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THE COMPARATIVE STUDY OF MULTI-CRITERIA DECISION MAKING INVENTORY METHODS IN FUZZY: A STATE OF ART SURVEY

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ABSTRACT

Multicriteria decision making has capability to improve the decision power in vague information of the fields. In present paper, authors discuss and spot lights on some of the most prevalently used methods for the multicriteria decision making (MCDM) because a systematic approach to inventory control may have a significance influence for any competitiveness. MCDM is concerned to well structure of complex problems with consideration of multiple criteria lead more information and better decisionexplicitlywith the fuzzy concept. Fuzzy enhancesthe probability/possibility factor in multicriteria analysis due to this the result decision is more accurate and informative. In practice, all the detail list of the things with their vitalness would not be controlled with equal potential. There are some different methods of MCDM (i) Out ranking (e.g. PROMETHEE and ELECTRE), (ii) Multi-attribute utility theory (MAUT), (iii) Analytic hierarchy process (AHP), (iv) Analytic Network Process.

Keywords: Analytic Hierarchy Process, ELECTRE, Inventory Classification, Multicriteria Decision making, PROMETHEE.

I. INTRODUCTION

Multi-criteria decision analysis is a particular area of the study of operation research that clearly works in multicriteria decision environments for multi-attributes or items. The authors are interested in getting high returns simultaneously with reducing risk in daily lives things or in professional settings as like selection of goods, recommendations of items, investment of money etc. such ascustomer satisfaction and the cost of giving services are the main conflicting criteria that would be useful to consider veer service industry.

Multi-criteria decision making (MCDM) is concerned to well structure of complex problems with consideration of multiple criteria lead more information and better decision explicitly. Typically, there doesn’t exist a distinct optimal solution for decision making related problems and it is necessary to use decision maker’s preferences to differentiate between solutions [1]. Multicriteria analysis prevalently needs of decision maker to provide the qualitative assessments for determining the performance of each alternative with respect to each criteria and relative importance of evaluated criteria with respect to overall objective of the problem. As a result, uncertainty, imprecise and subjective data are usually present which make the decision making process more complex and challenging [2]. The uncertainty, imprecise and subjective data problems are attempted to handle with use of probability theory or fuzzy theory [4]. Fuzzy theory interprets the value in the input vector and based on some set of rules to choose the output vector value. Fuzzy logic contains four distinct elements on which basis it works. These elements are (i) Fuzzy set, (ii) Membership function, (iii) Logical operation and (iv) If-then rule. Fuzzy set is distinct from the crisp set. In crisp set result is bounded only in between two value 1(true) and 0 (false) but fuzzy set contain element with only a partial degree of membership [3-4]. Membership function is a curve in which each valueof the input space is mapped between 0 and 1 to a membership value. Fuzzy logical operations are a superset of standard Boolean logic. The conditional statements are formulated by if-then rule base to comprise fuzzy logic which can be understood with the following example.

Fuzzy set rule   Logical operator

Example:- If pH is alkaline and lime is low and organic material is sufficient then productivity of crop is average.

Wojeiech Salabun [1] demonstrates a method in which free of rank reversal is helpful to construct the fuzzy rule based for the particular multi-criteria decision in non-linear problems solution model.P. Phani Bushan Rao [4] *et al.*, utilized ranking fuzzy numbers used the circumcenter of centroid and an index of optimum to reflect the decision maker's optimistic attribute and fuzzy numbers are ranked with normal, generalized trapezoidal and triangular fuzzy number along with crisp number. Ehsan Bijanzadeh [5] *et al.*, present a set of membership function was conducted to revel the soil fertility class with some soil parameters like organic content, phosphorus etc. with using AHP method. Xin Wang Liu [7] *et al.*, discussed weighing function in preference of ranking fuzzy number because it gives different emphasis on the possible value of the fuzzy number to demonstrate the decision maker's worst, neutral or optimistic attitude. Hepu Deng [11] presenteda simple and straight forward fuzzy pair comparison approach for tackling qualitative MA problems to obtain effective decision with an adequate modelling of the uncertainty and imprecision in human behavior.

Section 2 presents the inventory methods used for MCDM following discussion in section 3 and concluding remarks as demonstrated in Section 4. The next section of study presents a framework of inventory methods in MCDM.

