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Investment Company Uses Multiple Attributes in Decision Making: A Fuzzy Approach

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Abstract - One definition of decision making is the act of selecting one or more alternatives from a set that are deemed desirable enough to be pursued in order to reach a goal or set of objectives. The decision-making process is quite unpredictable. Therefore, it is essential for a useful decision aid to be able to handle imprecise and confusing information, such as "huge" profits, "rapid" speed, and "cheap" price. Diversity of thought, perspective, and belief must be honored. A decision model that takes into consideration the identification, evaluation, and combination of criteria and alternatives is needed to represent the decision-making and evaluative processes in a fuzzy situation. Sometimes, we're faced with a dilemma that requires us to choose the optimal course of action based on a single factor, such the potential financial reward or the level of personal danger involved. However, the key to solving most problems in the real world is learning to make judgments based on a wide range of information.

Keywords - Investment Company, Multiple Attributes, Decision Making, Fuzzy Approach

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1. INTRODUCTION

Every day, people make a number of decisions, some of which have little repercussions and others of which may permanently impact their lives. The goal of Operations Research is to provide quicker, more knowledgeable, and more reliable solutions to problems that need decision making. Our ability to make sound judgments has a lot of space for improvement. Every decision has three key parts: objectives, choices, and limitations. Having access to this data may aid in making educated choices. Management makes most of the decisions. Managerial judgment is enhanced when decision theory is used.[1]

One definition of decision making is the act of selecting one or more alternatives from a set that are deemed desirable enough to be pursued in order to reach a goal or set of objectives. The decision-making process is quite unpredictable. Therefore, it is essential for a useful decision aid to be able to handle imprecise and confusing information, such as "huge" profits, "rapid" speed, and "cheap" price. Most real-world decision-making, according to Bellman and Zadeh, takes place in a context of uncertainty, when goals, constraints, and results of various courses of action are not known in advance. Any method used to make a choice might be hindered by missing or ambiguous information. Diversity of thought, perspective, and belief must be honored. A decision model that takes into consideration the identification, evaluation, and combination of criteria and alternatives is needed to represent the decision-making and evaluative processes in a fuzzy situation.[2]

Sometimes, we're faced with a dilemma that requires us to choose the optimal course of action based on a single factor, such the potential financial reward or the level of personal danger involved. However, the key to solving most problems in the real world is learning to make judgments based on a wide range of information. It may be challenging to arrive at a reasonable judgment when there are several aspects to think about.[3]

2. GENERAL CHARACTERISTICS OF MADM PROBLEMS

Most decisions in the real world involve weighing a number of competing considerations. When deciding between jobs, it's important to weigh a number of aspects, including salary, benefits, office location, job title, working conditions, shift pattern, and promotion potential. However, a business may need to assess candidates according to factors including education, academic accomplishment, work experience, collaborative abilities, and desired salary. There may be some differences across the various MADM cases, but there are also many similarities.[4]

Entities

Decision issues typically have ambiguous nomenclature, with criteria being both qualities and objectives and limitations being either targets or goals.

Alternatives

The decision-maker is faced with a finite collection of decision alternatives, each of which represents a potential choice or course of action. In a nutshell, the options may be summed up as $A_i = \{A_1, A_2, \ldots, A_m\}$, $i = 1, 2, 3, \ldots, m$, from which one must pick, filter, prioritize, or rank. Some synonyms for alternative include choice, contender, and action. The alternatives to be compared can be described in terms of how well they perform against each specific performance criterion related to the objectives or standards to be met.

A collection of things, goods, deeds, options, or methods. Examples of such lists include potential vehicle purchases and potential construction site locations.

Attributes

There are defining features of each option. They can stand in for actual, tangible things like size and color.

Objectives

For example, the purpose of purchasing an automobile takes into account factors like cost, top speed, and passenger comfort, all of which are aspects that will be utilized to evaluate success.

