

Research Article

Analysis and Evaluation of Enterprise Performance Appraisal Index Based on Fuzzy AHP Model

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The decisive and decision-making challenges of business investment are for the good development of enterprises. In order to have a better market advantage of chemical granules for enterprises, the analytic hierarchy process (AHP) is constructed to analyze the company's performance. Under the environment of state-owned enterprises and foreign enterprises competing for market resources together, building a performance evaluation system suitable for the development stage of the company can adjust the planning strategy and analyze its own disadvantages in time. When analyzing the effective combination of performance appraisal and enterprise development, as well as the effective communication between employees and enterprise managers, feedback information is obtained through the experimental results. Under this analysis condition, this paper describes the feasibility and soundness of the AHP model system for enterprises, and what favorable decision-making methods can be provided for later development. Based on the selection of performance evaluation indicators, AHP analysis can clearly get the weight of each indicator and the correlation between them, in order to improve and build a new system of evaluation indicators. This paper concludes the following: (1) based on the analysis of enterprise performance appraisal indicators, using the AHP model evaluation method to calculate the indicators, the optimized indicators for the performance appraisal of the comprehensive and efficient significantly improved. (2) Comparing the traditional AHP calculation with the optimized model calculation, the results show that under the optimized calculation, the index is more concise and the fluctuation is reduced, which reduces the burden on administrators. (3) In the membership degree of index evaluation grade, the membership degree with an excellent grade is 0.9, which shows that the index plays a very important role in evaluation. (4) According to the development indicators of enterprises in recent years, it is found that the growth rate of resources is growing slowly, the demand for the talent market is still in a stable state as always, and its financial resources have increased by 120% in 2016.

1. Introduction

In today's world, enterprises are undergoing great changes, and various industries are entering the high-end leading market. In the early stage of enterprise development, it is necessary to carry out performance appraisals to meet the requirements of commercial supply and demand, so it is particularly important to choose appropriate and accurate evaluation indicators. Under the experimental research of the analytic hierarchy process, the reasonable and accurate selection of indicators will be the only way for the development of enterprises and security considerations. The economic situation at home and abroad has become

complicated, competition is fierce, and management strengthening, innovation reform, and economic performance are very urgent. Grasping the future development environment of an enterprise is the basic guarantee for the survival of the future market, and a reasonable evaluation of performance from the side is the performance of improving competitiveness. At the present stage of development, who first realizes a complete set of performance system evaluation standards will greatly improve the scientific nature of enterprise operation and management operation. Understand the scientific performance evaluation method, establish a correct, objective, and fair way to judge the economic effect of enterprises, and improve the performance of

enterprises by the AHP classification method, so as to realize the overall economic development. This paper analyzes the relationship between executives and compensation and evaluates whether it is reasonable to evaluate the actual ability of executives by performance appraisal [1]. It discusses the influence of innovative technology on enterprise performance and proves that the improvement of performance will promote the development of innovative enterprises [2]. It puts forward the concept of big data enterprise and discusses it, and studies the relationship between business performance and R&D investment [3]. The capital increment rate of added value is used to measure the performance of enterprises, and the simultaneous equations model is constructed to empirically analyze the effect of compensation incentives and equity incentives for R&D investment managers on high and new technology [4]. It systematically combs the research trends of performance correlation in China and clearly points out three basic characteristics of this research field [5]. Using Poisson fixed-effect model regression method, this paper tests the moderating effect of executives' incentives, innovation investment, and innovation performance, and executives' "dual" capital [6]. It discusses the influence of salary control on R&D activities of state-owned enterprises and reveals the mechanism between them [7]. It is analyzed that motivating employees has a high development effect on the production of enterprises to achieve high performance, and makes financial performance, and operational performance play a full regulatory role [8]. Selecting communication equipment, computer and other electronic equipment manufacturing, pharmaceutical manufacturing, and daily chemical products manufacturing as samples, this paper analyzes the impact of R&D expenditure and advertising expenditure on enterprise economic performance in these three industries [9]. Investment in R & D and personnel incentives will have a good chemical reflection on the innovation performance of enterprises, which is a good development strategy for enterprises [10]. The theoretical model of technological innovation performance is constructed, and regression analysis is used to analyze enterprise resources [11]. Exploring the influence relationship between R&D investment intensity and enterprise value is conducive to promoting enterprises to successfully break through the life cycle limit through R&D strategy [12]. It examines the relationship between executive compensation incentives and enterprise performance and shows that the relationship between them has a significant negative moderating effect [13]. This paper explores the potential mechanism of the impact of venture capital support on enterprise innovation and further analyzes the impact of venture capital support on enterprise innovation investment efficiency [14]. It discusses the mathematical relationship between industry input and output and carries out a linear regression analysis on the relationship between investment and performance of the manufacturing industry in China [15]. In enterprise performance management, usually because of more index systems, in order to correctly evaluate and describe the role of different indicators in enterprise performance management, it is

