International Journal for Housing Science and Its Applications
Publish August 6, 2025. Volume 46, Issue 3 Pages 5655-5670

https://doi.org/10.70517/ijhsa463488

Application of the Super-Efficiency DEA Model in the Performance Evaluation of Asset Management in Public Universities

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Abstract The current lack of comprehensive assessment tools and scientific assessment mechanism in universities makes it difficult to objectively reflect the level of asset management, and it is necessary to establish an assessment system based on the combination of quantitative and qualitative, to promote the modernization of asset management in universities and improve the efficiency of resource utilization. This study constructs a performance assessment and appraisal method for asset management in public colleges and universities, aiming to improve the efficiency of asset management and rationality of resource allocation in colleges and universities. The study firstly constructs an evaluation system containing 5 first-level indicators and 20 third-level indicators including talent training performance and research and education performance, applies hierarchical analysis to determine the subjective weights, CRITIC method to determine the objective weights, realizes the combination of weights based on the weighted least squares method, and finally establishes an evaluation model by combining with the theory of cloud modeling. The case analysis shows that the characteristic parameters of the comprehensive evaluation cloud model for asset management in University A are (71.2563, 1.3652, 0.2365), the risk level is "medium risk", and the risks of indicators such as academic learning, utilization of instruments and equipment, and external recognition are relatively high. The top three indicators in terms of comprehensive weight ranking are academic learning (0.085), asset income (0.084), and cultural quality (0.082) respectively. Based on the assessment results, the study puts forward three optimization suggestions, namely, strengthening the dynamic monitoring of the assessment process, establishing a smooth complaint and communication channel, and establishing a sound accountability mechanism for the assessment results, so as to provide scientific basis and decision-making support for the asset management of colleges and universities. The assessment model established in this study can effectively reflect the performance status of asset management in universities, which is of practical significance for improving the level of asset management in universities.

Index Terms public universities, asset management, performance assessment, weighted least squares, AHP-CRITIC, cloud modeling

I. Introduction

Public colleges and universities in all countries are competing to improve the visibility of the school, enhance the influence on society, and approach to the world level of higher education, in order to achieve this goal, it is essential to strengthen the management of public colleges and universities [1]. The management of public colleges and universities focuses on the management of assets, which is the basis and prerequisite for carrying out various educational activities. The quality and efficiency of the management of public universities' assets are related to the efficiency of teaching and research work, the quality of education and social services in public universities [2].

Nowadays, the pace of economic development continues to accelerate, the asset scale of public colleges and universities has been significantly expanded compared with the previous, the number of existing asset management organizations is increasing, and the internal structure and external forms are also transitioning towards the direction of diversification, which has led to the high rate of asset idleness, serious asset loss and other problems in the process of asset management [3]-[6]. Public colleges and universities should implement efficient management of assets to avoid the continuous spread of problems such as discrepancy between accounts and facts and serious loss in the process of asset management, make every effort to maintain the safety and integrity of assets, fulfill the task of asset management to guarantee the output of teaching and research results, and strive to achieve good management results [7]-[9]. To this end, the asset management of public universities can adopt the unified leadership of the school, categorization and hierarchical management, the combination of responsibility and authority, that is, set up the State-owned Assets Management Committee to undertake the management of all the assets of the public universities, guidance and supervision of the responsibilities, to strengthen the possession of the assets, the use of the process of the full range of management [10], [11]. However, at the same time, it is more important to build a scientific asset management performance evaluation system and assessment methods to urge the asset managers of public colleges and universities to perform their duties well, and to realize a significant improvement in the level and quality of asset management [12]. Therefore, the education authorities should pay attention to the role of performance evaluation in the asset management of public universities, explore the establishment of an assessment mechanism linking the performance evaluation of asset management of public universities to investment decisions, and maximize the utility of state-owned assets. However, the traditional evaluation and assessment methods are defective, with high deviation of actual asset data and distortion of the evaluation system. And the weighted least squares method is a linear regression method for dealing with data with different observation error variances, which opens up a new path for constructing the performance assessment and appraisal of asset management in public colleges and universities [13].