II. INVENTORY METHODS IN MCDM

The predictable and deterministic world of the past has been replaced by the uncertain, random and disorderly world of today. Technological advancements in multiple fields of human activity have caused that things happen at electronic speed. The availability of time for making decisions is reduced due to drastically increasing complexity and information overload. The decision-makers are stressed, overloaded with unsolicited information and yet must make decisions that have high-risk implications or consequences [6]. The simple and single-criteria decision-making requirements of the past has been replaced by complex decision involving multitudes of variables, which may be random, fuzzy or at worst unknown. The decision-making process has shifted to the lowest level of the hierarchy of organizations as the time required to make decisions has severely reduced. There are some prevalently used methods in the MCDM which are as discussed below with explanation:

2.1 Out Ranking Method

The outranking approach is based on the pioneering work by Bernard Roy, and is implemented in the ELECTRE and PROMETHEE methods;

2.1.1 Promethee

PROMETHEE method belongs to outranking methodsand Brans *et al.*, introduces the same [8]. PROMETHEE is worked for alternatives pairwise comparison in each single criterion like all outranking methods, to determine partial binary relations which denote the strength of preference of an alternative b over alternative c. The evaluations of the alternatives involve quantitative data mainly [9]. The implementation of PROMETHEE requires additional types of information, namely:

a) Information of the weights of the criteria considered,

b) Information of the decision maker preference function, when use them to each criteria's alternatives comparison.

The original PROMETHEE method can effectively deal with quantitative criteria. If, there is not available a quantitative value, some difficulty in the presence of qualitative criteria/a qualitative criterion a ranked value judgment conversion scale adopts [10]. In fuzzy set theory, linguistic terms are decided for the criteria's value to assign them weights after it they are converted into the crisp scores.

2.1.2 Electre Method

ELECTRE methods are the first representatives to outranking methods and have a number of versions basically I - IV; all are based on the same fundamental concepts but different mathematically in some extent. It is vital to note that ELECTRE is notbeing presented as the "best" decision aid [11].The ELECTRE original version has been utilized for the selection of a acyclic graph [12]. But it is not perfectto build a rank. Then advancement is done and the ELECTRE-II method has been invented [12-13]. The ELECTRE-III methodconducts for the imprecise, random and works with three thresholds (indifference, preference and veto threshold) to decide the performances of the alternatives. It also introduces a fuzzy outranking relation in place of a preference model having two crisp outranking relations only [14]. ELECTRE-IV methodgives ranking of alternatives has been designed to the relative importance indication of each criteria for specifically difficult situation [15]. For the sorting problem, evaluates the intrinsic value by assignthese values of each alternative to predefined categories, other electre methods have been designed [9, 15].

All ELECTRE methods comprise two main procedures: (i) building the outranking relation [12] and (ii) selection of problem statement [16]. The aim of construction of one or more outranking relations is comparison of each pair of actionsin comprehensive way. It pretends that one alternative dominates another one if sufficient advantages and no significant disadvantages are there. The Elaboration of recommendations is obtained in the first phase from the results by using exploitation procedure. Each method of out ranking is identified by the relation construction and exploitation procedures for outranking of criteria.

2.2 Multi Attribute Utility Theory

MAUT is ademanded utility theory that can choose the best course of action in a given problem by selecting a utility to every possible consequence and evaluating the best possible utility [17]. MAUT is an advance from of the MAVT as MAUT takes uncertainty into account for decision procedures. It has a utility, which is not an accounted quality for many MCDM methods. It is comprehensive, can account and incorporate the preferences

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of each action at every step of the method. This accuracy is convenient, despite it can lead to many possible disadvantages. Every step of the procedure require an incredible amount of input to record the decision maker's preferences accurately, making this method extremely data intensive. The preferences of the decision makers also should be exact or accurate to assign specific weights to each of the actions, which require strong assumptions at each level. It may be difficult to apply precisely and relatively subjective.The ability to take uncertain data for the decision into account is the MAUT lean on its major strength for common applications.

2.3 Analytical Hierarchy Process Method

The AHP is helpfultobuild the complexity, measurement and synthesis of rankings. The AHP has proved a theoretically sound and market-tested and accepted methodology and has been capable of producing results that agree with believes or opinions and expectations [17]. It is universally adopted as a new paradigm for decision-making joined with its ease of implementation and understanding part of its success [18] and provides decomposition of the problem into a hierarchy structure to easily comprehend and subjectively calculate. The subjective calculations are converted into numerical values after that processed to rank of each alternative and the methodology for the same is discussed in forthcoming steps [18].