Preferences/weights

Consideration of the decision maker's values and priorities in descending order of importance is typically beneficial when making a selection. It exposes the criteria or goals that were used to assess the possibilities and their relative relevance. It is common practice to assign a weight (wj) to each criterion or characteristic in order to take it into consideration all through the decision-making process. To express their inter-attribute preferences, decision-makers may offer or be directed to the creation of the appropriate weights to utilize with characteristics. It is possible to either implicitly or explicitly convey the criteria level and information about weight or degree of importance. When criteria are not weighted, they are all considered equally important. The value of one feature in comparison to another across attributes, and inside an attribute, are referred to as inter-attribute preference and intra-attribute preference, respectively.[5]

In a loosely-defined scenario, attributes, weights, and objectives may all take the form of fuzzy sets. It's also possible that the linguistic variables underlying the qualities are themselves unclear. For example, the 'price' attribute may be further subdivided into the more concrete categories of "cheap," "moderate," and "expensive." Turban defines decision making as the process of choosing one action from a set of alternatives in order to achieve one or more goals. According to Bellman and Zadeh, "the objectives and/or the restrictions, but not necessarily the system under management, are fuzzy in character," making decisions in such an environment a challenge. In other words, the possibilities have hazy boundaries where the objectives and/or constraints are concerned.[6]

3. MULTIPLE ATTRIBUTES AND THE PRESENCE OF CONFLICTS

A collection of qualities, goals, or criteria by which an alternative's performances are measured is used to establish the set of traits by which each alternative is characterized and by which the alternatives are evaluated. It is common practice to treat these aims, criteria, or characteristics as distinct entities and define them as $C_j = \{C_1, C_2, \ldots, C_n\}$, $j = 1, 2, 3, \ldots, n$. To pick or rank among the alternatives, the decision maker must weigh the relative importance of each alternative's key features. A large number of qualities, some of which may be hierarchical in structure and in conflict with one another, make up a difficult choice dilemma in the real world. A MADM issue appears to need the existence of many criteria, and these criteria must be sufficiently at odds with one another for both intrapersonal and extrapersonal causes. A set of criteria is said to be conflicting if meeting all of them will compromise the ability to meet all of the others, even though the criteria themselves are not inherently incompatible. In particular, the qualities can be subdivided into sub-attributes in a hierarchical structure matching the actual choice problem, making it easier to deal with the difficult problem.[7]

Decision matrix

In the context of MADM, if $A_i = \{A_1, A_2, \ldots, A_m\}$, represents different available decision alternatives and $C_j = \{C_1, C_2, \ldots, C_n\}$ associates with the set of criteria, then the MADM problem can be concisely expressed as a decision matrix. The columns indicate the attributes to be considered and the rows refer to the predetermined alternatives. Accordingly, the performance rating of alternative Ai with respect to criterion Cj, reflects implicit intra-attribute preferences, as given by the rating of $A_{ij} = \{A_{11}, A_{12}, \ldots A_{mn}\}$. An mxn decision matrix A is a typical way to describe the overall rating of a MADM issue, where each cell represents the performance of option Ai with regard to a particular choice criterion Cj. Yet, it's worth noting that the challenge is made more difficult by the fact that different criteria used to evaluate the performance of an alternative may be connected with distinct units of measurement, either quantitatively or subjectively.

Incommensurable units

Each alternative may be measured against its own set of criteria. It is hard to put a single number on factors such as income, perks, location, prestige, working conditions, flexibility, and career chances while looking for a job. Certain characteristics can be measured quantitatively, but each characteristic has its own unique unit of measurement, such as money, distance, height, speed, area, etc. Yet, other factors, including reputation, workplace amenities, and adaptability, may be difficult to quantify quantitatively. Making a reasonable judgment in a choice scenario combining both quantitative and qualitative measurements is made more difficult by the use of several units of measurement. The normalizing of attribute ratings is often performed after the quantification of qualitative measurements to get rid of computational issues brought on by different measurement units.[8]

Uncertainty imprecision

In fuzzy decision making, there are typically three basic types of imprecision:

(1) Inadequate data, such as when certain possible answers or characteristics are missing; (3) illusion of validity in this type of imprecision due to the detection of erroneous outputs, such as the selection of alternatives that do not fulfill imposed criteria, such as receiving a high score for a car which is expensive when the criterion is that the car should be cheap.

Decisions may be made with more certainty in light of the many ideas and solutions that have been proposed to deal with the multiple causes of uncertainty that have been highlighted. However, the most significant frameworks for handling uncertainty in decision making are probability theory and fuzzy sets theory.[9]

4. CLASSICAL MADM METHODS

A decision-making problem is broken down into three distinct phases in classical decision theory.

