SELECTION OF CARS USING COMBINED MULTI CRITERIA DECISION MAKING TECHNIQUES

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ABSTRACT:

Multi-criteria decision making (MCDM) plays a vital role in real life situations. Purchasing management is most essential in today's competitive world, especially the most useful and essential purchase of car by individuals. There are many characteristics possessed by car like engine displacement, mileage in city and highway and max power etc.., and a costumer has to choose the best car among the alternatives like Maruti, Hyundai etc..., In this project MCDM methods like TOPSIS, VIKOR and SAW are used to find the best car to be purchased.

KEYWORDS: TOPSIS ,VIKOR and SAW

1 INTRODUCTION TO MULTI CRITERIA DECISION MAKING (MCDM):

Multiple criteria decision making (MCDM) refers to making decisions in the presence of multiple, usually conflicting, criteria. MCDM problems are common in everyday life. In personal context, a house or a car one buys may be characterized in terms of price, size, style, safety, comfort, etc. In business context, MCDM problems are more complicated and usually of large scale. For example, many companies in Europe are conducting organizational self-assessment using hundreds of criteria and

Sub-criteria set in the EFQM (European Foundation for Quality Management) business excellence model. Purchasing departments of large companies often need to evaluate their suppliers using a range of criteria in different area, such as after sale service, quality management, financial stability, etc.. Although MCDM problems are widespread all the time, MCDM as a discipline only has a relatively short history of about 30 years. The development of the MCDM discipline is closely related to the advancement of computer technology. In one hand, the rapid development of computer technology in recent years has made it possible to conduct systematic analysis of complex MCDM problems. On the other hand, the widespread use of computers and information technology has generated a huge amount of information, which makes MCDM increasingly important and useful in supporting business decision making. There are many methods available for solving MCDM problems as reviewed by Hwang and Yoon [1981], though some of the methods were criticized as ad hoc and to certain degree unjustified on theoretical and/or empirical grounds [Stewart; 1992]. There were calls in early 1990s to develop new methods that could produce consistent and rational results, capable of dealing with uncertainties and providing transparency to the analysis processes [Stewart; 1992 and Dyer et al, 1992]. As part of the effort to deal with MCDM problems with uncertainties and subjectivity, the Evidential Reasoning (ER) has been devised, developed, and finally implemented into a window based software called Intelligent Decision Systems by Yang and his collaborators in a time span of more than 10 years [Zhang, Yang and Xu, 1989; Yang and Singh, 1994; Yang and Xu 2000a; Yang & Xu, 2000b; Yang 2001]. The ER approach and the software are now widely used in many areas. In the following section, the main characteristics of MCDM problems are summarized first, followed by a list of typical techniques used in MCDM analysis.

1.1 Main Features of MCPM:

In general, there exist two distinctive types of MCDM problems due to the different problems settings: One type having a finite number of alternative solutions and the other an infinite number of solutions. Normally in problems associated with selection and assessment, the number of alternative solutions is limited. In problems related to design, an attribute may take any value in a range. Therefore the potential alternative solutions could be infinite. If this is the case, the problem is referred to as multiple objective optimization problems instead of multiple attribute decision problems. Our focus will be on the problems with a finite number of alternatives. A MCDM problem may be described using a decision matrix. Suppose there are m alternatives to be assessed based on n attributes, a decision matrix is a m * n matrix with each element Yjj being the j^{th} attribute value of the i^{th} alternative.

1.2 Multi-criteria decision making (MCDM):

Multi criteria decision making is one of the well-known topics of decision making. Fuzzy logic provides a useful way to approach a MCDM problem. Very often in MCDM problems, data are imprecise and fuzzy. In a real-world decision situation, the application of the classic MCDM method may face serious practical constraints because of the criteria containing imprecision or vagueness inherent in the information.

With the continuing proliferation of MCDM methods and their variants, it is important to have an understanding of their comparative value. Each of these methods uses numeric techniques to help decision makers choose among discrete set of alternative decisions. This is achieved on the basis of the impact of the alternatives on the certain criteria and thereby on the overall utility of the decision maker(s).The difficulty that always occurs when trying to compare decision methods and choose the best of one is that a paradox is reached.

Despite the criticism that multi-dimensional methods have received, some of them are widely used. The weighted sum model (WSM)is the earliest and probably' the most widely used method. The weighted product model(WPM)can be considered as a modification of the WSM, and has been proposed in order to overcome some of its weaknesses .The analytic hierarchy process (AHP),as proposed by saaty [saaty,1980 and 1994],is a later development and it has recently become increasingly popular. Professors Belton and Gear [1983]suggested a modification to the AHP 9 which we will call the revised AHP)that appears (as it is demonstrated in later chapter) to be more consistent than the original approach. Some other widely used methods are the ELECTRE and the TOPSIS methods.

