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Research Paper

Construction of fuzzy multi-attribute group decision-making method

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Abstract: *The purpose of this study is to assist business managers in dealing with decision-making issues related to R&D project selection. In order to minimize the distance between fuzzy numbers representing expert fuzzy opinions in the decision-making process, this article adopts the method of measuring the distance between fuzzy numbers and conducts a repeated calculation program to optimize the consistency of the expert group. The fuzzy multi-attribute group decision-making method constructed in this article divides the relevant attributes of decision evaluation into three dimensions: performance, time, and risk. For the fuzzy decision matrix generated after each dimension operation, the decision box screening method developed in this study is used to place the clear values obtained after de fuzzification on the decision plane composed of performance, time, and risk axes in the decision box, in order to identify various decision environments, the best alternative solution closest to a positive ideal solution and the closest to a negative ideal solution. This enables decision-makers to make decisions that best align with the company's goals in the constantly changing industrial environment when selecting research and development projects.*

Keywords*: project selection; fuzzy multi-attribute; decision matrix*

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I. Introduction

Buckley, J.J. [2] argue that the decision-making problem of project selection essentially involves selecting the option that best aligns with the development goals of the enterprise from a set of suitable solutions. During the entire decision-making process, when decision-makers have a vague understanding of their preference for various alternative solutions, or when precise numerical values cannot be used to evaluate their preference for solutions, using semantic nouns instead of numerical evaluation may be a more practical method. The value of semantic nouns is not numerical values, but artificial language sentences that conform to human thinking logic. Due to the use of semantic noun concepts, it fills the gap of ambiguity in the decision-making process. The ultimate goal of the company's research and development project selection is its sustainable operation. Therefore, in a situation where customers, competitors, and information all change over time, an effective and correct method for selecting research and development projects is crucial for the long-term development of enterprises.

Therefore, this study constructs a fuzzy multi-attribute group decision-making method for the selection of enterprise R&D projects. This method divides the evaluation factors for R&D project selection into three dimensions: performance, time, and risk, and optimizes the fuzzy weights and fuzzy opinions of the relevant attributes of each evaluation factor. Therefore, for

In order to provide decision-makers with a comprehensive evaluation of R&D project selection in a dynamic environment, this study integrated the methods of Chen, C.T. [4], and proposed a decision box model based on fuzzy operations as the screening method for the best alternative solution. The purpose is to determine the alternative solution that is farthest from the negative ideal solution and closest to the positive ideal solution, for reference by enterprise managers in decision-making.

II. Research model

This study focuses on the development of fuzzy multi-attribute group decision-making methods for project selection, which can optimize the fuzzy opinions of group decision-making and enable decision-makers to make the most favorable decisions for enterprises based on different factors and changing industrial environments in decision-making practice. The fuzzy multi-attribute group decision-making method constructed in this study is as follows

Stage 1: Collect project related data and establish a project selection decision-making committee.

（1）Collect project related data based on the company's development strategy, short-term and long-term goals, available resources, technical capabilities, and customer needs.

（2） Establish a research and development project selection decision-making committee Ep.

Among them, Ep Å □ E1, E2,..., EP Å, p Å 1, 2,..., P, P Å 2.

（3） Conduct preliminary screening of research and development projects to form a suitable set of alternative solutions.

（4） Based on the collected project related data, select the evaluation dimensions and attributes of the R&D project.

（5） Define the set of alternative solutions Am, and the set of attributes Cn:

Among them, Am Å □ A1, A2,..., Am Å, m Å 1, 2,..., M, M Å 2.

Cm Å □ C1, C2,..., Cm Å, n Å 1, 2,..., N, N Å 2.

（6） Define relevant semantic measurement scales.

1. Define the weight semantic measurement scale of attributes.
2. Define performance semantic measurement scales for attributes
3. Define the corresponding attribution function of triangular fuzzy numbers.

（1） Calculate the performance, time, and risk of each decision member, and the fuzzy pairwise comparison matrix Ep of the three dimensions.

（2） Using the geometric averaging technique of equations (2.12-2.14), calculate the fuzzy synthesis of each facet Paired comparison matrix a, and normalized fuzzy comprehensive weight matrix W, as shown in equation

(P, T, R)

Equation (3.1).

W 1 61690

W(P, T, R)

(3.1) Wn

Among them, P, T, and R represent three dimensions: performance, time, and risk.