As an important part of state-owned assets, the assets of public colleges and universities bear the important mission of cultivating talents, scientific research and serving the society. With the expansion of the scale of higher education and the increase of education investment, the scale of university assets is expanding and the types of assets are getting richer and richer, so how to scientifically manage and efficiently utilize these assets has become an important issue in the management of colleges and universities. Asset management performance evaluation is the key link of university asset management, through scientific and reasonable evaluation methods, it can comprehensively understand the asset management situation, discover the problems in management, and provide the basis for management decision-making. However, there are many problems in the current performance evaluation of asset management in public universities, such as the imperfect evaluation index system, single evaluation method, and insufficient application of the evaluation results, which restrict the improvement of the level of asset management and the enhancement of the efficiency of resource allocation in colleges and universities. Scholars at home and abroad have carried out certain research on the performance assessment of university asset management, Muluken and Asregedew (2024) used fuzzy hierarchical analysis to study the asset management of public buildings, and proposed that BIM technology can optimize the management of asset information.Wu et al. (2024) evaluated the level of knowledge sharing of university teachers by using the improved AHP-CRITIC method, and confirmed the effectiveness of the method. The effectiveness of the method was confirmed.Lin et al. (2024) proposed a full least squares asymptotic iterative approximation method for NURBS curves and surfaces, which realized the optimization of weights and nodes.Sun et al. (2024) probabilistically evaluated the risk of shield tunneling project in karst area based on an improved two-dimensional cloud model, which improved the accuracy of the evaluation.van Aalderen et al. (2023) presented the a stakeholder engagement framework for integrated asset management in water utilities, emphasizing the importance of stakeholders in asset management. Existing studies provide some reference for the assessment of university asset management performance, but most of them fail to fully consider the subjectivity and objectivity of the assessment indexes, and lack a comprehensive assessment model integrating multiple assessment methods, which makes it difficult to comprehensively and objectively reflect the status of university asset management performance.

This study constructs a complete set of evaluation and assessment methods from the perspective of improving the scientificity and effectiveness of asset management performance assessment in public universities. Firstly, the assessment index system is constructed from five dimensions, namely, talent cultivation performance, scientific research and education performance, tangible asset performance, intangible asset performance and school-run industry performance, which comprehensively takes into account the characteristics and requirements of university asset management. Second, the hierarchical analysis method with a scale of 0.1~0.9 is used to determine the subjective weights of the indicators, the CRITIC method is used to determine the objective weights, and the weighted least squares method is used to realize the effective combination of weights, taking into full consideration the subjective and objective factors of the indicator weights. Third, the cloud model theory is introduced to establish the asset management performance evaluation model, and the effective conversion of qualitative and quantitative is realized through the positive and negative generator of the cloud model to improve the reliability of the evaluation results. Fourth, an empirical analysis is carried out in university A as an example to verify the feasibility and validity of the constructed evaluation model, and targeted suggestions are proposed to optimize the working mechanism of asset management assessment based on the assessment results. This study provides new ideas and methods for the performance assessment of asset management in public universities, which is of great significance for improving the level of asset management and resource allocation efficiency in universities.

II. Methodology for assessing the performance of asset management in public higher education institutions

This paper first constructs a public university asset management evaluation index system. Then it applies the use of hierarchical analysis method (AHP) to determine the subjective weights of each evaluation index, the CRITIC method to determine the objective weights, and the least squares based method to determine the combination weights. Finally, the evaluation model is established by combining the cloud model theory to realize the assessment of the asset management performance of colleges and universities.

II. A. Construction of Asset Management Assessment Indicator System

Asset management assessment indicators of public universities should fully consider multiple indicators to accurately and comprehensively assess performance. The asset management evaluation index system constructed through research in this paper is shown in Table 1. It contains five aspects: talent cultivation performance, scientific research and education performance, tangible assets performance, intangible assets performance, and university-run industry performance.

Table 1: Asset management assessment index system

Primary index	Secondary index	Symbol	Tertiary index	Tertiary index
Asset management assessment(A)	Talent training performance	B1	Academic learning	C11
			Student employment	C12
			Culture quality	C13
			Talent incentive	C14
	Research education performance	B2	Teaching research	C21
			Teaching Staff	C22
			Laboratory construction	C23
			Result transformation	C24
	Tangible asset performance	B3	Equipment efficiency	C31
			Human resource utilization efficiency	C32
			Asset revenue	C33
			Resource allocation efficiency	C34
	Intangible asset performance	B4	Social satisfaction	C41
			Recognition among universities	C42
			Academic attainments	C43
			External recognition	C44
	School performance	B5	Industrial appreciation	C51
			Industrial profit	C52
			Industrial asset operation	C53
			Industrial potential	C54

II. B. Least squares based AHP-CRITIC combination assignment method

II. B. 1) Hierarchical analysis on a scale of 0.1 to 0.9

A common interpretation of the 0.1 to 0.9 scale method is: two and two elements are compared, if the overall is ten percent, two individuals each account for how many percent. Compared with other scaling methods, its biggest advantage is that it is no longer necessary to test the consistency of the judgment matrix.

