Research on scientific research performance evaluation based on IAHP-ICRITIC combined weighting

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Abstract: In the field of scientific research, performance evaluation is a complex task with common and typical characteristics of the industry. Reasonable and effective performance evaluation can help motivate scientific researchers and optimize resource allocation. In order to give a reasonable performance distribution plan, it is necessary to evaluate the scientific research results of each employee first. Considering that the indicator data in the attachment are all positive indicators, the extreme value standardization method is first used to standardize the data. Then, the subjective indicator weights are obtained by the interval hierarchical analysis method, and the objective indicator weights are obtained by the improved CRITIC method. Based on the idea of game theory, the combined weight value of the subjective and objective weights is obtained by solving the Nash equilibrium point. Finally, the performance scores of 20 scientific researchers are calculated according to the weights of each indicator, and the total bonus is distributed according to the performance score ratio. The first worker received the highest bonus of 74,321 yuan; the eighth worker received the lowest bonus of 72,330 yuan; the specific distribution plan is shown in Table 7.

Keywords: IAHP; ICRITIC; Combination Empowerment; Scientific Research Performance Evaluation

1 INTRODUCTION

With the rapid development of modern scientific research, scientific research performance evaluation has become an important topic of concern to the academic community and scientific research institutions. Scientific research performance evaluation can not only truly reflect the work results of scientific researchers, but also provide a scientific basis for the establishment and optimization of resource allocation and incentive mechanisms. A reasonable scientific research performance evaluation system can stimulate the innovative spirit of scientific researchers, improve scientific research efficiency, and thus promote the continuous improvement of scientific research level [1]. With the increasing complexity and diversity of scientific research activities, how to objectively, fairly and comprehensively evaluate the performance of scientific researchers has become a difficult problem to be solved.

Traditional scientific research performance evaluation methods often rely on simple quantitative indicators or subjective expert evaluations, but these methods each have certain limitations. For example, a single quantitative indicator may not be able to fully reflect the comprehensive ability and actual contribution of scientific researchers, while expert evaluations may be affected by personal bias and are difficult to meet the standards of scientific fairness [2]. In order to overcome these problems, in recent years, the multi-indicator evaluation method of combined empowerment has gradually received attention. This method integrates subjective and objective evaluation information, comprehensively considers the relationship between multiple indicators, and helps to improve the accuracy and reliability of performance evaluation.

Based on the existing scientific research performance evaluation framework, this study proposes a combined weighting model based on the IAHP (interval analytic hierarchy process) and the improved CRITIC (criteria importance through intercriteria correlation) method. Through this method, not only can the weights of each evaluation indicator be reasonably determined, but also the shortcomings of a single evaluation method can be effectively overcome, and the organic integration of subjective and objective evaluation information can be achieved, thereby providing a more scientific and reasonable solution for scientific research performance evaluation [3]. In addition, based on the Nash equilibrium idea of game theory, this study further optimizes the final evaluation weights to ensure the fairness and rationality of the combined weights.

In the process of constructing a scientific research performance evaluation system, the selection of indicators is crucial. Combined with the actual situation of scientific researchers in universities, this paper establishes a comprehensive evaluation system including scientific research conditions, awards, academic achievements and talent exchanges. Through this system, the scientific research performance of scientific researchers in different fields can be comprehensively evaluated, further improving the scientificity and practicality of performance evaluation [4]. Through the analysis and comparison of experimental results, the effectiveness and superiority of the combined weighting model proposed in this paper in practical applications are verified, providing strong support for the reasonable allocation of scientific research performance.

2 RELATED WORK

As an important tool to measure the effect and contribution of scientific research activities, scientific research performance evaluation has received widespread attention in recent years. Traditional performance evaluation methods mostly rely on quantitative indicators or subjective expert evaluation, but these methods often have certain limitations. For example, although quantitative indicators can reflect some scientific research results, they cannot comprehensively evaluate comprehensive factors such as the innovation ability and academic influence of scientific researchers; and although expert evaluation can consider more details, it is easily affected by subjective bias [5]. Therefore, how to objectively and impartially evaluate scientific research performance has become an urgent problem to be solved.