necessary to carry out a hierarchical analysis of the index system, so as to determine the weight of each index in the different index system. In order to achieve in the enterprise management of some indicators continue to improve the corresponding indicators, and improve the enterprise management system.

2. Fuzzy AHP Model Analysis

2.1. Fuzzy Sets and Membership Functions. It is defined in the region U , and A is a fuzzy subset of the region. For any element in the region, there is a deterministic function, that is,

$$\begin{aligned} f &= UA(x), \\ x &\in [0, 1]. \end{aligned} \quad (1)$$

As a mathematical tool for the analysis of uncertain problems, fuzzy sets usually adopt the method of a comprehensive evaluation to combine quantitative and qualitative analysis.

2.1.1. Analysis of Fuzzy Comprehensive Evaluation Method. In order to combine fuzzy mathematics with realistic evaluation problems and use quantitative methods to evaluate problems, objective index data sets are constructed to determine the membership degree. The specific evaluation steps are as follows:

- (1) The establishment of evaluation object and index set
The index set of evaluation object P is

$$U = \{u_1, u_2, \dots, u_n\}. \quad (2)$$

Where n is the number of evaluation factors and u is the index value.

- (2) Determination of evaluation grade V
Grade function [16] is defined as

$$v = \{v_1, v_2, \dots, v_m\}. \quad (3)$$

M is the number of index grades, and V can select the appropriate evaluation grade, such as

$$V = \{Excellent, Good, Medium, bad\}. \quad (4)$$

- (3) Calculate the weight vector A [17].
Determine the importance of indicators.

$$A = \{a_1, a_2, \dots, a_n\}. \quad (5)$$

A represents indicator weights and satisfies

$$\sum_{i=1}^n a_i = 1. \quad (6)$$

- (4) Establishing fuzzy evaluation matrix R
The evaluation matrix R is obtained by fuzzy evaluation of the evaluation grade V in the U region.

Evaluation matrix [18]:

$$R = \begin{bmatrix} r_{11} & \cdots & r_{1m} \\ \vdots & & \vdots \\ r_{n1} & \cdots & r_{nm} \end{bmatrix}, \quad (7)$$

where R is the evaluation object, which meets the conditions

$$\sum r_{ij} = 1. \quad (8)$$

(5) Comprehensive evaluation index [19]:

The comprehensive result of weight vector A and evaluation matrix R is obtained by fuzzy synthesis algorithm, which is represented by B :

$$B = A \bullet R = \{b_1, b_2, \dots, b_m\}. \quad (9)$$

B is the membership degree under each level, and the comprehensive index is obtained from single-level fuzzy evaluation to multi-level calculation.

(6) The final evaluation result of the experiment.

According to the evaluation score, the final grade is obtained, and the specific steps are as shown in Figure 1.

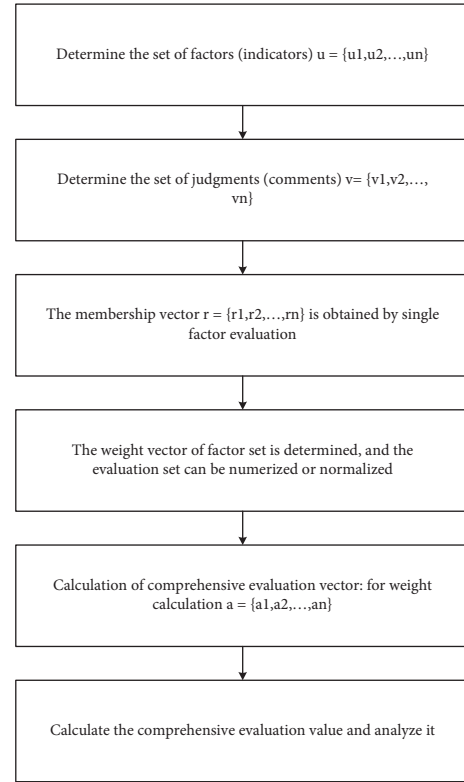


FIGURE 1: Specific steps of fuzzy comprehensive evaluation method.

