criteria for possible selection of the best/suitable alternative (s). These alternatives may be further explored in-depth for their final implementation.

Multi criterion Decision-Making (MCDM) analysis has some unique characteristics such as the presence of multiple non-commensurable and conflicting criteria, different units of measurement among the criteria, and the presence of quite different alternatives. It is an attempt to review the various MCDM methods and need was felt of further advanced methods for empirical validation and testing of the various available approaches for the extension of MCDM into group decision-making situations for the treatment of uncertainty

Decision-making can be treated as the intellectual process where choosing the best option among the alternatives is logical. It consists of a set of criteria and alternatives. Each criterion has a weighted value that can be obtained from decision-maker or expert group. After evaluating the weighted value of different criteria, the decision-making can be made.

Depending on the type of problem, MCDM model contains various elements and the following picture depicts the most widely found elements.

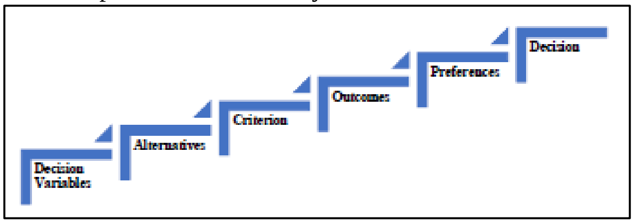

Fig. 1: MCDM Model's elements

II. MCDM TERMINOLOGIES

A. *Alternatives:*

Alternatives represent the different choices of action available to the decision maker. Usually, the set of alternatives is assumed to be finite, ranging from several to hundreds. They are supposed to be screened, prioritized and eventually ranked.

B. *Multiple attributes:*

Each MADM problem is associated with multiple attributes. Attributes are also referred to as "goals" or "decision criteria". Attributes represent the different dimensions from which the alternatives can be viewed. In cases in which the number of attributes is large (e.g., more than a few dozens), attributes may be arranged in a hierarchical manner. That is, some attributes may be major attributes. Each major attribute may be associated with several sub-attributes. Similarly, each sub- attribute may be associated with several sub-sub-attributes and so on. Although some MADM methods may explicitly consider a hierarchical structure in the attributes of a problem, most of them assume a single level of attributes (e.g., no hierarchical structure).

C. *Conflict among attributes:*

Since different attributes represent different dimensions of the alternatives, they may conflict with each other. For instance, cost may conflict with profit, etc.

D. *Incommensurable units:*

Different attributes may be associated with different units of measure. For instance, in the case of buying a used car, the attributes "cost" and "mileage" may be measured in terms of dollars and thousands of miles, respectively. It is this nature of having to consider different units which makes MADM to be intrinsically hard to solve.

E. *Decision weights:*

Most of the MADM methods require that the attributes be assigned weights of importance. Usually, these weights are normalized to add up to one.

F. Decision matrix:

An MADM problem can be easily expressed in matrix format.

A decision matrix A is an (M × N) matrix in which element aij indicates the performance of alternative Ai when it is evaluated in terms of decision criterion Cj, (for i = 1,2,3,..., M, and j = 1,2,3,..., N).

It is also assumed that the decision maker has determined the weights of relative performance of the decision criteria (denoted as Wj, for j = 1,2,3,..., N). This information is best summarized in figure 1.3.

	Criteria				
	C_1	C_2	C_3	…	C_N
Alt.	W_1	W_2	W_3	…	W_N
A_1	a_{11}	a_{12}	a_{13}	…	a_{1N}
A_2	a_{21}	a_{22}	a_{23}	…	a_{2N}
A_3	a_{31}	a_{32}	a_{33}	…	a_{3N}
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
A_M	a_{M1}	a_{M2}	a_{M3}	…	a_{MN}