In order to make up for the shortcomings of traditional methods, many scholars and researchers have proposed a variety of new scientific research performance evaluation methods. Among them, the analytic hierarchy process (AHP) is a widely used subjective weighting method. By establishing a hierarchical structure, experts can assign different weights according to the relative importance of each indicator. Although this method can effectively deal with multi-dimensional evaluation problems, it also has certain limitations. For example, when experts make judgments, they are often limited by personal preferences or knowledge and experience, which may lead to deviations in evaluation results. Therefore, the AHP method that relies solely on expert judgment cannot fully meet the needs of complex scientific research performance evaluation.

In order to overcome these problems, objective weighting methods have gradually attracted attention. The CRITIC method is an objective weighting method based on the information entropy theory of the data itself. It objectively determines the weight of each indicator by calculating the coefficient of variation and correlation of each indicator. This method does not rely on the subjective judgment of experts and can better reflect the differences and information content of the data itself [6]. However, the CRITIC method also has certain limitations. It mainly relies on the intrinsic characteristics of the data and ignores the value of expert judgment. Therefore, when the CRITIC method is used alone, it is often difficult to fully consider the multi-dimensional characteristics of scientific research performance.

With the deepening of the understanding of scientific research performance evaluation methods, the combined weighting method combining subjective and objective weights has gradually become a mainstream trend. This method can make up for the shortcomings of a single method and improve the scientificity and fairness of the evaluation results by integrating the subjective judgment of experts and the objective analysis of data. By combining methods such as AHP and CRITIC, the combined weighting model can fully consider the relationship and information content between various indicators to form a more comprehensive scientific research performance evaluation system [7]. This method not only improves the accuracy of the evaluation, but also makes the contribution of scientific researchers more reasonable and comprehensive.

In summary, although the traditional performance evaluation method has achieved certain application results, with the continuous development of scientific research activities, the limitations of a single method are becoming increasingly apparent. Therefore, the combined weighting method combining subjective and objective information has become an ideal solution, which can overcome the shortcomings of traditional methods and provide more scientific and fair performance evaluation results.

3 MODEL BUILDING

3.1 Interval Analytical Hierarchy Model

Subjective weighting methods often use methods such as hierarchical analysis, which are all based on expert judgment matrices. However, in actual operations, experts may be affected by subjective biases during the evaluation process, such as personal preferences, biases or prejudices, which may lead to over- or under-evaluation of certain performance evaluation indicators [8]. In order to solve this problem, this paper uses the construction of interval number judgment matrix based on hierarchical analysis to determine the weight of the indicator.

Considering that experts have uncertainty in the evaluation process due to various reasons, the median of the judgment matrix can only be an approximate value. Therefore, this paper uses intervals to describe the uncertainty. Assume that the initial judgment matrix is $A = (a_{ij})n \times n$, where $a_{ij} = [a_{ij}^l, a_{ij}^r]$, the approximate representation of any true value $\frac{w_i}{w_j}$ is $a_{ij}^* \in [a_{ij}L, a_{ij}R]$, and at this time $a_{ij}^* \approx \frac{w_i}{w_j}$. Let $F(w) = \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}(a_{ij}^* \times \frac{w_j}{w_i} - a_{ij}^*) \times \frac{w_j}{w_i} - 2$ represent the generalized deviation function [9]. For different $A^* = a_{ij}^* \in A, w^T = (w_1, w_2, \ldots, w_n)$, there will be different deviation values. Taking all the deviations into consideration, the overall deviation function can be expressed as $T(w) = \int_A F(w)$. Let $b_{ij} = \int_A a_{ij}^*$, then the planning model is established as:

$$\begin{cases} minT(w) = \frac{1}{2}\sum_{i=2}^{n}\sum_{j=1}^{n}(b_{\bar{y}} \times \frac{w_j}{w_i} + b_{\bar{y}} \times \frac{w_i}{w_j}) \\ \sum_{i=1}^{n} w_i = 1 \\ w_i > 0, i = 1,2, \ldots n \end{cases} \quad (1)$$

Construct the Lagrange function $L(w, \lambda) = T(w) + \lambda(\sum_{i=1}^{n} w_i - 1)$ and set the first-order partial derivative to 0:

$$\frac{\partial L(w,\lambda)}{\partial w_i}=\sum_{i=1}^{n}\left(-b_{ij}\frac{w_j}{w_i}\cdot\frac{1}{w_i}+b_{ji}\frac{w_i}{w_j}\cdot\frac{1}{w_i}\right)+\lambda=0 \quad (2)$$

$$\frac{\partial L(w,\lambda)}{\partial \lambda}=\sum_{i=1}^{n} w_i-1=0 \quad (3)$$