2.2. An Overview of AHP Theory. Based on quantitative analysis, the model research method of structural decision is constructed. Its main content is the multi-level model construction, through the weight of the proportion of the relationship to achieve comprehensive evaluation. The unique idea of AHP skillfully uses the comprehensive consideration analysis method of modeling, hierarchy, and systematization to realize the evaluation of the total performance weight score of the evaluation object. Test the consistency of evaluation objects and build a judgment matrix, with subjective awareness of identification and judgment, and good evaluation feedback to carry out the next optimization measures.

2.2.1. AHP Construction Steps. AHP (Analytic Hierarchy Process) model is a qualitative and quantitative combination, systematic, hierarchical analysis method. The characteristic of this method is that based on deeply studying the essence, influencing factors, and their internal relations of complex decision-making problems, it makes the thinking process of decision-making mathematized by using less quantitative information, thus providing a simple decision-making method for complex decision-making problems with multiple objectives, multiple criteria or no structural characteristics. It is a model and method for making decisions on complex systems which are difficult to be completely quantified.

Taking the establishment of the company's performance appraisal system as the main purpose, the weight distribution system is obtained by comprehensive consideration and analysis. Therefore, when calculating the weight, AHP

will scientifically realize the weight ranking of the importance of factors at all levels, and effectively obtain the comprehensive specific gravity value under each stage. The basic steps are carried out as shown in Figure 2.

2.2.2. Establish a Hierarchy. Based on the performance evaluation system of the company, the hierarchical index is established, and the decision-making objectives and influencing factors are decomposed into various levels, so as to build the hierarchical structure. The structure diagram of hierarchical analysis according to the development of the enterprise is as follows in Figure 3.

2.2.3. Establishment of Judgment Matrix. In order to establish a complete fuzzy AHP model, a judgment matrix will be further established to judge the importance of index weight, so as to calculate the important score. The judgment matrix is in the following form:

$$B_k = \begin{pmatrix} c_{11} & \cdots & c_{1n} \\ \vdots & \ddots & \vdots \\ c_{m1} & \cdots & c_{mn} \end{pmatrix}. \quad (10)$$

It compares and judges the matrix through the comparison and difference between bid evaluation indicators, and has the following requirements:

The judgment matrix [20] is defined as

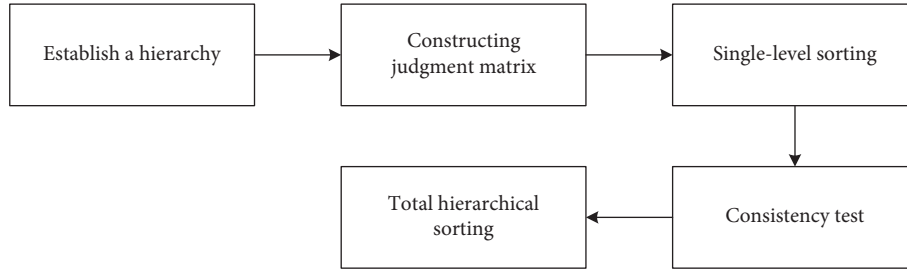


FIGURE 2: Basic construction steps of AHP.

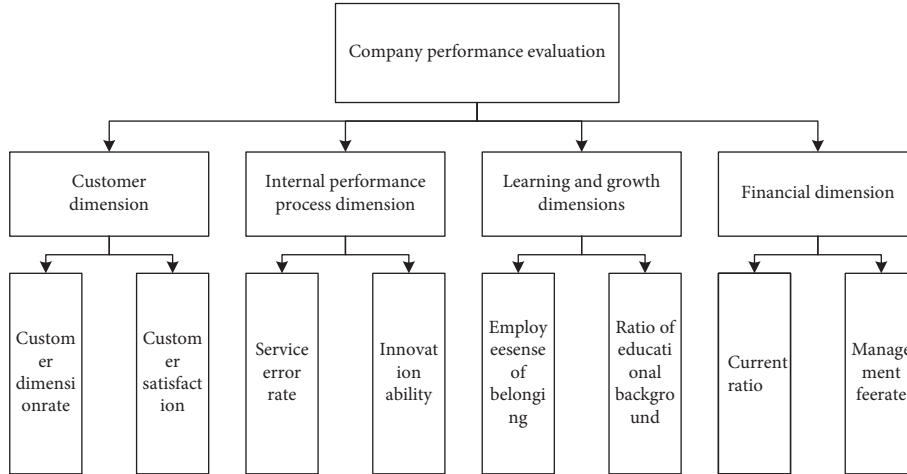


FIGURE 3: Analysis diagram of enterprise hierarchy.