1.3 MCDM methods:

The following MCDM methods are available, many of which are implemented by specialized decision-making software:

. ELECTRE (Outranking)
. Goal programming
. Grey relational analysis (GRA)
. Inner product of vectors (IPV)
. Measuring Attractiveness by a categorical Based
. Multi-Attribute Global Inference of Quality (MAGIQ)
. Multi-attribute utility theory (MAUT)
. Multi-attribute value theory (MAVT)
. Non structural Fuzzy Decision Support System (NSFDSS)
. PROMETHEE (Outranking)
. Technical for Order Preference Similarity to Ideal Solution (TOPSIS)
. Value analysis (VA)
. Value engineering (VE)
. VIKOR method . Fuzzy VIKOR method . Weighted product model (WPM)
. Weighted sum model (WSM)

2 GOAL PROGRAMMING:

Goal Programming is a pragmatic programming method that is able to choose from an infinite number of alternatives. One of its advantages is that it has the capacity to handle large-scale problems. Its ability to produce infinite alternatives provides a significant advantage over some methods, depending on the situation. A major disadvantage is its inability to 62 Velasquez and Hester: An Analysis of Multi-Criteria Decision Making Methods IJOR Vol. 10, No. 2, 56-66 (2013) weight coefficients. Many applications find it necessary to use other methods, such as AHP, to properly weight the coefficients. Goal programming has seen applications in production planning, scheduling, health care, portfolio selection, distribution system design, energy planning, water reservoir management, timber harvest scheduling, and wildlife management problems. Many of these applications have been used in combination with other methods to accommodate proper weighting. By doing so, it eliminates one of its weaknesses while still being able to choose from infinite alternatives. This follows a common theme where MCDM methods are most often utilized in applications that avoid most of their disadvantages.

2.1 ELECTRE:

ELECTRE, along with its many iterations, is an outranking method based on concordance analysis. Its major advantage is that it takes into account uncertainty and vagueness. One disadvantage is that its process and outcomes can be hard to explain in layman's terms. Further, due to the way preferences are incorporated, the lowest performances under certain criteria are not displayed. The outranking method causes the strengths and weaknesses of the alternatives to not be directly identified, nor results and impacts to be verified (Konidari and Mavrakis, 2007, p. 6237). ELECTRE has been used in energy, economics, environmental, water management, and transportation problems. Like other methods, it also takes uncertainty and vagueness into account, which many of the mentioned applications appear to need.

2.2 PROMETHEE:

PROMETHEE is similar to ELECTRE in that it also has several iterations and is also an outranking method. The PROMETHEE family of outranking methods, including the PROMETHEE I for partial ranking of the alternatives and the PROMETHEE II for complete ranking of the alternatives, were developed and presented for the first time in 1982. A few years later, several versions of the PROMETHEE methods such as the PROMETHEE III for ranking based on interval, the PROMETHEE IV for complete or partial ranking of the alternatives when the set of viable solutions is continuous, the PROMETHEE V for problems with segmentation constraints, the PROMETHEE VI for the human brain representation (Behzadian et al., 2010, p. 199). Its advantage is that it is easy to use. It does not require the assumption that the criteria are proportionate. The disadvantages are that it does not provide a clear method by which to assign weights and it requires the assignment of values but does not provide a clear method by which to assign those values. PROMETHEE has seen much use in environmental management, hydrology and water management, business and financial management, chemistry, logistics and transportation, manufacturing and assembly, energy management, and agriculture. PROMETHEE has been utilized for many decades and its ease of use has made it a common method as its iterations have improve.

2.3 TOPSIS:

TOPSIS (Technical for Order Preference Similarity to IdealSolution) the principal behind TOPSIS is simple: The chosen alternative should be as close as to the ideal solution as possible and as far from the negative-ideal solution as possible. The ideal solution is formed as a composite of the best performance values exhibited (in the decision matrix) by any alternative for each attribute.

2.4 VIKOR Method:

VIKOR is one of the multi criteria decision making (MCDM) models to determine the preference ranking from a set of alternatives in the presence of conflicting criteria. The justification of VIKOR is to use the concept of the compromise programming to determine the preference ranking by the results of the individual and group regrets.

