Research on Evaluation Method Based on Different Principles

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Abstract: Reasonable and effective evaluation methods are of great significance for measuring the service level and economic benefits of enterprises and individuals, and can better assist managers in making decisions. First of all, this paper introduces the commonly used evaluation methods and the five-element connection number method based on set pair analysis, explains their principles respectively. Secondly, the paper analyzes their respective advantages and disadvantages. Finally, the paper summarizes and compares them. The comparison results presented in this paper show that although each evaluation method has its own application field, it is not applicable to all evaluation systems. The advantages and disadvantages of these evaluation methods should be weighed comprehensively when evaluating specific systems.

Foreign scholars study the evaluation earlier, and the conventional evaluation methods are fuzzy set theory and analytic hierarchy process (AHP). The evaluation of evaluation by domestic scholars started late, and the commonly used evaluation methods are AHP, gray clustering method, fuzzy comprehensive evaluation method, data envelope analysis (DEA), etc. In the beginning, many domestic scholars mostly used a certain method to conduct model evaluation in many evaluation studies. Subsequently, scholars prioritize the advantages of different evaluation methods when constructing models, and reorganize their methods to pursue more accurate evaluation results.

1. Introduction to Evaluation Methods

1.1 Common Evaluation Methods

1.1.1 Analytic hierarchy process

In the 1970s, American operations researcher Professor T.L. Saaty first proposed the Analytic Hierarchy Process (AHP) for solving multi-objective, multi-criteria, multi-factor, and multi-level problems [1]. AHP classifies the decision-making problem studied into different hierarchical structures, usually divided into target layer, criterion layer, and plan layer (or index layer). The eigenvectors and eigenvalues are solved by constructing a judgment matrix of 1-9 scale. The weights of the indicators are given, and the consistency test is carried out. Finally, the indicators of the upper level are weighted and summed from the bottom level until the summation data of the target layer is obtained, and then sorted according to their size [2]. The hierarchy diagram is shown in Figure 1.
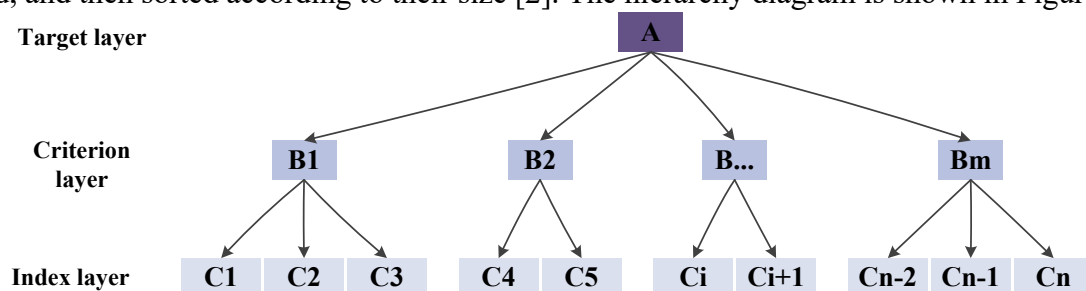

Fig. 1. Hierarchy diagram

1.1.2 Grey clustering method

GCM was proposed by Professor Deng Julong of China. By constructing the whitening function,

the gray unclear system is transformed into a white clear system, and the clustering principle is used to classify different observation systems [3]. GCM assigns weights to different indicators based on different forms of whitening functions [4], quantizes the indicators of the gray system into computable indicators, and finally weights the indicator data for clustering judgment [5]. At present, GCM is often used in evaluation systems in the fields of water quality, air pollution, and public transportation.

1.1.3 Fuzzy comprehensive evaluation

Fuzzy set theory was proposed by American automatic control expert Professor L.A. Zadeh in 1965 to express the uncertainty of things [6]. The membership degree of fuzzy mathematics is used to transform qualitative problems into quantitative data, so as to solve fuzzy and difficult to quantify non-deterministic problems. Fuzzy Comprehensive Evaluation (FCE） uses fuzzy operators to set up the index membership and fuzzy evaluation matrix, and uses fuzzy operators to evaluate the data of the evaluation system, and finally obtains quantitative evaluation results.

1.1.4 Data envelopment analysis

Data Envelopment Analysis (DEA) is a method to solve the problem of efficiency evaluation. It was first proposed by the famous American operations researcher Charnes and others. DEA uses decision making unit (Decision Making Unit, DMU) as the basic unit. It was originally used to study single-input and single-output problems. Later, scholars generalized it to multiple-input and multiple-output problems [7]. DEA is mainly used to analyze the relative efficiency of input and output. It regards the evaluated unit as DMU and comprehensively evaluates multiple DMUs. The DEA method has many applications in performance evaluation, economic efficiency evaluation, and effectiveness evaluation.