Using the AHP method to compare the two-by-two importance of the same level indicators of the asset management assessment index system, the original judgment matrix is constructed [14]. It is determined that there are m first-level indicators, and there are n second-level indicators under the first-level indicator layer. First of all, each subordinate first-level indicator under the first-level indicator is compared two by two to construct the original judgment matrix A, then each subordinate second-level indicator under the first-level indicator is compared two by two to construct the original judgment matrix B_j, and the original judgment matrix is transformed to construct the consistency matrix, and the subjective weights are derived after further processing. Take matrix A as an example, the specific steps are as follows:

(1) Normalize each column of the original judgment matrix, i.e., $a_{ij}^{'} = \frac{a_{ij}}{\sum_{i=1}^{m} a_{ij}}$, to construct the consistency judgment matrix $A^{'}$.

(2) Sum the elements of each row of the matrix $A^{'}$ to get the column vector β, and then divide each element of the column vector β by the column direction of the column vector β to find the summation value, and then the subjective weights of each level of indicators can be derived.

(3) The original judgment matrix $B_j (j = 1, 2, \cdots, n)$ is calculated according to the steps (1), (2) described in the same way can be derived from the subjective weight of each secondary indicator.

The subjective weight of each indicator $\varphi_j (j = 1, 2, \cdots, n)$ can thus be derived.

II. B. 2) CRITIC method

CRITIC method belongs to the objective assignment method, the use of this method, first of all, the indicators of the numerical value of the dimensionless processing, and then through the calculation of the same indicator of the variability between different programs, as well as different indicators of the conflict between the comprehensive calculation and finally arrive at the objective weights [15]. The CRITIC method of the computational process is as follows.

Assuming the existence of m evaluation samples and n evaluation indicators, its original data matrix X is derived from the scoring of each indicator according to the degree of risk of relying on asset management:

$$X = \begin{pmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{pmatrix} \tag{1}$$

where x_i is the indicator raw score, $i = 1, 2, 3, \cdots, m, j = 1, 2, 3, \cdots, n$.

Since the indicators have different scales and the higher the score, the normalization indicator is used to normalize the raw data, and then the normalization matrix X' is obtained. Its elements are determined by equation (1).

Normalization index:

$$x_{ij}^{'} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)} \tag{2}$$

where $x_{ij}^{'}$ is the normalized value, $\max(x_j)$ is the maximum value of the j th indicator, and $\min(x_j)$ is the minimum value of the j th indicator.

The objective weights are calculated as:

$$\sigma_j = \frac{C_j}{\sum_{j=1}^{n} C_j} \tag{3}$$

where: C_j is the amount of information, the larger its value, the larger the weight of the j th indicator. σ_j is the objective weight of the j th indicator.

II. B. 3) Weighted Least Squares Based Combinatorial Assignment

In this paper, we use AHP-CRITIC combination assignment based on weighted least squares [16] to combine subjective weights φ_j and objective weights σ_j.

Let the combined weights be $w_j (j = 1, 2, \cdots, n)$ The above conditions are satisfied:

$$\sum_{j=1}^{n} w_j = 1, w_j \geq 0 \tag{4}$$

Then the evaluation value y_i of the i th evaluation object is:

$$y_i = \sum_{j=1}^{n} w_j x_{ij}^{'} \tag{5}$$

where $x_{ij}^{'}$ is the normalized value obtained in the CRITIC method.

At the same time, the Euclidean distance function is introduced to reduce the assessment deviation between the combination of empowerment assessment value and subjective and objective empowerment assessment value, then the Euclidean distance between the combination of empowerment assessment value and subjective empowerment assessment value is:

$$\Phi_i = \sum_{i=1}^{m}\sum_{j=1}^{n}\left[(w_j - \varphi_j)x_{ij}^{'}\right]^2 \tag{6}$$

Then the Euclidean distance between the combined empowerment rating value and the objective empowerment rating value is:

$$\Psi_i = \sum_{i=1}^{m}\sum_{j=1}^{n}\left[(w_j - \sigma_j)x_{ij}^{'}\right]^2 \tag{7}$$

To make the resulting combination weights more effective, it is necessary to ensure that the sum F of the Euclidean distances of the two methods superimposed on each other is minimized, and therefore the computational formula is constructed as follows:

$$\left.\begin{aligned} &\min F = \sum_{i=1}^{m}\sum_{j=1}^{n} u\left[(w_j - \varphi_j)x_{ij}^{'}\right]^2 + (1-u)\left[(w_j - \sigma_j)x_{ij}^{'}\right]^2 \\ &s.t. \sum_{j=1}^{n} w_j = 1, w_j \geq 0 \end{aligned}\right\} \tag{8}$$

where u is the preference degree of the main objective assignment method and $0 \leq u \leq 1$.