Fig. 2: A Typical Decision Matrix

III. MCDM STEPS

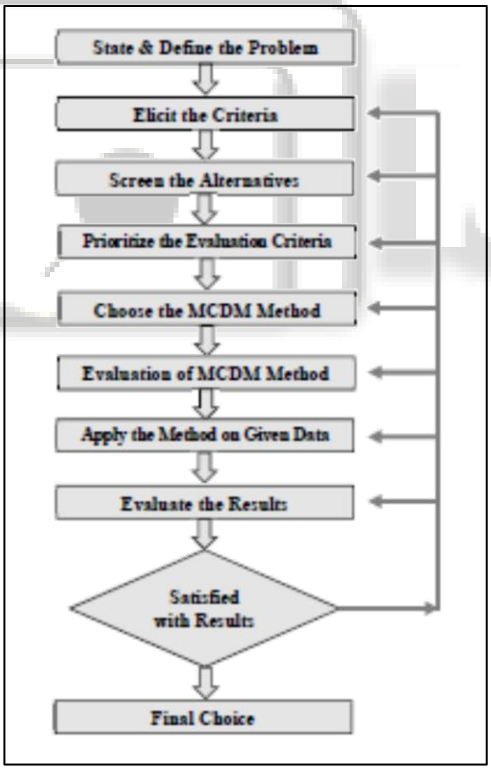

Fig. 3: MCDM Steps

A. Technique for the order of prioritisation by similarity to ideal solution (TOPSIS)

The principle of the TOPSIS is to select the alternative that is closest the positive ideal solution and farthest from the negative ideal solution. The positive ideal solution$A^+$is formed as a composite of the best performance values exhibited. The negative ideal, A^-, is the composite of the worst performance values.

The process of the TOPSIS method is carried out as follows

1) Step-1

Construct the Normalized Decision Matrix using the alternatives m and criteria n. The normalized value r_{ij} is calculated by the following equation

$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}^2}$$

2) Step-2

Calculate the weighted normalized decision matrix $V = [v_{ij}]$. The weighted normalized value vij is calculated as follows:

$$v_{ij} = (r_{ij})(w_j),$$

$i = 1, 2, \ldots, m$

$and\ j = 1, 2, \ldots, m$

w_j is the weight of the j^{th} attribute

3) Step-3

Determine the positive ideal solution (PIS) A^+ and negative ideal solution (NIS) A^-

$$A^+ = \{(\max_i v_{ij} \mid j \in J), (\min_i v_{ij} \mid j \in J'), i = 1, 2, \ldots \ldots .m\} = \{v_1^+, v_2^+, \ldots \ldots .v_n^+\}$$

$$A^- = \{(\min_i v_{ij} \mid j \in J), (\max_i v_{ij} \mid j \in J'), i = 1, 2, \ldots \ldots .m\} = \{v_1^-, v_2^-, \ldots \ldots .v_n^-\}$$

Where J is a set of benefit attributes and J' is a set of cost attributes.

4) Step 4

Calculate the separation measures

The separation measures of each alternative from the positive ideal solution are as follows

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2} \quad , i = 1, 2, \ldots \ldots m$$

The separation measure of each alternative from the negative ideal solution is as follows

$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \quad , i = 1, 2, \ldots \ldots m$$

5) Step 5:

Calculate the relative closeness to the ideal solution. The relative closeness of the
alternative A_i with respect to A^+ is defined as follows:

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-} \quad i = 1, 2, \ldots \ldots ..m \;\; ; \;\; 0 \le C_i \le 1$$

6) Step 6:

Rank the alternatives in descending order with respect to Ci.

IV. PROBLEM FORMULATION

Multiple criteria decision-making techniques can be applied in variety of fields. Depending upon the conditions associated with problem, suitable MCDM technique is applied into it to reach into final decision.

In this work, a MCDM technique is used to select the best automobile among the multiple alternatives available on the basis of certain criterion. Intense survey has been carried out in an automobile showroom in Raipur (Capital of Chhattisgarh State). – Shivnath Hyundai, having selling rate of more than 60 automobiles per month. Petrol version of automobile is selected for the study, as it is more sold as compare to diesel version.