1.2 Five-Element Connection Number

Chinese scholar Zhao Keqin first proposed set pair analysis theory in 1989. Connection mathematics is a mathematical expression based on set pair analysis theory. It is used to deal with complex decision-making problems with certainty and uncertainty. Connection number is a characteristic function used in set pair analysis to describe the degree of connection between two sets, also known as the same, different, and inverse connection number [8]. Five-Element Connection Number (FECN) is an evaluation method developed based on set pair analysis theory. By constructing the "same degree", "difference degree" and "opposite degree" of the set to be evaluated and the ideal set, combining the partial connection number of each order and the set pair potential to determine the development trend and situation of the evaluation system, and finally judging the evaluation system by confidence Level. The corresponding diagram is shown in Figure 2. FECN refers to dividing the evaluation level into five levels, hence the name. FECN has been widely used in the fields of modern scientific management, system control, decision analysis, pattern recognition, and economic problem research, but it is still under development.
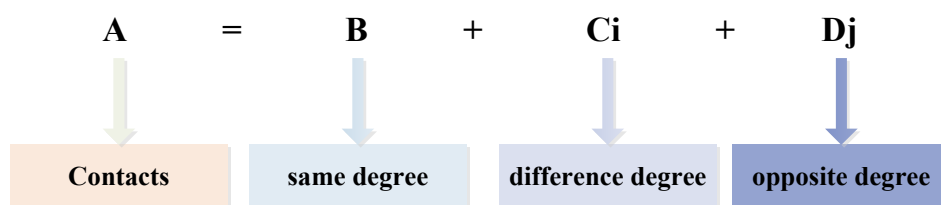
$$A \quad = \quad B \quad + \quad Ci \quad + \quad Dj$$

| Contacts | same degree | difference degree | opposite degree |

Fig. 2. Mapping of five-yuan contact number and contact degree

2. Comparison of Evaluation Methods

2.1 Element Comparison

The comparison between common evaluation methods and FECN adopted in this paper is shown

in Table 1.

Table 1 Comparison of Method Elements

Evaluation method	Weight determination method	Key function	Applicability
AHP	Subjective assignment	Consistency index	Solve complex decision-making problems with many goals and elements
GCM	Objective assignment	Whitening function	Solve the complex and random gray system of the relationship between the elements.
FCE	Subjective assignment	Fuzzy evaluation matrix and fuzzy operator	Solve vague non-deterministic problems.
DEA	Subjective assignment	Efficiency evaluation index	Evaluate the effectiveness of a system with multiple input and multiple output units.
FECN	Subjective and objective assignment	Connection number, partial connection number, set pair potential	Solve the problem of uncertainty classification and trend prediction.

2.2 Comparison of Advantages and Disadvantages

2.2.1 AHP

● Advantage

1) Use the idea of hierarchical analysis to simplify complex problems; 2) The principle is simple and easy to understand; 3) The amount of data required is small, and subjective opinions are considered more for qualitative analysis.

● Disadvantages

1) The analysis results are incomplete and cannot provide new solutions for decision-making; 2) The amount of data required is too small, qualitative analysis, lack of quantitative data support, and the credibility is not high; 3) Only applicable to systems with few evaluation indicators; 4) Consistency testing needs to be repeated, and weight calculation is cumbersome.

2.2.2 GCM

● Advantage

1) The gray system that can effectively evaluate the coexistence of clear and unclear information; 2) There is no strict requirement on the sample size and its distribution; 3) The calculation workload is also small.

● Disadvantages

1) Using the traditional whitening function to calculate the index to the whitening function of the evaluation level, there will be more zeros, and there is a loss of information, which leads to deviations in the evaluation results; 2) Different whitening functions may have different evaluation results, that is, the form of the whitening function Impact evaluation results.

2.2.3 FCE

● Advantage

1) The fuzzy problem can be quantified through the membership function; 2) The fuzzy applicability is strong, which can not only evaluate the subjective system, but also the objective system.

● Disadvantages

1) Large amount of calculation, when constructing fuzzy judgment matrix to calculate index weights, subjectivity is strong; 2) When there are many indexes, constructing matrix calculation weights will have more indexes with similar weights, and it is impossible to judge the degree of membership.

2.2.4 DEA

Advantage

1) The relative efficiency of input and output is used for evaluation, the principle is simple, and there is no need to perform non-quantitative processing on the data; 2) The weight can be given by the model, which depends on the actual data and has strong objectivity.

Disadvantages

1) The weights are automatically generated by the model, and often do not match the index weights of concern to the decision makers, which affects the evaluation results; 2) The evaluation results are the relative development levels of each unit, and it is impossible to obtain independent actual levels.

2.2.5 FECN

● Advantage

1) By constructing the connection degree of the two sets, the degree of connection between the evaluation system and the evaluation level can be intuitively displayed; 2) The partial connection number can objectively reflect the development trend of the indicator and assist decision makers to make correct decisions; 3) The calculation method is simple, evaluation and prediction results are scientific and reasonable.

● Disadvantages

FECN cannot calculate the index weight, and the evaluator needs to combine other methods to calculate the index weight.

3. Conclusion

This paper first introduces in detail the basic principles of commonly used evaluation methods such as analytic hierarchy process, gray clustering method and fuzzy comprehensive evaluation, and data envelopment method. At the same time, it introduces the five-element connection number method and makes a comprehensive comparison of them, pointing out their respective advantages and disadvantages. And its applicable conditions. The comparison results show that although each evaluation method has its own application field, it is not applicable to all evaluation systems, and the advantages and disadvantages of these evaluation methods should be weighed comprehensively when evaluating specific systems.

Because the evaluation system is affected by many factors, the research on evaluation methods is still in the exploratory stage. On this basis, it is necessary to make a deeper academic research on the following work. Set pair theory and its quaternary connection number are still in the development stage, and their relevant properties and theories are not yet perfect, but studies have shown that this method can be used for systematic evaluation. In the future, it can be combined with traditional evaluation methods to obtain their respective advantages, and then construct a more reasonable evaluation model.

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