$$\begin{aligned}
 C_{ij} &> 0, \\
 C_{ij} &= \frac{1}{C_{ji}}, \\
 C_{ii} &= 1 \quad (i = 1, 2, \dots, n).
 \end{aligned} \tag{11}$$

The basic theory shows that the greater the value of C_{ij} , the stronger the important correlation between evaluation indexes i and j .

2.2.4. Implementation of Single-Level Sorting

- (1) Calculation of product of influencing elements on each row of the matrix.

$$\bar{W}_i = \left(\prod_{j=1}^n a_{ij} \right)^{1/n}, \quad i, j = 1, 2, \dots, n. \tag{12}$$

- (2) Normalization [21]:

$$W_i = \frac{\bar{W}_i}{\sum_{j=1}^n \bar{W}_j}, \quad i, j = 1, 2, \dots, n. \tag{13}$$

$$W^T = [W_1, W_2, \dots, W_n]^T, \tag{14}$$

the eigenvector is obtained.

- (3) Calculate the maximum eigenvalue [22].

$$\lambda_{\max} = \frac{1}{n} \sum_{i=1}^n \frac{\left(\sum_{j=1}^n a_{ij} W_j \right)}{W_i}, \quad i, j = 1, 2, \dots, n, \tag{15}$$

where λ_{\max} is the maximum eigenvalue.

2.2.5. Consistency Test. Calculate the eigenvalue of the matrix [23].

$$\sum_{i=1}^n \lambda_i = n. \tag{16}$$

The condition of the consistency matrix is as follows:

$$\begin{aligned}
 n &= \lambda_{\max}, \\
 \lambda_1 &= \lambda_{\max} > n.
 \end{aligned} \tag{17}$$

When the characteristic roots are 0 and inconsistent, the remaining roots are treated as follows:

Remaining roots [24]:

$$\sum_{i=2}^n \lambda_i = n - \lambda_{\max}. \tag{18}$$

Consistency indicators [25]. That is,

$$CI = \frac{\lambda_{\max} - n}{n - 1}. \quad (19)$$

When $CI=0$, it means that the evaluation indexes are completely consistent, and the smaller it is, the stronger the consistency is

$$CR = \frac{CI}{RI} < 0.1. \quad (20)$$

CR is the ratio of consistency index to RI of the same order, which is called the random consistency ratio.

2.2.6. Total Hierarchical Sorting. The target layer, criterion layer, and index layer will be sorted on the weight, and the final fuzzy index will be formed.

$$W_j = \sum W_i W_j^i. \quad (21)$$

3. Feasibility and Necessity of Enterprise Performance Analysis Based on AHP

3.1. Feasibility Analysis of AHP

3.1.1. Systematicness under the Process. The quantitative analysis of the relationship factors between different levels and the judgment and influence degree of key points is relatively clear. Adhering to the system performance evaluation with multicriteria, multidecision-making, and multiobjective without structural characteristics will make a good start for enterprises in the development process.

3.1.2. The Rapidity and Simplicity of the Method. Analytic Hierarchy Process (AHP) can understand the development of the company under the high depth, optimize the complex company structure in many aspects, and achieve the transformation of dealing with problems and making decisions one by one. It is more convenient and easy for managers to carry out the accurate mathematical calculation and simple solution, and compare the relationships under various influencing factors. Easy to understand the evaluation index so that decision-making managers in the implementation process can quickly and efficiently complete the task so that each employee can understand their own value.

3.1.3. Minimization of Data Information. In order to understand the comprehensive factors that enterprises need to influence employees, facilities, costs, and interests in the decision-making process, an important index analysis is given by adopting hierarchical thinking logic judgment. Considering the actual environment, combined with the cultural literacy of enterprise engineering technology and management concept to enhance the global position of enterprises.