- Structuring the problem: Objectives and Constraints
- Defining choices based on joint consideration of objectives constraints
- Identifying an optimal strategy over all possible choices

In this case, both declarative and procedural knowledge must be taken into account. The declarative component is relied on by decision-makers, since it describes "what" items (facts, words, ideas, etc.) are used and the relationships between them. The procedure component explains how this data may be used in subsequent calculations to draw a conclusion. This is where instructions or guidance are given. To aid decision makers in making sense of this information in the context of complex, real-world scenarios, decision support methods have been developed. The quality of decisions may be maintained via gathering relevant information, making inferences, and presenting findings. It is important that a decision support model may be easily scaled up or down depending on requirements. To effectively interact with users and human experts, a decision support model must be consistent with human natural language. It has to be able to reason with incomplete or missing information and a high degree of ambiguity. In certain cases, you need to make a judgment based on only one factor, such how much money or risk you're willing to take. However, in most real-world problems, you have to make choices depending on a lot of criteria. Without any kind of decision support system, it may be challenging to make a final conclusion when there are numerous elements to consider.[10]

A decision support model is required for multiple-attribute analysis if the following steps are to be carried out with any degree of precision: (a) correctly identify decision attributes and/or alternatives; (b) correctly weight these attributes based on their relevance to the decision; (c) precisely define the attainments of alternatives for each attribute; (d) aggregate attainments of each alternative with respect to attribute weights, providing a utility degree for each alternative; and (e) compare and rank the alternatives based on utility.

With these factors in mind, the next section will offer a summary of conventional methods for evaluating many criteria simultaneously. In this thesis, "I" and "j" represent different faculties and avenues for making choices, respectively.

Simple Additive Weighting Method

The overall score of an alternative is the weighted sum of its attribute values.

Procedure:

Step1- Compute weighted average of attribute attainments for each alternative.

Step2- Rank the alternatives based on the above computed scores.

There has to be a mathematical and consistent weighting system for the accomplishments. This is the most popular approach since it is straightforward. The total evaluation is based on a convergence of attainments and weights, which takes into account the tradeoff of qualities.

Weighted Product Method

It is recommended to use a product rather than a sum of values, with the attribute significance weights as the exponents, to punish alternatives with low attainment of attributes.

Procedure:

Step1- Raise each attribute attainment of an alternative to a power equal to the importance weights of that attribute. Then multiply the results over all attributes for that alternative.

Step2- Rank the alternatives based on the computer products.

Assumptions:

The attribute values and their weights must be both numerical and comparable.

This procedure is basic and straightforward. The convergence of accomplishments and weights are taken into account to arrive at an overall evaluation or tradeoff of qualities.

Distance from Target Method

There are problems where a desired value must be determined for each attribute. That's why it's important to compare the attribute value to some standard. There is a greater ranking for the alternative that is closer to the goal alternative.

Procedure:

Step1- For each alternative, compute the distance from target alternative:

$$d_i = \sqrt{\sum_{i=1}^{n} w_j^2 \left(x_{ij} - t_j\right)^2} \qquad i = 1, 2, \ldots, m$$

Where tj is the target value of attribute 'j'.

Step 2- Rank the alternatives based on their distance from target values.

Each metric has to have a predetermined goal associated with it. Attribute values and weights should both be quantifiable numbers that can be compared. This procedure is basic and straightforward. It weighs the importance of different accomplishments and traits to form an overall rating.[11]

5. FUZZY MADM METHODS

Fuzzy set theory generalizes earlier work in set theory to account for human fallibility within a precise mathematical framework. In fuzzy set theory, there is a great deal of elasticity since everything is a matter of degree. Fuzzy interpretations of data structures are particularly well-suited to the formulation and solution of a broad variety of practical difficulties because of their intuitive character. The philosophy upon which fuzzy sets are constructed is very similar to that upon which people think and make decisions. When parameter uncertainty is due to randomization, the stochastic method is utilized, but when the uncertainty is due to vague, ill-defined information and subjective opinions or assessments, the fuzzy logic method is used. Fuzzy set theory was first given by L.A. Zadeh in 1965. It's a more subtle approach than just saying "0" or "1" or "true" or "false," instead expressing uncertainty between those two poles. In accordance with the mathematical theory of sets, fuzzy set theory incorporates ideas like:[12]

A classical set is defined as a collection of elements: $A = \{x | x \in A\}$.

Therefore, for each element x, we can say that $x \in A$ OR $x \notin A$ (x belongs to A or not). It means that membership of x in A can be 1 or 0. Also a subset B of a classical set $A (B \subseteq A)$ is defined as $x \in B \Rightarrow x \in A$.