2.5 Simple Additive Weighting (SAW) method:

In decision theory, the weighted sum model i.e. simple additive weight is the best known and simplest multi criteria decision making (MCDM) method for evaluating a number of alternatives in terms of a number of decision criteria. It is very important to state here that is applicable only when all the data are expressed in exactly the same unit. If this is not the case, then the final result is equivalent to “adding apples and oranges”.

3 MCDM TECHNIQUES:

3.1 TOPSIS method:

The Technique for order of Preference by similarity to ideal solution (TOPSIS) is a multi-criteria decision analysis method, which was originally developed by Hwang and Yoon in 1981, with further developments by Yoon in 1987, and Hwang, Lai and Liu in 1993.TOPSIS is based on the concept that the chosen alternative should have the shortest geometric distance from the positive ideal solution and the longest geometric distance from the negative ideal solution. It is a method of compensatory aggregation that compares a set of alternatives by identifying weights for which criterion, normalizing score for each criterion and calculation the geometric distance between each alternative and the ideal alternative, which is the best score in each criterion. An assumption of TOPSIS is that the criteria are monotonically increasing or decreasing. Normalization is usually required as the parameters or criteria are often of incongruous dimensions in multi-criteria problems.

ALGORITHM

The procedure of TOPSIS can be described a follows.

Given a set of alternatives, A={Ai | i=l,2,....,n} and a set of criteria C={Cj | j=l,2, ,m} where X={xij | i=l,...,nj=l,......,m} denotes the set of ratings and W={ Wj | j=l,...,m} is the set of weights. Then the information table I = (A,C,X ,W) can be represented as

I	**C1**	**C2**	**............**	**Cm**
A1	**x11**	**x12**	**............**	**x1m**
A2	**x21**	**x22**	**............**	**x2m**
.	**.**	**.**		**.**
.	**.**	**.**		**.**
.	**.**	**.**		**.**
An	**xn1**	**xn2**	**...........**	**xnm**
W	**w1**	**w2**	**...........**	**wm**

Step 1: Calculate normalized ratings by

$$rij(x)=\frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}}} : i = 1, \dots \dots, n$$

j=1,………,m

Step 2: Calculate weighted normalized ratings by

$Vij(x) = Wj\text{-}r_{ij}(x)$ i=l,…..,n; j=l,…….,m;

Step3: Calculate PIS (positive ideal solution)and NIS(negative ideal solution)by

$PIS = A^{+}= \{ \max_i V_{ij}(x)|j\in J_1(\min_i V_{ij} \mid j\in J_2\}$

$= \{v_1^+, v_2^+, \ldots\ldots\ldots V_n^+\}$

NIS = $A^- = \{ \min_i \mathbf{Vij}\ (x)\ j\in J_1, (\max_I \mathbf{Vij} \mid j\in J_2\}$

$= \{ v_1^-, v_2^- \ldots\ldots\ldots\ldots v_n^-\}$

Step 4: Calculate separation from PIS and NIS between the alternatives. The separation values can be measured using the Euclidean distance which is given by

$$S_i^+ = \sqrt{\sum_{j=1}^{m}[Vij(x) - V_j^+(x^2)]^2} \quad ; i=l,\ldots,n;$$

$$S_i^- = \sqrt{\sum_{j=1}^{m}[Vij(x) - V_j^+(x^2)]^2} \; ; i=l,\ldots,n;$$

Step 5:Similarities to the PIS can be derived as

$$C_i^* = \frac{S_i^-}{S_i^+ + S_i^-}, i=l,\ldots,n; \quad \text{Where } C_i^* \in [0,1]\forall; i=l,\ldots,n;$$

PROBLEM

Consider a problem of selecting suppliers of best car for a particular specification of the cars under 4 different criteria namely engine displacement (cc), mileage city and highway and max power. The problem is to find best car to use:

Alternatives	EngineDisplacement(cc)	MileageCity	Mileage Highway	Max power
Hyundai Elite i20	1396	18.4	22.54	88.73
Maruti Baleno 1.3	1248	22.59	27.39	74
Maruti Swift	1249	20.9	25.2	76
Renault Duster	1461	16.1	19.7	108.45

SOLUTION:

Step 1: Calculate normalized ratings

Alternatives	rl	r 2	r 3	r 4
SI	0.520	0.468	0.503	0.505
S2	0.465	0.575	0.573	0.421
S3	0.465	0.532	0.528	0.432
S4	0.544	0.410	0.412	0.617
WEIGHT	0.111	0.148	0.5	0.241