3.2. Necessity Analysis of AHP. Performance evaluation systems and indicators have been used in various fields, including the use of the weighted-average method in calculating the frequency of weights will become more

practical. In order to solve the problem of recursive structure, AHP adopts the qualitative analysis under circumvention to solve the problem of complex structure. Multi-objective and multi-level stage remarkable effect will perfectly improve the defects of the evaluation system and realize the index selection under high dimension. Compared with the traditional performance evaluation methods, the performance evaluation system based on AHP has a substantial promotion effect on the development of enterprises. In the case of evaluating the work efficiency and performance progress among employees, running for excellent employees will select excellent talents as basic equipment for the future development of enterprises. Establish a complete and comprehensive system structure, and the dimension splitting and detailed indicators under the structure are the components of the system.

3.3. Selection Principles of Performance Appraisal Indicators

3.3.1. Objectivity. In the evaluation index selected by enterprises to assess employees, it is necessary to choose according to the company's development concept. There will be special circumstances in the performance appraisal on each node, and the indicators may not be applicable, which cannot achieve the evaluation purpose.

3.3.2. Comprehensiveness. According to the development of each stage and the evaluation of personal emotional factors, the comprehensive index is applied to the assessment to achieve comprehensive evaluation. This is the basic requirement for the fairness and impartiality of performance appraisal. In the face of nonconflicting results, we should make comprehensive and comprehensive selection indicators in everyone's selection. Realize the effectiveness of the evaluation and achieve the purpose of this assessment.

3.3.3. Operability. Therefore, in order to make the indicators convenient for people to carry out, that is, when the operability of indicators is reduced, the performance can be carried out smoothly. For employees, the announcement of assessment results is an incentive to people, and the enthusiasm for the next work will have a great impact.

3.4. Improvement of the Evaluation Method. Under the traditional mode, the assessment methods are mainly subjective and objective. The subjective method is based on the evaluation of the decision-maker's attention to the personnel, while the objective method is based on the assessment method of job performance, difficulty, and weight. Therefore, the reasonable approach is to combine the weight coefficients obtained by different weighting methods and explore the calculation of specific weight values on the effectiveness standard. Considering the objective conditions, considering the correlation between indicators, whether the gap will be difficult to control when the real value is combined with reality, and how to set and improve the methods next.

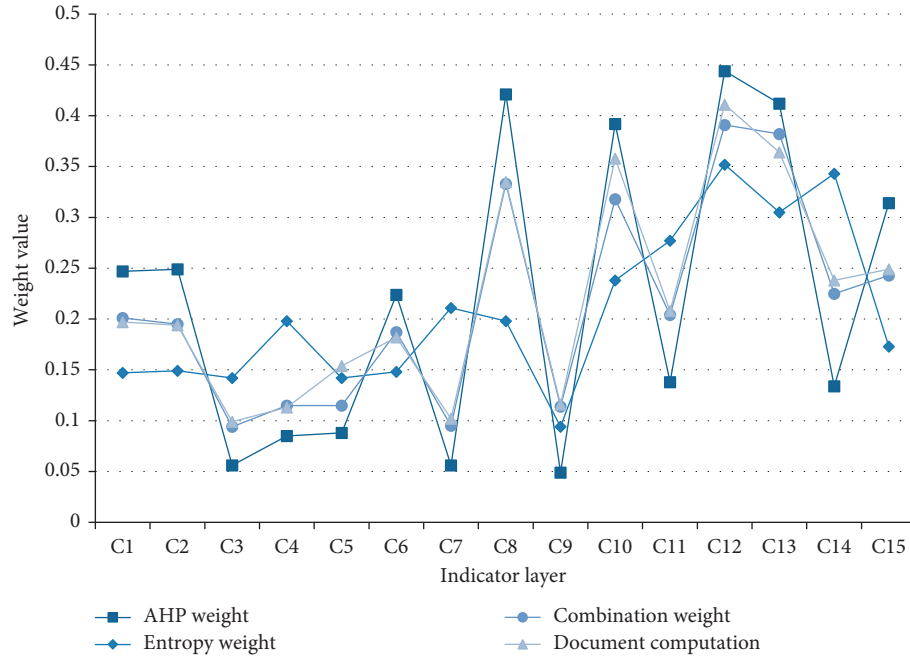


FIGURE 4: Comparison chart underweight calculation results.