Step 1: The hierarchy of problem is decomposed of target, criteria and sub-criteria. Hierarchy indicates a relationship between elements of one level with those of the level immediately below can be seen in Fig. 1 [21].

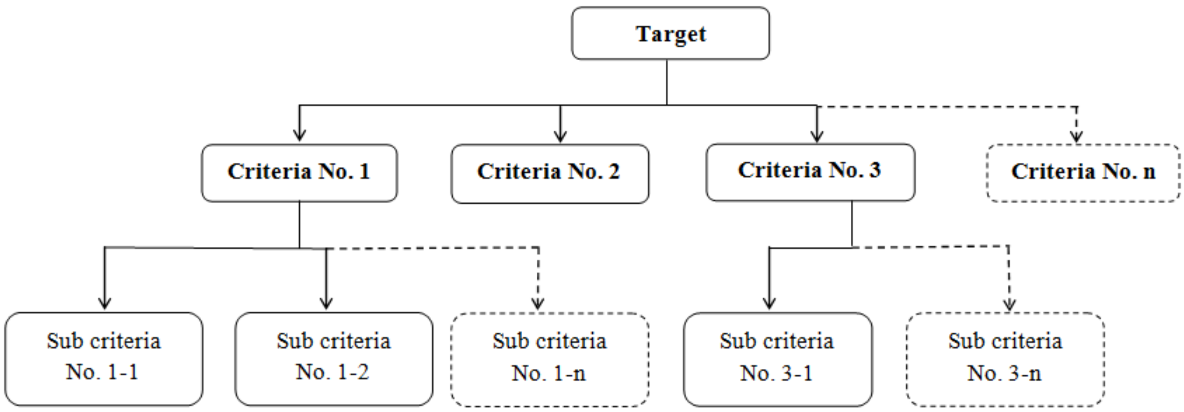

Fig. 1 Analytical Hierarchy Process of Criteria

Step 2: Data corresponds to the hierarchic structure is collected from experts or decision-makers; a qualitative scale for the pairwise comparison of alternatives is described in Fig. 2. Experts can rate the comparison as preferred, less preferred, fair, not preferred, and highly preferred. The opinion can be collected in a specially designed format as shown in Figure 2. "X" in the column marked "preferred" indicates that B is much preferred compared with A in terms of the criterion on which the comparison is being made. For each criterion's comparisons are doneand are converted into quantitative numbers.

A								"X"		B

ghly Preferred Less Not Fair Not Less Preferred Highly

Preferred Preferred Preferred Preferred Preferred Preferred

Fig. 2 Pairwise Comparison Format of Various Criteria

Step 3: The pairwise comparisons of various criteria generated at step 2 are arranged into a matrix. The matrix diagonal values are 1. The ith row criterion is better than criterion in the jth column when the element (i,j) value is more than 1; otherwise the criterion in the jth column is better than in the ith row. The (i,j) element of the matrix has reciprocal (j,i) element.

Step 4: The principal eigen value and the corresponding normalized right eigen-vector of the comparison matrix assignbeing compared different criteria's relative importance. Weights with respect to the criteria or sub-criteria and ratings with respect to the alternatives are given with the help of the normalized eigen vector elements.

Step 5: The consistency order of the matrix is calculated. Subjective comparisons are made by this method and the AHP faces inconsistency in the approach. If consistency index is less than a required level thenreexamine answers to comparisons. The consistency index, CI, is evaluated as:

$$CI = \frac{(\lambda_{max} - n)}{(n-1)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (1)$$

Where λ_{max} is the maximum eigen value of the judgement matrix. The CI can be compared with that of a random index, RI.There is a consistency ratio term whose value should be less than 0.1. The consistency ratio is a derived ration of consistency index and random index.

Step 6: To obtain the local rating with respect to each criteria rating of the alternatives is additively multiplied with weights function values matrix. The local ratings are multiplied by the weights of the criteria and then aggregated to obtain finalglobal ratings.