Step 2: Calculate weighted normalized ratings

Alternatives	VI	V2	V3	V4
SI	0.058	0.069	0.252	0.122
S2	0.052	0.085	0.287	0.101

S3	0.052	0.079	0.264	0.104
S4	0.060	0.061	0.206	0.149

MAXVJ+	0.06	0.085	0.287	0.149
MINVJ-	0.052	0.061	0.206	0.101

Step3: Calculate PIS (positive ideal solution)and NIS(negative ideal solution)

Alternatives	S^+	S^-	C*	Rank
SI	0.045	0.049	0.521	3
S2	0.055	0.087	0.613	1
S3	0.051	0.059	0.528	2
S4	0.081	0.048	0.372	4

TOPSIS Method

Alternatives	**S^+**	**S^-**	**C***	**Rank**
SI	0.045	0.049	0.521	3
S2	0.055	0.087	0.613	1
S3	0.051	0.059	0.528	2
S4	0.081	0.048	0.372	4

The preferred order of alternatives are S2>S3>S1>S4. On the basis of preferred order, Altemative-II (ie) **Maruti Baleno 1.3** should be the **best** choice

3.2 VIKOR method:

Introduction to VIKOR method:

The VIKOR method is a multi-criteria decision making (MCDM).multicriteria decision analysis or method. It was originally developed by serafimOpricovic to solve decision problems with conflicting and non commensurable (different units) criteria, assuming that compromise is acceptable for conflict resolution ,the decision maker wants a solution that is the closest to the ideal, and the alternatives are evaluated according to all established criteria. VIKOR ranks alternatives determines the solution named compromise that is the closest to the ideal .The VIKOR method of compromise ranking determines a compromise solution, providing a maximum ''group utility" for the "majority" and a minimum of an individual regret for the "opponent". The TOPSIS method determines a solution and the greatest distance from the negative-ideal solution, but it does not consider the relative importance of these distances. A comparative analysis of these two methods is illustrated with a numerical example, showing their similarity and some differences.

VIKOR algorithm was posed by Opricovic (1998) which is a multi-attribute decision making method for complex system based on ideal point method. The basic view of VIKOR method is determining positive-ideal solution and negative-ideal solution. The positive ideal solution is the best value of alternatives under assessment criteria. The procedure for evaluating the best solution to an MCDM problem include computation the utilities of alternatives and ranking these alternatives. The alternative solution with the highest utility is considered to be the optimal solution.

ALGORITHM

Step 1: Representation of normalized decision matrix.

The normalized decision matrix can be expressed as follows

$F = [fij]_{m\times n}$ Where $fij=\frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}}} : i = 1, \dots \dots, m$

and Xjj -Performance of alternative Aj with respect to the j^th criterion.

Step 2: Determination of positive ideal and negative ideal solution.

The positive ideal solution A^+ and negative ideal solution A~ are determined as

$A^+ = \{(maxf_{ij})$ j ∈ J or $(minf_{ij}|$ j ∈ J); i=l,...,m}

$= \{f_1^+, f_2^+, \dots \dots \dots, f_n^+,\}$

$A^- = \{(minf_{ij})$ j ∈ J or $(maxf_{ij}|$ j ∈ J); i=l,...,m}

$= \{f_1^-, f_2^-, \dots \dots \dots, f_n^-,\}$

where J is the attributes.

Step 3: Calculation of utility measure and regret measure by

$S_i = \sum_{j=0}^{n} W_j \frac{(f_j^+ - fij)}{(f_j^+ - f_j^-)}$; $R_i=Max_j\left[W_j \frac{(f_j^+ - fij)}{(f_j^+ - f_j^-)}\right]$

Sj Utility measure

Ri Regret measure

Step 4:Computation of J VIKOR index

The VIKOR index can be expressed as

$Q_i = V\left[\frac{S_i - S^+}{S^- - S^+}\right] + (1 - V)\left[\frac{R_i - R^+}{R^- - R^+}\right]$

Where $S^+=min_i(Si)$; $S^- =maxj(Sj)$; $R^+=min,(Rj)$; $R^- =max_i(R_i)$

V- weight of maximum group utility(usually it is to be set to 0.5),

The alternative having smallest VIKOR value is determined to be the best solution.

Entropy method is used to determine the weight of each indicator:

Step 1: Calculate Pjj $=\frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}}$; r_{ij}- i^th scheme, j^th indicator value.

Step 2: Calculate **j^th** indicator entropy value ej

$e_j = -K\sum_{i=1}^{m} P_{ij} InP_{ij}$;

K = $\frac{1}{\text{Inm}}$; m is the no. of assessment.