From Eq. (8), the Lagrangian function $L(w,\lambda)$ can be introduced (with constraints on the extremes), i.e., let:

$$L(w,\lambda) = \sum_{i=1}^{m}\sum_{j=1}^{n}\left\{u\left[(w_j - \varphi_j)x_{ij}^{'}\right]^2 + (1-u)\left[(w_j - \sigma_j)x_{ij}^{'}\right]^2\right\} + 2\lambda\left(\sum_{j=1}^{n} w_j - 1\right) \tag{9}$$

The independent variables w_j, λ in Eq. (9) are each subjected to partial derivatives, and after a series of matrix operations the combination weights $w_j (j = 1, 2, \ldots, n)$ can be derived as:

$$\begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix} = \begin{pmatrix} u\varphi_1 + (1-u)\sigma_1 \\ u\varphi_2 + (1-u)\sigma_2 \\ \vdots \\ u\varphi_n + (1-u)\sigma_n \end{pmatrix} \tag{10}$$

II. C.Asset Management Risk Evaluation Based on Cloud Modeling

The cloud model evaluation method can complete the direct conversion of qualitative concepts and quantitative information, taking into account the arbitrariness and ambiguity of the asset management evaluation process. In this paper, on the basis of the identified asset management evaluation index system, each index is quantized, subjective and objective weights are determined respectively, and weight combinations are carried out. The cloud model theory is introduced to establish the asset management evaluation model based on the cloud model. Finally, with the help of MATLAB software, through the inverse cloud generator, input the comprehensive cloud of indicators, output the comprehensive cloud diagram, compare it with the standard cloud diagram, determine the preliminary asset management grade, and in order to make the evaluation results more accurate, calculate the similarity between the indicator cloud and the standard risk grade, select the maximum value of the similarity as the comprehensive risk evaluation grade, and finally arrive at the asset management grade. The specific asset management management evaluation process is shown in Figure 1.

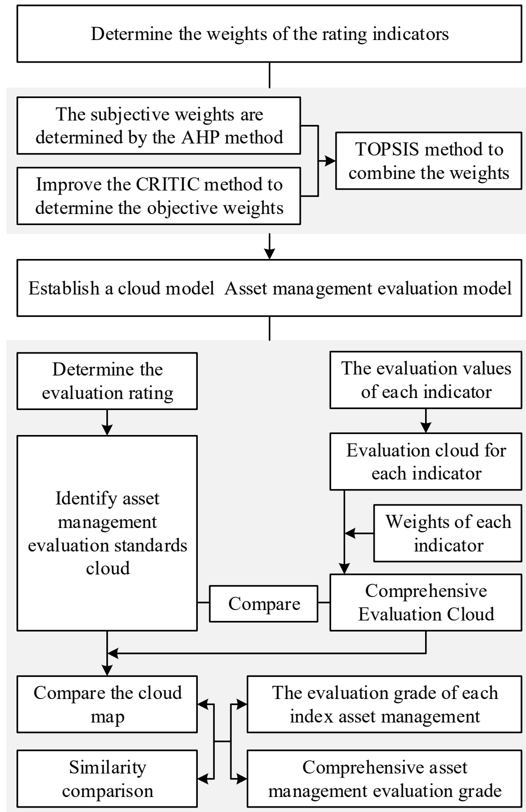

Figure 1: Asset management evaluation process

II. C. 1) Basic cloud algorithms

The basic cloud algorithm is composed of a forward cloud generator and an inverse cloud generator. Forward cloud generator is the process of changing three cloud digital features into cloud droplets, i.e., completing the conversion from qualitative concepts to qualitative data [17]. The inverse cloud generator is the inverse of the forward cloud generator, i.e., it is the process of transforming the cloud droplets into cloud digital features, i.e., it realizes the conversion from quantitative data to qualitative concepts.

II. C. 2) Cloud Model Calculation Steps

(1) Forward cloud generator

The main computational steps of the forward cloud generator are as follows:

1) Input the cloud digital features (E_x, E_n, H_e) and cloud drop numbers into MATLAB software and program them.

2) Generate normal random numbers $E_n \sim N(E_n, H_e)$ and $X^{-}N(E_x, E_n^{'})$.

3) Calculation:

$$y_i = \exp\left[-\frac{(x_i - E_x)^2}{2(E_x^{'})^2}\right] \tag{11}$$

4) Let (x_i, y_i) be a cloud droplet, X denotes the quantitative value from which the qualitative concept is transformed by means of a forward generator, and Y denotes the measure.