Multiply both sides of the equation by w_i and sum over i to get:

$$\sum_{i=1}^{n}\sum_{j=1}^{n}\left(b_{ij}\frac{w_j}{w_i}-b_{ji}\frac{w_i}{w_j}\right)-\lambda\sum_{i=1}^{n} w=0 \quad (4)$$

When i and j in the summation sign are interchanged, it is easy to get $\lambda=0$, then we have:

$$\sum_{j=1}^{n}\left(b_{ij}\frac{w_j}{w_i}-b_{ji}\frac{w_i}{w_j}\right)=0 \quad (5)$$

Formula (5) is solved by using the iteration method. The algorithm flow is as follows:

Step 1 Initial parameters $w^{(0)}=\left(w_1^{(0)},\ldots,w_n^{(0)}\right)^T=(1,\ldots,1)^T$; set iteration accuracy $\varepsilon>0$; set counter $k=0$. Calculate $b_{ij}=\int_A a_{ij}^*$.

Step 2 Calculate error:

$$err_i^k=\sum_{j=1}^{n}\left(b_{ij}\frac{w_j^{(k)}}{w_i^{(k)}}-b_{ji}\frac{w_i^{(k)}}{w_j^{(k)}}\right)=0, i\in 1,\ldots n \quad (6)$$

If for any pair $\left|err_i^k\right|\le\varepsilon$, end the iteration and output the result $w^*=w^{(k)}$, otherwise proceed to step 3.

Step 3 Determine m so that $\left|err_m^k\right|=max(\left|err_i^k\right|)$ holds, and let:

$$g_1=\sum_{j\neq m}\left(b_{mj}\frac{w_j^{(k)}}{w_m^{(k)}}\right) \quad (7)$$

$$g_2=\sum_{j\neq m}\left(b_{jm}\frac{w_m^{(k)}}{w_j^{(k)}}\right) \quad (8)$$

$$x_i^{(k)}=\begin{cases}\sqrt{\frac{g_1}{g_2}}w_i^{(k)} & i=m\\ w_i^{(k)} & i\neq m\end{cases} \quad (9)$$

$$w_i^{(k)}=\frac{w_i^{(k)}}{\sum_{j=1}^{n} x_i^{(k)}}, i\in\{1,2,\ldots,n\} \quad (10)$$

Let $k=k+1$ and jump to step 2.

3.2 Improved CRITIC evaluation model

This paper improves the CRITIC method, using the coefficient of variation to measure the conflict of indicators, and the correlation coefficient between each indicator is expressed in absolute value. The specific steps of the algorithm are as follows:

Construct an evaluation indicator matrix. Assume that there are n objects to be evaluated, and each object to be evaluated has m evaluation indicators. At this time, the evaluation matrix is:

$$S = \begin{pmatrix} s_{11} & \cdots & s_{1m} \\ \vdots & \cdots & \vdots \\ s_{n1} & \cdots & s_{nm} \end{pmatrix} \tag{11}$$

In the formula, s_{nm} represents the mth evaluation indicator of the nth evaluation.

(1) Indicator preprocessing

In order to retain the variability between data, this paper adopts the forward data processing method.

$$I = \frac{S - S_{min}}{S_{max} - S_{min}} \tag{12}$$

(2) Calculate the coefficient of variation and correlation coefficient

$$\begin{gathered} \xi_j = \sqrt{\frac{1}{m}\sum_{t=1}^{m}\left(s_{ij}^{'} - \bar{s_j}^{'}\right)^2} \quad j = 1,2,\dots,n \\ \bar{s}_j^{'} = \frac{1}{m}\sum_{i=1}^{m} s_{ij} \\ v_j = \frac{\bar{\xi}_j}{s_j^{'}} \end{gathered} \tag{13}$$

In the formula, ξ_j represents the standard deviation of the j-th indicator; $s_j^{'}$ represents the mean of the j-th indicator; v_j represents the coefficient of variation of the j-th indicator.

$$r_{ij} = \frac{\text{cov}\left(s_i^{'}, s_j^{'}\right)}{\xi_i \xi_j} \tag{14}$$

In the formula, r_{ij} represents the correlation coefficient between indicator i and indicator j.

(3) Calculate the conflict coefficient

$$R_j = \sum_{i=1}^{m}\left(1 - \left|r_{ij}\right|\right) \tag{15}$$

In the formula, R_j represents the conflict value of the jth indicator.