Step 3: Calculate Wj

$W_j = \frac{(1-e_j)}{\sum_{j=1}^{n}(1-e_j)}$; n is the no. of indicators

And 0< Wj < l ;$\sum_{j=1}^{n} Wj = 1$.

PROBLEM:

Alternatives	Engine displacement(cc)	Mileage City	Mileage highway	Max power
S1	1396	18.4	22.54	88.73
S2	1248	22.59	27.39	74
S3	1249	20.9	25.2	76

S4	1461	16.1	19.7	108.45

SOLUTION:

Step1:calculate normalized ratings

Alternatives	r l	r 2	r 3	r 4
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S3	0.465	0.532	0.528	0.432
S4	0.544	0.410	0.412	0.617
Weight	0.111	0.148	0.5	0.241

Step2: To calculate utility measures and regret measures

Alternatives	**Sj**	Rj
S1	0.278 (S^-)	0.99 (R^-)
S2	0.352	0.241
S3	0.516 (S^+)	0.226
S4	0.648	0.5 (R^+)

Step3: Calculate VIKORindex

	VIKOR index	**Ranking**
SI	Ql=l	4
S2	Q2=0.72	3
S3	Q3=0.52	2
S4	Q4=0	**1 best**

AS,VIKOR INDEX Renault Duster of is the least, Renault Duster is to be selected FIRST followed by Maruti Swift, Maruti Baleno 1.3 and Maruti Elite i20.

3.3 SIMPLE ADDITIVE WEIGHTING (SAW)

Introduction to SAW method

The SAW method consists of quantifying the values of attributes (criteria) for each alternative constructing the decision matrix A containing these values , deriving the normalized decision matrix R, assigning importance (weights) to criteria, and calculating the overall score for each alternative. Then, the alternative with the highest score is selected as the perfect or best one. The analytical structure of the SAW method for N alternatives and M alternatives (criteria) can be summarized as follows:

$S_i=\sum_{j=1}^{M} W_j \ r_{ij}$ for i= 1,2,.... ,N

Where

S_i is the overall score of the i^{th} alternatives

r_{ij} is the normalized rating of the i^{th} alternative for the j^{th} criterion, which is computed as

$r_{ij}=\frac{x_{ij}}{max_i x_{ij}}$ for the benefit and $r_{ij}=\frac{\frac{1}{x_{ij}}}{[max_i(1-x_{ij})]}$

for the cost criterion representing an element of the normalized matrix R.

x_{ij} is an element of the decision matrix A, which represents the original value of the j^{th} criterion of the i^{th} alternative.

Wj is the importance (wt) of the j^{th} criterion.

N is the number of alternatives.

W is the number of criteria.

PROBLEM:

Here, max power is calculated by using the benefit formula and the engine displacement, mileage city

Alternatives	**Engine displacement(cc)**	**Mileage City**	**Mileage highway**	**Max power**
Hyundai Elite i20	1396	18.4	22.54	88.73
Maruti Baleno 1.3	1248	22.59	27.39	74
Maruti Swift	1249	20.9	25.2	76
Renault Duster	1461	16.1	19.7	108.45

and mileage high way is calculated by using the cost formula

SOLUTION:

STEP1:To calculate SAW method

Alternatives	**Engine displacement(cc)**	**Mileage City**	**Mileage highway**	**Max power**	Si
Hyundai Elite i20	0.013	**1**	0.815	**1**	0.7979
Maruti Baleno 1.3	0.018	**1**	0.841	**1**	0.8115
Maruti Swift	0.016	**1**	0.823	**1**	0.8025

Renault Duster	**0.011**	**1**	0.823	**1**	0.8015

Finally, we conclude that **Maruti Baleno 1.3** is ranked first, next **Maruti Swift,** next **Renault Duster,** and the last is ranked to **Hyundai Elite i20.**

CONCLUSION

This project aims to give awareness to the public in selection of the best car among several brands of cars available with the help of mathematical technique namely Multicriteria decision making techniques. TOPSIS, VIKOR and SAW methods are used. Entropy method is used assign weights for the criteria's. We found in both TOPSIS and SAW. methods the car Maruti Baleno 1.3 is the best car and in VIKOR the car Renault Duster is the best car. The alternatives are ranked and compared in order to arrive at an efficient result. This approach can be demonstrated with any real world case study involving main evolution criteria and the user to determine the most appropriate and beneficial cars, which results in great savings in both costs and mileage.

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