III. Empirical Research

After preliminary screening by the decision-making committee, X Company retained a set of five suitable alternative solutions for the R&D project selection of its next generation products. The decision-making committee combines past product research and development experience, market demand status, customer opinion surveys, existing resources and technical capabilities, enterprise development strategies and goals, and other relevant factors to classify the selection of research and development projects into three dimensions: performance, time, risk, and thirteen evaluation attributes.

l	W (l)					R (l + 1)				S2 (R1,R(1))	S2 (R2,R(1))	S2 (R3,R(1))	S2 (R4,R(1))	S2 (R5,R(1))
0	**1**	**0**	**0**	**0**	**0**	**0.1000**	**0.3000**	**0.3000**	**0.5000**	**1.0000**	**0.5895**	**0.9506**	**0.8025**	**0.9506**
1	**0.3149**	**0.1729**	**0.2866**	**0.2257**	**0.2949**	**0.3088**	**0.5088**	**0.5088**	**0.6974**	**0.9476**	**0.8301**	**0.9999**	**0.9535**	**0.9999**
2	**0.2538**	**0.2093**	**0.2804**	**0.2566**	**0.2731**	**0.3705**	**0.5705**	**0.5705**	**0.7531**	**0.9125**	**0.8806**	**0.9945**	**0.9778**	**0.9945**
3	**0.2361**	**0.2239**	**0.2744**	**0.2656**	**0.2643**	**0.3915**	**0.5915**	**0.5915**	**0.7715**	**0.8986**	**0.8957**	**0.9907**	**0.9840**	**0.9907**
4	**0.2303**	**0.2292**	**0.2720**	**0.2685**	**0.2611**	**0.3986**	**0.5986**	**0.5986**	**0.7778**	**0.8936**	**0.9007**	**0.9891**	**0.9859**	**0.9891**
5	**0.2284**	**0.2311**	**0.2711**	**0.2694**	**0.2600**	**0.4011**	**0.6011**	**0.6011**	**0.7799**	**0.8919**	**0.9023**	**0.9886**	**0.9865**	**0.9886**
6	**0.2277**	**0.2317**	**0.2708**	**0.2697**	**0.2596**	**0.4019**	**0.6019**	**0.6019**	**0.7806**	**0.8913**	**0.9029**	**0.9884**	**0.9867**	**0.9884**
7	**0.2275**	**0.2319**	**0.2707**	**0.2698**	**0.2595**	**0.4022**	**0.6022**	**0.6022**	**0.7809**	**0.8911**	**0.9031**	**0.9883**	**0.9868**	**0.9883**
8	**0.2274**	**0.2320**	**0.2707**	**0.2699**	**0.2595**	**0.4023**	**0.6023**	**0.6023**	**0.7809**	**0.8910**	**0.9031**	**0.9883**	**0.9868**	**0.9883**
9	**0.2274**	**0.2320**	**0.2707**	**0.2699**	**0.2594**	**0.4024**	**0.6024**	**0.6024**	**0.7810**	**0.8910**	**0.9032**	**0.9883**	**0.9868**	**0.9883**
10	**0.2274**	**0.2321**	**0.2707**	**0.2699**	**0.2594**	**0.4024**	**0.6024**	**0.6024**	**0.7810**	**0.8910**	**0.9032**	**0.9883**	**0.9868**	**0.9883**

Calculate the semantic average evaluation value xij of the kth decision maker on the jth attribute in the ith scheme, and the semantic weight average evaluation value w j of each attribute is shown in equations (2.36).

IV. Result

The decision-making problem of project selection is to select the most suitable solution that best meets the enterprise's goals from a suitable set of alternative solutions, and make the most appropriate use of limited resources. However, in fiercely competitive industries, decision-makers face complex, fuzzy, and uncertain decision-making environments. Enterprises must adopt a more cautious attitude in order to improve the success rate of project management. The commonly used method for project selection is to refer to the professional knowledge of experts, but these experts often solve such uncertain decision-making problems in a fuzzy way. In order to enable decision-makers to effectively apply this vague opinion in project selection, this study constructs a project selection model that can simultaneously examine three dimensions of performance, time, and risk. X Company is used as a case study to verify the feasibility of this model. It is hoped that in the decision-making process of project selection, uncertainty in the real situation can be eliminated.

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