A fuzzy set is a collection of items that have varying degrees of "belonging" to the set. Membership function is a measure of this quality. This leads to the following definition of a fuzzy set:

$$\tilde{A} = \left\{\left(x, \mu_{\tilde{A}}(x)\right)\right\}$$

Support of a fuzzy set is a classical crisp set, which contains elements of that fuzzy set:

$$S(\tilde{A}) = \left\{x \middle| \mu_{\tilde{A}} x > 0\right\}$$

α– level set or α–cut of a fuzzy set is a classical crisp set, which contains elements of that fuzzy set with a membership function of at least α:

$$A_\alpha = \left\{x \middle| x \in \tilde{A}, \mu_{\tilde{A}} x \geq \alpha\right\}$$

$A'\alpha$ is called a strong a–cut of the fuzzy set $\tilde{A}$ if:

$$A_\alpha = \left\{x \middle| x \in \tilde{A}, \mu_{\tilde{A}} x \geq \alpha\right\}$$

A fuzzy set $\tilde{A}$ is called convex if its membership function is a convex function:

$$\forall x_1, x_2 \in \tilde{A}, \lambda \in [0,1] \Rightarrow \mu_{\tilde{A}}(\lambda x_1 + (1-\lambda)x_2) \geq Min(\mu_{\tilde{A}}(x_1), \mu_{\tilde{A}}(x_2))$$

Operations with fuzzy sets are defined via their membership functions.

Assume that $\tilde{A} = \left\{\left(x, \mu_{\tilde{A}}(x)\right)\right\}$ and $\tilde{B} = \left\{\left(x, \mu_{\tilde{B}}(x)\right)\right\}$ are fuzzy sets:

Intersection of fuzzy sets $\tilde{A}$ and $\tilde{B}$ is a fuzzy set $\tilde{C}$ defined as:

$$\tilde{C} = \tilde{A} \cap \tilde{B} = \left\{\left(x, \mu_{\tilde{C}}(x)\right) \middle| \mu_{\tilde{C}}(x) = \mu_{\tilde{A}}(x) \wedge \mu_{\tilde{B}}(x) = Min\left(\mu_{\tilde{A}}(x), \mu_{\tilde{B}}(x)\right)\right\}$$

Union of fuzzy sets $\tilde{A}$ and $\tilde{B}$ is a fuzzy set $\tilde{C}$ defined as:

$$\tilde{C}=\tilde{A}\cup\tilde{B}=\left\{\left(x,\mu_{\tilde{C}}(x)\right)\middle|\mu_{\tilde{C}}(x)=\mu_{\tilde{A}}(x)\vee\mu_{\tilde{B}}(x)=Max\left(\mu_{\tilde{A}}(x),\mu_{\tilde{B}}(x)\right)\right\}$$

Complement of fuzzy set $\tilde{A}$ is a fuzzy set defined as:

$$\tilde{A}=\not\subset\tilde{A}=\tilde{A}'=\left\{\left(x,\mu_{\tilde{A}}(x)\right)\middle|\mu_{\tilde{A}'}(x)=1-\mu_{\tilde{A}}(x)\right\}$$

Cartesian product of fuzzy sets $\tilde{A}_1,\tilde{A}_2,\ldots,\tilde{A}_n$ is a fuzzy set $\tilde{C}$ called Cartesian fuzzy set:

$$\tilde{C}=\tilde{A}_1\times\tilde{A}_2\times\ldots\times\tilde{A}_n$$

$$=\left\{\left(y,\mu_{\tilde{C}}(y)\right)\middle|y=(x_1,x_2,\ldots,x_n)\mu_{\tilde{C}}(y)=Min(\mu_{\tilde{A}}(x_1),\mu_{\tilde{A}}(x_2),\ldots,\mu_{\tilde{A}}(x_n)\right\}$$

m th power of a fuzzy set $\tilde{A}$ is defined as a fuzzy set:

$$\tilde{A}^m=\left\{\left(x,\mu_{\tilde{A}^m}(x)\middle|\mu_{\tilde{A}^m}(x)=\left[\mu_{\tilde{A}}(x)\right]^m\right)\right\}$$