3.4.1. Objective Analysis-Entropy Weight Method. Through the early assessment of the problems of enterprises, the AHP model in in-depth analysis and improvement, optimization method will be given according to the importance of the weight of value right. Relevant experts put forward the objective weighting method, which can calculate the weight more accurately, meet the evaluation requirements and ensure the overall utilization rate of index quality. The specific steps are as follows:

- (1) Dimensionless processing of the original matrix.
- (2) Calculate the index weight P_{ij} under the evaluation object:

$$P_{ij} = \frac{x_{ij}}{\sum_{j=1}^n x_{ij}}. \quad (22)$$

- (3) Calculate the entropy of the evaluation index

$$H_i = -k \sum_{j=1}^n p_{ij} \ln p_{ij}. \quad (23)$$

H_i is the index entropy value, k is the constant, and p_{ij} is the weight. When $H_i = 1$, the index will have no effect on this assessment.

- (4) Defining entropy weights

$$u_i = \frac{(1 - H_i)}{[\sum_{i=1}^m (1 - H_i)]}. \quad (24)$$

- (5) The establishment of subjective and objective empowerment.

Combining the judgment matrix and the final weight under the system analysis, subjective and objective weighting

methods under the combination form, will re-establish the weight proportion. The subjective weight of AHP and the objective weight of the entropy weight method are used to calculate the comprehensive weight, and the error is calculated by average distribution.

3.5. Establishment of Evaluation Model. Based on the evaluation system of the company's performance appraisal management, through the comprehensive and operable index standard treatment, and the analytic hierarchy process to calculate the weight of comprehensive indicators. Finally, the fuzzy analytic hierarchy process model is obtained, and its specific evaluation steps are as follows:

- (1) Construct the Enterprise Performance Management Index System based on the principle of selecting the target index by AHP.
- (2) AHP gives subjective weight to the management evaluation index.
- (3) The entropy method is used to weigh the index of management evaluation objectively.
- (4) Subjective and objective weighting to calculate index weights.
- (5) The comprehensive evaluation model is obtained.

4. Guiding Experiment of Fuzzy AHP Model in Enterprise Performance Appraisal

4.1. Calculation Results of Weight Index under Hierarchy. To verify the weight ratio between each level, we get more detailed data sets to build the evaluation index system. The judgment result of index weight is shown in Figure 4.

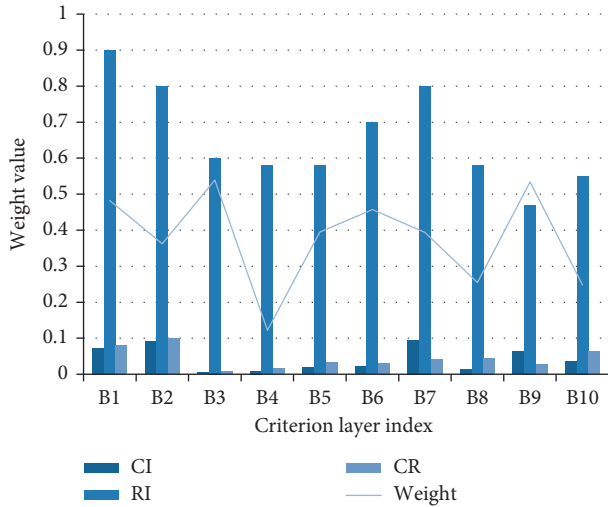


FIGURE 5: Judgment matrix and consistency of development ability.

In Figure 4, the abscissa represents 15 evaluation indexes, and the ordinate represents the weight value of each index. In literature calculation, it is a qualitative analysis method to describe the development trend of the company by using statistical algorithms in mathematical methods to evaluate indexes and forecast methods. According to the weight values under the four calculation results, it is found that the AHP method has an extreme value in weight calculation, and its fluctuation is too strong. Enterprise performance appraisal is mainly a decision-making means for the future development of the company, which is convenient for analysis and optimization. Combination weight and literature calculation are mainly in the central position, which shows that the stability of the two methods in the implementation process is convenient to get the real index weight.

4.2. Judgment Matrix and Consistency Test of Performance Appraisal. According to the current development of enterprises to judge the financial performance at the end of the year, at the same time, build a judgment matrix and carry out consistency test calculation index weight calculation. The resulting diagram is as shown in Figure 5.

It can be seen from the experimental results that when $CR < 0.1$, the development of the enterprise is good. B in the figure represents the criterion layer in the analytic hierarchy process, which is the index of the second layer, aiming at building the consistency test of the judgment matrix.

4.3. Membership Matrix of Performance Evaluation Grade. According to the Membership Matrix of the evaluation grade between each level, it lays a good foundation for the next step to get a fuzzy set, and will combine the practical problems to complete the work perfectly. Its index membership matrix is shown in the following Figure 6.