(4) Calculate the information amount of the indicator

$$C_j = v_j R_j \tag{16}$$

In the formula, C_j represents the information content of the jth indicator.

(5) Calculate the objective weight

$$\sigma_j = \frac{C_j}{\sum_{j=1}^{m} C_i} \tag{17}$$

Where σ_j represents the weight of the j-th indicator.

3.3 Combined weighted model

This paper assumes that the weights obtained by the interval analytic hierarchy process are $\varpi = (\varpi_1, \ldots, \varpi_n)$; the weights obtained by the improved CRITIC method are $\sigma = (\sigma_1, \ldots, \sigma_m)$. The obtained subjective weight ϖ and objective weight σ are linearly combined, and the final weights are:

$$W = \alpha\varpi + \beta\sigma \tag{18}$$

In the formula, W represents the final weight; α and β represent the coefficients of subjective weight and objective weight respectively [10].

Based on the idea of solving Nash equilibrium point in game theory, this paper establishes a model with the minimum deviation between the final weight and subjective weight and objective weight as the objective function:

$$minZ = [\alpha\omega^T + \beta\sigma^T - \omega - \sigma] \tag{19}$$

$$s.t.\ \alpha + \beta = 1 \tag{20}$$

Solving the objective function Lagrange function and taking the first-order derivative as 0, we can get:

$$\begin{bmatrix} \omega\omega^T & \omega\sigma^T \\ \sigma\omega^T & \sigma\sigma^T \end{bmatrix} \begin{bmatrix} \alpha \\ \beta \end{bmatrix} = \begin{bmatrix} \omega\omega^T \\ \omega\sigma^T \end{bmatrix} \tag{21}$$

The combined weight can be obtained by normalizing the solved α and β.

4 EXPERIMENTAL RESULTS ANALYSIS

4.1 Construction of evaluation index system

When establishing a scientific research performance evaluation index system, it is crucial to ensure scientific and reasonable evaluation indicators. The evaluation index system should cover all aspects of scientific research activities, including the quantity and quality of scientific research results, the acquisition and management of scientific research projects, academic influence and other aspects, so as to comprehensively reflect the scientific research performance of universities [11].

Based on the relevant data in the appendix, this paper divides it into four aspects: scientific research conditions, awards, academic achievements, and talent exchanges to construct a scientific research performance evaluation index system. The specific framework is shown in Table 1.

Table 1: Scientific research performance evaluation index system.

First-level indicators	Secondary indicators
Scientific research conditions	Number of graduate students
	Horizontal funds received/10,000 yuan
	Newly approved national projects
	Newly approved provincial and ministerial projects
Awards	National standards/specifications
	Provincial or industry standards/specifications
	National science and technology awards
	Provincial and ministerial science and technology awards
Academic achievements	SCI
	EI

	Chinese core
	Invention patents
	Other intellectual property rights
	Book publishing
Talent exchange	Talent plan
	Academic part-time job

4.2 Dimensionless processing of evaluation indicators

The scientific research performance evaluation indicators established in this paper are all positive indicators, that is, the larger the indicator value, the better, and the data meets the requirements of homogeneity. Therefore, when processing the evaluation indicators dimensionlessly, this paper uses the extreme value method to standardize the data in the appendix.

$$x^* = \frac{x - min}{max - min} \tag{22}$$

In the formula, min represents the minimum value and max represents the maximum value.

4.3 Constructing a judgment matrix

This paper adopts two different judgment matrices. Taking the first-level indicator as an example, the judgment matrix 1 given by experts is shown in Table 2:

Table 2: Expert judgment matrix 1.

Scientific research performance	Scientific research conditions	Awards	Academic achievements	Talent exchange
Scientific research conditions	1	1/4	1/5	2
Awards	4	1	1	5
Academic achievements	5	1	1	5
Talent exchange	1/2	1/5	1/5	1

The judgment matrix 2 given by the experts is shown in Table 3:

Table 3: Expert judgment matrix 2.