Bounded sum of fuzzy sets $\tilde{A}$ and $\tilde{B}$ is a fuzzy set $\tilde{C}$ defined as:

$$\tilde{C}=\tilde{A}\oplus\tilde{B}=\left\{\left(x,\mu_{\tilde{C}}(x)\right)\middle|\mu_{\tilde{C}}(x)=Min\left(1,\mu_{\tilde{A}}(x)+\mu_{\tilde{B}}(x)\right)\right\}$$

Bounded difference of fuzzy sets $\tilde{A}$ and $\tilde{B}$ is a fuzzy set $\tilde{C}$ defined as:

$$\tilde{C}=\tilde{A}\quad\tilde{B}=\left\{\left(x,\mu_{\tilde{C}}(x)\right)\middle|\mu_{\tilde{C}}(x)=Min\left(1,\mu_{\tilde{A}}(x)+\mu_{\tilde{B}}(x)\right)\right\}$$

Functions on fuzzy sets are defined via their elements and membership functions. Let $\tilde{A}=\left\{x,\mu_{\tilde{A}}(x)\right\}$ be a fuzzy set and f be a real valued function $(f:\Re\to\Re)$:

Extension Principle: $f(\tilde{A})$ is a fuzzy set which maps from $\tilde{A}$ into a fuzzy set $\tilde{B}$:

$$\begin{cases} f(\tilde{A})\to\tilde{B} \\ \tilde{B}=f(\tilde{A})=\left\{(y,\mu_{f(\tilde{A})}(y))\mid y=f(x),\mu_{f(\tilde{A})}(y))=\sup_{f^{-1}(y)}(\mu_{\tilde{A}}(x))\right\} \end{cases}$$

Cartesian function $f(\tilde{A}_1,\tilde{A}_2,\ldots,\tilde{A}_n)$ on fuzzy sets $\tilde{A}_1,\tilde{A}_2,\ldots,\tilde{A}_n$ is defined as:

$$\begin{cases} f(\tilde{A}_1,\tilde{A}_2,\ldots,\tilde{A}_n)\to\tilde{B} \\ \tilde{B}=f(\tilde{A}_1,\tilde{A}_2,\ldots,\tilde{A}_n)=\left\{(y,\mu_{\tilde{B}}(y))\right\} \end{cases}$$

Where $y=f(x_1,x_2,\ldots,x_n)$ and $\mu_{\tilde{B}}(y))=\sup_{f^{-1}(y)}(Min(\mu_{\tilde{A}}(x))$

Therefore, the real valued function f(x, y) (o is an algebraic operation like +, -, ∗, ÷, etc.) on fuzzy sets $\tilde{A}_1$ and $\tilde{A}_2$ defines a fuzzy set $\tilde{B}$:

$$\tilde{B}=f(\tilde{A}_1,\tilde{A}_2)=\left\{(y,\mu_{\tilde{B}}(y))\mid y=x_1\circ x_2,\mu_{\tilde{B}}(y))=\sup_{f^{-1}(y)}\left\{Min(\mu_{\tilde{A}_1}(x),(\mu_{\tilde{A}_2}(x)\right\}\right\}$$

Maximizing set of a real valued function f which is bounded from below by “L” and from above by “U” is defined as:

$$M_f=\left\{(x,(\mu_{\tilde{M}_f}(x))\mid\mu_{\tilde{M}_f}(x)=\frac{f(x)-L}{U-L}\right\}$$

Fuzzy maximum of a real valued function $f:\tilde{A}\to\tilde{B}$ is defined as:

$$M\tilde{a}xf=\left\{(z,\mu_{M\tilde{a}xf}(z))\mid z=Max(y),\mu_{M\tilde{a}xf}(z)=Min(\mu_{f(\tilde{A})}(y))\right\}$$

Fuzzy minimum of a real valued function $f:\tilde{A}\to\tilde{B}$ is defined as:

$$M\tilde{i}nf=\left\{(z,\mu_{M\tilde{i}nf}(z))\mid z=Min(y),\mu_{M\tilde{i}nf}(z)=Min(\mu_{f(\tilde{A})}(y))\right\}$$

6. CONCLUSION

In order to better handle ambiguity, more and more people are turning to fuzzy sets and intuitionistic fuzzy sets. Over the course of the last several decades, researchers have pursued many avenues of investigation into these collections. This has also helped solve many problems in the real world. Chapter one consists of a comprehensive literature analysis of both classic and cutting-edge studies in the study's main areas, with the goal of identifying research gaps. This chapter also provides an overview of the work presented in the next chapters, as well as basic definitions and study goals

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