According to the rating results of membership degree in the figure, the difference in C11 and the excellent membership

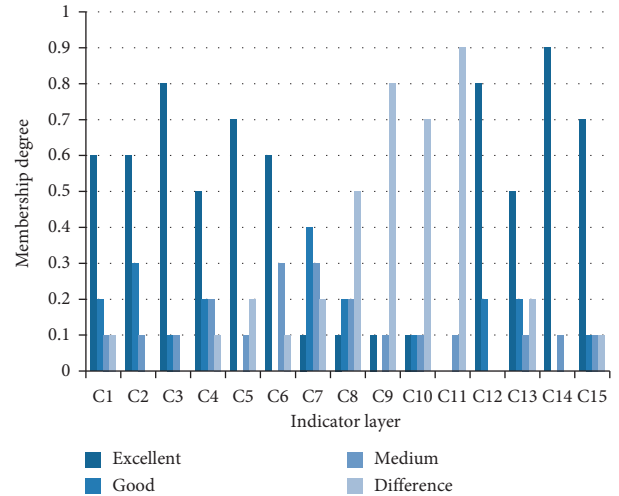


FIGURE 6: Membership matrix of evaluation index.

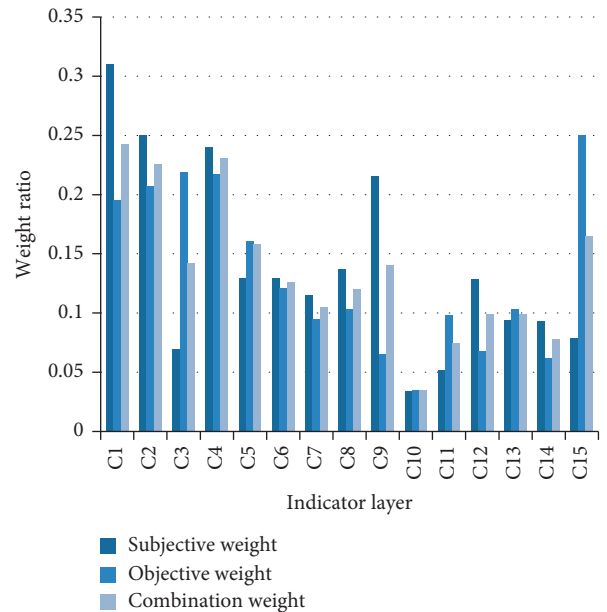


FIGURE 7: Comparison of subjective and objective weights.

degree in C14 are 0.9, which also shows that the index weight under the given level is very high, and the assessment needs to be taken more seriously. When the membership degree of some index layers is 0, it should not be ignored, but should be considered according to the actual situation.

4.4. Fuzzy Comprehensive Index Evaluation. Combined with subjective and objective weight calculation, a fuzzy comprehensive evaluation will reflect the importance of indicators. The analysis results are as shown in Figure 7.

Through the calculation results, we can see that the weight value of subjective weight is obviously higher than that of objective weight, and objective weight cannot reflect part of the weight. The combined weight of this paper is obviously between the two, which can reflect the importance of different indicators.

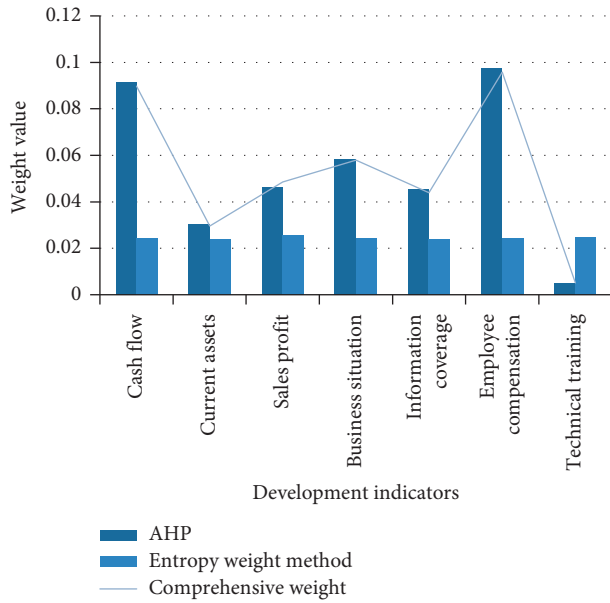


FIGURE 8: Weight result diagram of enterprise development index.