Scientific research performance	Scientific research conditions	Awards	Academic achievements	Talent exchange
Scientific research conditions	1	1/5	1/5	4
Awards	5	1	1	5
Academic achievements	5	1	1	5
Talent exchange	1/4	1/5	1/5	1

The calculated consistency ratios CR are all less than 0.1, so it can be considered that the judgment matrix has satisfactory consistency. By integrating the evaluation matrices given by multiple experts, we can get the interval evaluation matrix as follows:

$$C_1=\begin{pmatrix}[1,1] & \left[\frac{1}{4},\frac{1}{5}\right] & \left[\frac{1}{5},\frac{1}{5}\right] & [2,4]\\ [4,5] & [1,1] & [1,1] & [5,5]\\ [5,5] & [1,1] & [1,1] & [5,5]\\ \left[\frac{1}{4},\frac{1}{2}\right] & \left[\frac{1}{5},\frac{1}{5}\right] & \left[\frac{1}{5},\frac{1}{5}\right] & [1,1]\end{pmatrix} \tag{23}$$

Similarly, we can get the secondary indicator judgment matrix of scientific research conditions as follows:

$$C_2=\begin{pmatrix}[1,1] & \left[\frac{1}{4},\frac{1}{5}\right] & \left[\frac{1}{5},\frac{1}{5}\right] & \left[\frac{1}{3},\frac{1}{3}\right]\\ [4,5] & [1,1] & [2,3] & [3,4]\\ [5,5] & \left[\frac{1}{2},\frac{1}{3}\right] & [1,1] & [5,3]\\ [3,3] & \left[\frac{1}{3},\frac{1}{4}\right] & \left[\frac{1}{5},\frac{1}{3}\right] & [1,1]\end{pmatrix} \tag{24}$$

The secondary indicator judgment matrix for award-winning situations is:

$$C_3=\begin{pmatrix}[1,1] & [3,3] & [1,1] & [5,5]\\ \left[\frac{1}{3},\frac{1}{3}\right] & [1,1] & \left[\frac{1}{3},\frac{1}{3}\right] & [2,3]\\ [1,1] & [3,3] & [1,1] & [5,6]\\ \left[\frac{1}{5},\frac{1}{5}\right] & \left[\frac{1}{2},\frac{1}{3}\right] & \left[\frac{1}{5},\frac{1}{6}\right] & [1,1]\end{pmatrix} \tag{25}$$

The secondary indicator judgment matrix for academic achievements is:

$$C_4=\begin{pmatrix}[1,1] & [1,1] & [3,2] & [3,4] & \left[\frac{1}{2},\frac{1}{2}\right] & [2,2]\\ [1,1] & [1,1] & [1,1] & [3,3] & [1,1] & [2,2]\\ \left[\frac{1}{3},\frac{1}{2}\right] & [1,1] & [1,1] & [1,1] & \left[\frac{1}{2},\frac{1}{2}\right] & [3,3]\\ \left[\frac{1}{3},\frac{1}{4}\right] & \left[\frac{1}{3},\frac{1}{3}\right] & \left[\frac{1}{3},\frac{1}{3}\right] & [1,1] & \left[\frac{1}{3},\frac{1}{3}\right] & [3,3]\\ [2,2] & [2,2] & [2,2] & [3,3] & [1,1] & [3,3]\\ \left[\frac{1}{2},\frac{1}{2}\right] & \left[\frac{1}{2},\frac{1}{2}\right] & \left[\frac{1}{3},\frac{1}{3}\right] & \left[\frac{1}{3},\frac{1}{3}\right] & \left[\frac{1}{3},\frac{1}{3}\right] & [1,1]\end{pmatrix} \tag{26}$$

The secondary indicator judgment matrix for talent exchange is:

$$C_5=\begin{pmatrix}[1,1] & [5,6]\\ \left[\frac{1}{5},\frac{1}{6}\right] & [1,1]\end{pmatrix} \tag{27}$$

4.4 Calculating weights

(1) Interval analytic hierarchy process

Using the iterative algorithm program, the indicator weights are obtained as shown in Table 4.

Table 4: Weights of scientific research performance evaluation indicators.

First-level indicator	Secondary indicators
	Number of graduate students (0.1309)
Scientific research conditions (0.1410)	Horizontal funds received/10,000 yuan (0.3555)
	Newly approved national projects (0.3555)
	Newly approved provincial and ministerial projects (0.1581)

Lin et al., ISTAER. 2534 (2025)., 30 Jun 2025 https://doi.org/10.71451/ISTAER2534

Awards (0.3827)	National standards/specifications (0.3655)
	Provincial or industry standards/specifications (0.1783)
	National science and technology awards (0.3655)
	Provincial and ministerial science and technology awards (0.0907)
Academic achievements (0.3828)	SCI (0.2081)
	EI (0.2081)
	Chinese core (0.2081)
	Invention patents (0.0858)
	Other intellectual property rights (0.2081)
	Book publishing (0.0816)
Talent exchange (0.0935)	Talent plan (0.8462)
	Academic part-time job (0.1583)

(2) Improved CRITIC method

The improved CRITIC evaluation model is used to solve the program. The solution results are shown in Table 5.