2.4 Analytical Network Process Method

The ANP is implemented in the software Super Decisions. ANP is a coupling of two parts: (i) A network of criteria and sub-criteria to control the interactions in the system,(ii) A network effects all the elements and clusters [20]. A decision network has clusters, elements, and links and the Cluster is the collection of related elements within a network. The determination of system clusters with their elements is done for each control criterion as like benefits, opportunities, costs, and risks etc. [14]. All interactions and feedbacks withinthe clusters are called innerdependencies whereas outer dependencies are interactions and feedbacks between the clusters. Inner and outer dependencies are utilized for decision-makers to capture and represent the concepts of being influenced, with respect to criteria between elements and clusters [17]. In the pairwise comparisons all the combinations of element/cluster relationships are used systematically. ANP issimilarly used the scale of comparison (1-9) as the AHP. This comparison scale enables incorporate of knowledge and experience of the decision-maker[19-20] and identified how many times an element impact on another with respect to the criterion. To express the decision-maker's preference between each pair of elements linguistic terms can be usedsuch as preferred, less preferred, fair, not preferred, and highly preferred. Table 1 below shows the comparative scale used by the analytical network process method for subjective preferences which will be converted into numerical values of odd and even intermediate values [21].

Table 1: Comparison Scale for ANP/AHP

Alternative	**Numerical value**	**Description**
Fair	1	Two action contribute similarly for the objective
Not preferred	3	Both Actions not contribute for the objective
Less preferred	5	Experience and judgement less favorable
Preferred	7	Experience and judgment highly favorable
Highly preferred	9	The highest possible order of affirmation in the evidence
Intermediate values to reflect fuzzy inputs	2,4,6,8	Sometimes one needs to add a numerically compromise judgment

The next section of study under reference provides a framework of comparison of some Multi-criteria decision making methods.

III. DISCUSSION

A large number of MCDM methods have been invented and utilized in several fields in past decades. On the analysis or literature reviewed for each method, is summarized in Table 2. There are mostly a usual pattern of improvement and development such as the changes from MAVT to MAUT and AHP to ANP. Ranking of the fuzzy subsets is obtained by the fusion of the outranking methods (PROMETHEE , ELECTRE) with some other methods / approaches such as AHP, ANP etc. Multicriteria outranking, MAVT, AHP methods are usually used in the certainty cases which contain explicitly defined alternatives. In the multicriteria uncertainty MAUT is prevalently used and it is the advancement of the MAVT with the inclusion of probabilities and risk attributes as utility have. Fuzzy ranking methods rate the result with some values with the help of quiet distinct methods (i) direct rating (decision maker attach a value to each alternative direct), (ii) Class rating (decision maker attach a value to a measurement scale of class or interval), (iii) Ratio evaluation (one take as reference and give value to others after comparison with the reference). A comparative framework of all the discussed methods with the features of the present study is discussed and presented in the Table 2.

Table 2: Comparison of Some Multi-criteria Decision Making Methods

	METHODS			
Features	**Outranking**	**MAUT**	**ANP**	**AHP**
Ease to use	Medium	Low	High	High
Working idea	In ELECTRE: Takes uncertainty and vagueness into account. In PROMETHEE: assumptions are not required as the criteria are proportionate.	Due to uncertainty into account and can incorporate preference.	Control network of criteria or sub-criteria to control the interactions in the system, and influences among the elements and clusters.	Hierarchy structure is used to easily adjust or fit many sized problems; not data Intensive.
Threat	In ELECTRE: the strengths and weaknesses of the alternatives are not be directly identified. In PROMETHEE: Assigning weights are difficult.	Preferencesfor a lot of input should to be accurate.	Linear top-to-bottom form of strict hierarchy, the ANP model provides a looser network structure and possibly represents any decision problem.	Interdependence between criteria and alternatives; influence thejudgment, ranking criteria, and rank reversal in consistencies.

After a detailed survey on different inventory methods used for MCDM, the authors presented a comparative framework for the same methods with the features as discussed and presented in the Table 1. The succeeding section presents the concluding remarks of the present study under reference.

IV. CONCLUSION

Combination of different methods have become often in MCDA as ease of use due to advance technology in upcoming years. The survey of present study contains and judges the some prevalent methods of decision making for benefit practitioners to select a method for optimal solution for management, knowledge etc. based specific problem because the study explored the comparison of Multi-criteria decision making methods for various features such as ease to use, working idea, and threat etc. to achieve the solution. Identification of prevalent MCDM methods with their strengths and threats are major step to establish a foundation stone for further research in this area. MCDM methods decision should contain less historical data, ex-post decision quality matter which are taken into accounts the views of all decision makers and at the end communicate the result which are responsible for the implementation field. Many researchers have devoted themselves to obtaining the appropriate balancing in the risk management, selection of appropriate items using recommendation systems which are the main application areas of the MCDM methods. Multi-class is used multiple criteria methods for accurate classification and processing a large number of inventory items.

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