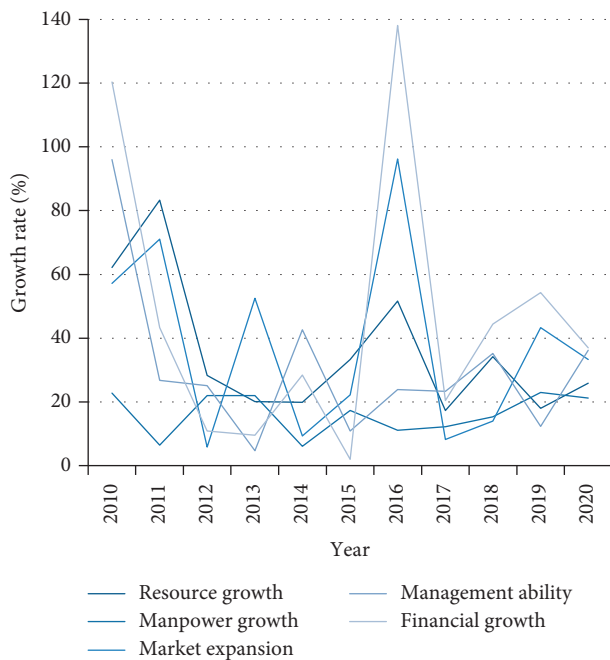


FIGURE 9: AHP calculation of evaluation index growth rate from 2010 to 2020.

4.5. *Comprehensive Weight Value of Enterprise Development Index.* It is a case study on the transitional stage of an enterprise by taking the actual operation situation, the interests' situation, and the staff training that an enterprise needs to face during its development. The experimental analysis results of income indicators and business indicators are as shown in Figure 8.

At the end of the year and midterm performance, an appraisal is a necessary management means, but the main concern of enterprises is the income situation in that year,

and employees consider salary. That is, in the weight ratio, the employee salary accounts for 0.0976 and the current flow weight ratio of 0.0914. This is also the focus of the company's development and the concept of market survival, which builds a working atmosphere for a good living environment.

4.6. *General Analysis of AHP Performance Appraisal.* According to the weight calculated by AHP, multiplying the production index of enterprises, we can get the growth of enterprises in various aspects in recent years. The experimental growth rate results are shown in the following figure.

As can be seen from Figure 9. From 2010 to 2020, the resource growth of enterprises is weakening, which is lower than the growth rate of 60%. In 2016, the financial growth increased by 120% compared with 2015, achieving a year of high economic income. There is no obvious fluctuation in the market in terms of personnel training. Based on the level of 15%, recruitment is only carried out according to market demand.

5. Conclusion

In combination with the development of enterprises and the influence of internal and external environmental factors, quantitative and qualitative index analysis of assessment indicators will greatly improve the objectivity and accuracy of indicators. For the imprecision and low performance of some evaluation indexes, the comparison of weights is realized by combining subjective and objective calculation methods (combined weighting method). In the overall evaluation results of the whole enterprise system, calculating the true weight value and getting the total evaluation score will fully explain that new measures will be made in the development stage of the enterprise. The experimental contents are summarized as follows: (1) Under the analysis of the analytic hierarchy process model, the enterprise performance appraisal shows a comprehensive and comprehensive result, and the index combination that is difficult to understand is given a weighting treatment method. (2) Comprehensive weight under the combination of subjective and objective functions, qualitative index analysis is carried out, which greatly improves the accuracy of the analysis. (3) Fuzzy AHP model for the evaluation of enterprise assessment indicators, there is a great gap in the grade, further optimization of the actual use of more convenient. (4) The calculation result of the entropy method is closer to the real weight, which will fully explain that enterprise managers should fully understand the examiners in detail before implementing it.

The deficiency and improvement of the evaluation system are as follows: (1) Fuzzy synthesis method cannot understand the correlation between indicators, which is easy to cause the reuse of information. (2) Judges need to understand the meaning of each index, and choose the index again, so they will reject the index that is not suitable for this assessment. (3) In order to ensure the rational development of efficient information systems, an objective and accurate evaluation must be carried out to achieve a

high-value contribution to system application performance. (4) To improve the accuracy of the weighting method, more in-depth research is needed, including the consideration of emotional factors in the assessment process, which fully reflects the comprehensiveness of evaluation indicators.

Data Availability

The experimental data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declared that they have no conflicts of interest regarding this work.

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