Table 5: Weights of scientific research performance evaluation indicators.

Secondary indicators	Weight
SCI	0.0372
EI	0.0466
Chinese core	0.0531
Invention patents	0.0492
Other intellectual property rights	0.0416
National science and technology awards	0.1107
Provincial and ministerial science and technology awards	0.0883
Book publishing	0.0735
National standards/specifications	0.1025
Provincial or industry standards/specifications	0.0796
Newly approved national projects	0.0680
Newly approved provincial and ministerial projects	0.0573
Number of graduate students	0.0622
Horizontal funds received/10,000 yuan	0.0168
Talent plan	0.0585
Academic part-time job	0.0549

(3) Combination weighting

The improved combination weighting model is used to solve the program. The solution results are shown in Table 6.

Table 6: Weights of scientific research performance evaluation indicators.

Secondary indicators	Interval analytic hierarchy process	Improved CRITIC method	Combined weighting
Number of graduate students	0.0185	0.0622	0.0258
Horizontal funds received/10,000 yuan	0.0501	0.0168	0.0445
Newly approved national projects	0.0501	0.0680	0.0531
Newly approved provincial and ministerial projects	0.0223	0.0573	0.0282
National standards/specifications	0.1399	0.1025	0.1336
Provincial or industry standards/specifications	0.0682	0.0796	0.0701
National science and technology awards	0.1399	0.1107	0.1350
Provincial and ministerial science and technology awards	0.0347	0.0883	0.0437
SCI	0.0797	0.0372	0.0726
EI	0.0797	0.0466	0.0742

Chinese core	0.0797	0.0531	0.0752
Invention patents	0.0328	0.0492	0.0355
Other intellectual property rights	0.0797	0.0416	0.0733
Book publishing	0.0312	0.0735	0.0383
Talent plan	0.0791	0.0585	0.0756
Academic part-time job	0.0148	0.0549	0.0215

(4) Performance distribution

The performance scores and bonus distribution results of the 20 scientific research staff are calculated based on the combined weighting results as shown in Table 7.

Table 7: Performance distribution plan.

Serial number	Performance score	Bonus amount (10,000 yuan)
1	6.4106	7.4321
2	3.8006	4.4062
3	1.4219	1.6485
4	0.7972	0.9242
5	3.7574	4.3561
6	2.4424	2.8316
7	1.2443	1.4426
8	0.6239	0.7233
9	1.7026	1.9739
10	1.7493	2.0280
11	0.7616	0.8830
12	0.8164	0.9465
13	2.8572	3.3125
14	2.6836	3.1112
15	1.7464	2.0247
16	1.0319	1.1963
17	4.7981	5.5626
18	2.7459	3.1834
19	0.8006	0.9282
20	0.9361	1.0853

5 DISCUSSION

In this study, the combined weighting model based on IAHP-ICRITIC, combined with the interval analytic hierarchy process and the improved CRITIC method, was used to comprehensively evaluate and analyze scientific research performance. Through the construction of the model and the analysis of the experimental results, it was found that the combined weighting model has significant advantages in the evaluation of scientific research performance, which can effectively integrate subjective and objective information and overcome the singleness problem in traditional methods. However, in the actual application process, some areas that need further optimization and improvement were also exposed.

First, although this study effectively overcomes the bias of single expert judgment through the improved CRITIC method, the method still has certain limitations. For example, the CRITIC method relies too much on the inherent variability and correlation of the data, and ignores the actual complex environment and the configuration of scientific research resources faced by scientific researchers. Therefore, although CRITIC can objectively reflect the amount of information between indicators, in some cases, it may fail to fully reflect the comprehensive

Lin et al., ISTAER. 2534 (2025)., 30 Jun 2025 https://doi.org/10.71451/ISTAER2534

contribution of scientific researchers. In addition, although the interval analytic hierarchy process avoids the subjective bias of experts to a certain extent, the accuracy and consistency of interval judgment still need to be further optimized, especially in the process of calculating the indicator weights, how to deal with the uncertainty of the judgment matrix is still a key issue that needs further discussion.