Following information were collected from the showroom in the form of questionnaires:

- Question - Which models of automobile is mostly sold in a specified period of time?
- Answer – Grand i10, i20 Active, Xcent, Creta, i20 Elite, Eon
- Question - Number of automobiles sold in a specified period of time
- Answer – A total of approximately 40
- Question - What were the criterion of selecting particular automobile?
- Answer – Looks, Features, Performance, Value for money. Also taken from enquiry form for buying new car.
- Question – How many customers have given their individual priority to specified criterion while finalizing an automobile for buying.
- Answer – All enquiry forms of a month is carefully analysed and weightage of each criterion is calculated, which is as shown below:

S.N.	Criterion	Weight Percentage	Weight Factor
1	Looks	15 %	0.15
2	Features	40 %	0.4
3	Performance	25 %	0.25
4	Value for Money	20 %	0.2

Table 1: Formulation of Weight Factor

As per TOPSIS rule, the sum of all weight factor, should be 1, here also, 0.15 + 0.4 + 0.25 + 0.2 = 1

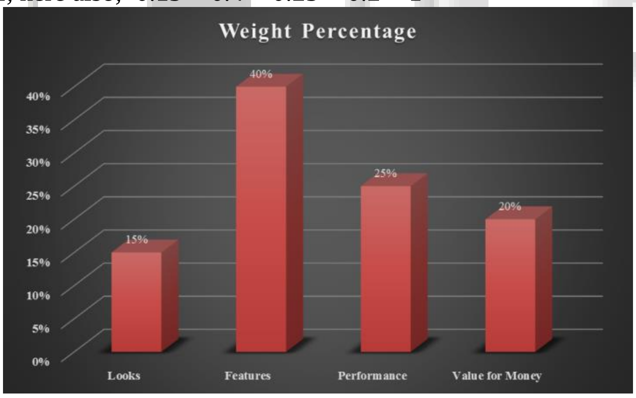

Fig. 4: Graph between criterion and weightage

- Question – How much priorities and ranking has been given against each criterion for a automobile by all customers in a month while selecting an automobile.
- Answer – All enquiry forms and data in the showroom is closely observed and studied and following output is observed:

	Looks	Features	Performance	Value for Money
Grand i10	Very Good	Good	Very Good	Good
i20 Active	Excellent	Average	Very Good	Excellent
Elite i20	Good	Excellent	Excellent	Very Good
Creta	Average	Good	Very Good	Average

Table 2: Rank allotment of each automobile with respect to specified criteria

Ranking Parameter	Rank Factor
Average	2
Good	3
Very Good	4
Excellent	5

	Looks	Features	Performance	Value for Money
Grand i10	4	3	4	3
i20 Active	5	2	4	5
Elite i20	3	5	5	4
Creta	2	3	4	2

After collecting the above information, following problem is formulated for study and analysis

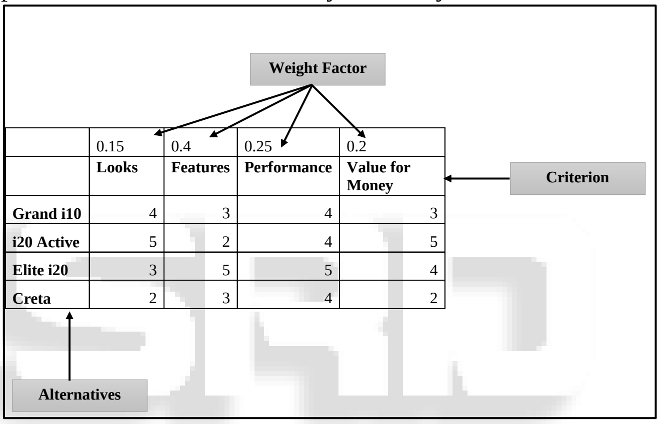

Table 3: Final problem statement

V. METHODOLOGY

The problem statement which was formulated in the previous section will be solved in this section by the application of a Multiple Criteria Decision-Making Technique – Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