Secondly, the advantage of the combined weighting model is that it can reduce the bias of a single evaluation method and improve the scientific nature of the evaluation through comprehensive consideration of weights. However, the setting of the α and β coefficients in the combined weights is still a key issue. Although the Nash equilibrium idea in game theory is used in this study to optimize the difference between subjective and objective weights, how to reasonably determine the specific values of these two coefficients is still challenging. If the weights of α and β are set unreasonably, the final evaluation results may be biased towards one side, thereby affecting the accuracy of the overall evaluation. Therefore, future research can further explore how to dynamically adjust these two coefficients through more precise algorithms and optimization methods to achieve a more balanced and fair weight distribution.

In addition, in the selection of scientific research performance evaluation indicators, this study mainly focuses on scientific research conditions, awards, academic achievements and talent exchanges. These indicators can fully reflect the scientific research achievements and academic influence of scientific researchers to a certain extent. However, in actual operations, the performance of scientific researchers is affected by many factors, such as teamwork ability, sharing and utilization of scientific research resources, etc., which are often difficult to quantify and standardize. Therefore, the future scientific research performance evaluation system can consider introducing more non-quantitative indicators, such as the innovation ability, social service, and interdisciplinary collaboration of scientific researchers, so as to more comprehensively evaluate the comprehensive performance of scientific researchers.

Finally, although the combined weighting model proposed in this study has improved the accuracy and scientificity of scientific research performance evaluation to a certain extent, in actual operation, how to ensure the reliability of data and the fairness of evaluation is still an urgent problem to be solved. The accuracy of scientific research data, the transparency of the evaluation process, and the fairness of expert review all directly affect the final performance evaluation results. Therefore, in future research, information technology, such as big data analysis and artificial intelligence technology, can be combined to more accurately process and analyze scientific research data to improve the fairness and scientificity of scientific research performance evaluation.

In short, the combined weighting model based on IAHP-ICRITIC provides a new idea and method for scientific research performance evaluation, but there are also some areas that need further optimization and improvement. With the continuous development of scientific research activities and the continuous improvement of evaluation methods, it will help to measure the performance of scientific researchers more accurately and fairly and promote the healthy development of the scientific research field.

6 CONCLUSION

The combined weighting model based on IAHP-ICRITIC proposed in this study can effectively evaluate scientific research performance comprehensively, overcoming the singleness and limitations of traditional methods. Combining the interval analytic hierarchy process and the improved CRITIC method, this study provides a more scientific, objective and comprehensive evaluation framework for the performance evaluation of scientific researchers. The experimental results show that the combined weighting model can make full use of the advantages of subjective evaluation and objective data, and effectively improve the accuracy and reliability of performance evaluation. This method can balance subjective and objective factors in actual operation, and provide an important basis for the fair distribution of scientific research performance.

In addition, the study shows that the combined weighting model has strong adaptability and operability in the process of scientific research performance evaluation. Through reasonable indicator weight allocation, the model can comprehensively consider the contributions of scientific researchers in different fields, so as to more comprehensively reflect the comprehensive results of scientific research work. In the experiment, the combined weighting scheme adopted can better balance the performance of scientific researchers at different levels, making the performance evaluation results more reasonable and scientific, and can provide strong support for the resource allocation and incentive mechanism of scientific researchers.

Although the model has shown significant advantages in scientific research performance evaluation, the study also found some aspects that can be improved. First, the selection of the coefficients α and β of the subjective and objective weights in the model still requires more precise algorithms for optimization to avoid weight imbalance in certain situations. Secondly, the selection and setting of scientific research performance evaluation indicators is still a topic that needs to be explored continuously. How to better reflect the contributions of scientific researchers in terms of innovation ability and interdisciplinary collaboration will be an important direction for future research.

In general, this study proposed a new scientific research performance evaluation model by combining IAHP with the improved CRITIC method, which made up for the shortcomings of traditional methods and achieved relatively ideal results in the experiment. With the continuous changes in the scientific research environment and evaluation needs, the various parameters in the model can be further optimized in the future, the dimensions of evaluation indicators can be broadened, the scientificity, accuracy and comprehensiveness of scientific research performance evaluation can be improved, and the sustainable development of the scientific research field can be promoted.

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