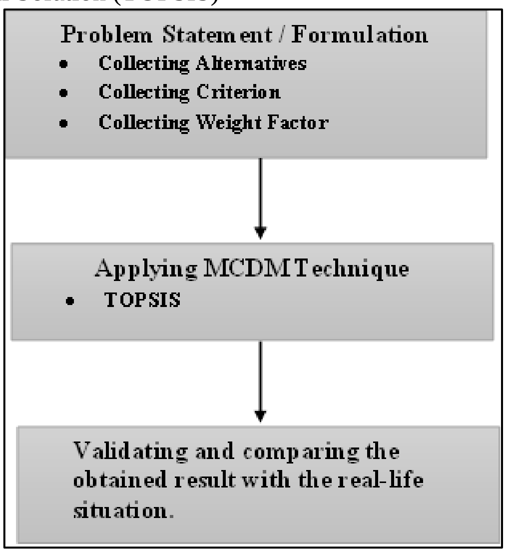

Fig. 5: Methodology Flowchart

1) Step 1 - Construction of Normalized Decision Matrix

	0.15	0.4	0.25	0.2
	Looks	Features	Performance	Value for Money
Grand i10	4	3	4	3
i20 Active	5	2	4	5
Elite i20	3	5	5	4
Creta	2	3	4	2
	54	47	73	54
	7.3485	6.8557	8.5440	7.3485

Sum of Squares of Individual Columns

Square root of each summation

2) Step 2 - Construction of Weighted Normalized Decision Matrix

	0.15	0.4	0.25	0.2
	Looks	Features	Performance	Value for Money
Grand i10	0.08165	0.17504	0.11704	0.08165
i20 Active	0.10206	0.11669	0.11704	0.13608
Elite i20	0.06124	0.29173	0.14630	0.10887
Creta	0.04082	0.17504	0.11704	0.05443

3) Step 3 - Determine the positive ideal solution (PIS) A^+ and negative ideal solution (NIS) A^-

	0.15	0.4	0.25	0.2
	Looks	Features	Performance	Value for Money
Grand i10	0.08165	0.17504	0.11704	0.08165
i20 Active	0.10206	0.11669	0.11704	0.13608
Elite i20	0.06124	0.29173	0.14630	0.10887
Creta	0.04082	0.17504	0.11704	0.05443
A^+	0.10206	0.29173	0.14630	0.05443
A^-	0.04082	0.11669	0.11704	0.13608

Positive Ideal Solution

Negative Ideal Solution

4) Step 4 - Calculate the separation measures

$S_i^+ =$	Grand i10	0.1250	$S_i^- =$	Grand i10	0.0896
	i20 Active	0.1953		i20 Active	0.0612
	Elite i20	0.0680		Elite i20	0.1807
	Creta	0.1350		Creta	0.1004

5) Step 5 - Calculate the relative closeness to the ideal solution.

Grand i10	0.417564133
i20 Active	0.23866169
Elite i20	0.726455442
Creta	0.426408117

VI. RESULTS AND DISCUSSION

Arrange the data obtained in previous section in descending order for the selection of best automobile

Elite i20	0.726455442
Creta	0.426408117
Grand i10	0.417564133
i20 Active	0.23866169

Table 4: Final order of preference

Therefore, it can be concluded that, following is the order of preference, while selecting the best car for buying.

Elite i20 >> Creta >> Grand i10 >> i20 Active

The above order of preference matches exactly with the order of rate of selling cars, as studied and analysed in the showroom. This shows that, this MCDM method can be applied in this case, which can help customers to choose the best automobile.

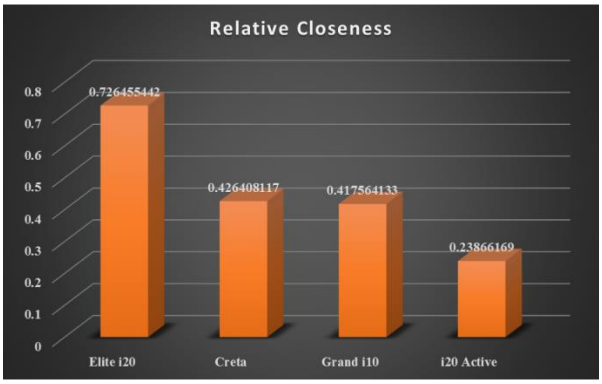

Fig. 6: Graph between alternative and relative closeness

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