(5) Repeat the above steps, to be repeated until the number of cloud droplets that meet the conditions of the study can be generated.

(2) Inverse Cloud Generator

The reverse cloud generator refers to the conversion of the sample from a quantitative process to a qualitative process.

Input: cloud droplets X and their quantitative values u, i.e. (x_i, y_i).

Output: features (E_x, E_n, H_e) reflecting the qualitative concept of cloud droplets.

1) Calculate the sample mean:

$$\overline{x}=\frac{1}{n}\sum_{i=1}^{n}x_i \tag{12}$$

(a) Center distance of the sample:

$$A=\frac{1}{n}\sum_{i=1}^{n}|x_i-\overline{x}| \tag{13}$$

(b) Variance:

$$S^2=\frac{1}{n-1}\sum_{i=1}^{n}(x_i-\overline{x})^2 \tag{14}$$

2) Calculate expectations:

$$E_x=\overline{x} \tag{15}$$

3) Calculate entropy:

$$E_n=\sqrt{\frac{\pi}{2}}\times\frac{1}{11}\sum_{i=1}^{n}|x_i-\overline{x}| \tag{16}$$

4) Calculate the superentropy:

$$H_e=\sqrt{(S^2-E_n^2)} \tag{17}$$

II. C. 3) Steps for cloud model-based evaluation of asset management

(1) Determination of portfolio weights

1) Determination of subjective weights

Expert questionnaire survey for the identified factors affecting asset management in public universities, using the AHP method to categorize the degree of importance of the five first-level indicators and assigning weight coefficients, i.e., the mth factor $m_i(i=1,2,3,\cdots,n)$, and the vector of indicator weights for this level is $\omega_1=(\omega_{11},\omega_{12},\omega_{13},\cdots,\omega_{1n})^T$.

2) Determination of objective weights

Using the CRITIC method, the weight indicators are assigned and the weight vector is obtained as $\omega_2=(\omega_{21},\omega_{22},\omega_{23},\cdots,\omega_{2n})^T$.

3) Determine the combined weights

Use the least squares method to combine the weights on the basis of subjective and objective weights.

(2) Determine the evaluation set and criteria cloud

The rating set V is the composition of the evaluation results of the university asset management after relevant experts. Denote the set of rating results by V, i.e. $V=\{V_1,V_2,V_3,\cdots V_n\}$. Where n denotes the number of rubric levels, n should be taken at an appropriate value, otherwise the evaluation results will have strong or weak ambiguity due to subjective factors. Therefore, in combination with the characteristics of asset management in colleges and universities, this paper classifies the risk levels into five grades, namely: "High risk", "relatively high risk", "Medium risk", "relatively low risk", and "low risk".

According to the evaluation set, the thesis domain U is sliced into M sub-intervals, and the standard cloud numerical features of each risk interval $[x_{\min},x_{\max}]$ are derived from the formula E_x,E_n,H_e, from which a standard cloud model is obtained as a comparison reference.

(3) Determine the evaluation index cloud

The raw data are obtained by distributing questionnaires to experts and scoring the risk level. Input the raw data into the inverse cloud generator and use the following formula to calculate and obtain the evaluation cloud of the evaluation indexes of asset management in public universities:

$$E_{xj}=\frac{\sum_{p-1}^{t}x_{pj}}{t} \tag{18}$$

$$E_{nj}=\sqrt{\frac{\pi}{2}}\sum_{p-1}^{t}\frac{|x_{pj}-E_{xj}|}{t} \tag{19}$$

$$H_{ej}=\sqrt{|S_j^2-E_{nj}^2|} \tag{20}$$

In order to ensure that the obtained data are real and objective, it is necessary to adjust the expert scoring data several times. First, the standard cloud parameters obtained from the first scoring results of the experts are input into the forward cloud generator to obtain the evaluation cloud diagram. Observe the dispersion of the cloud map to determine whether the expert scoring data is feasible; if the dispersion is too strong, it indicates that the scoring difference is large and needs to be adjusted. Coordinate with experts to modify the scoring results until the results are more centralized in the cloud diagram and meet the cloud model input data requirements.

(4) Determine the comprehensive indicator cloud

Through the evaluation cloud and comprehensive weights obtained above, a comprehensive evaluation cloud can be obtained by using the following formula calculation:

$$E_x^*=\sum_{j-1}^{n}\omega_j^*E_{xj} \tag{21}$$

$$E_n^*=\sqrt{\sum_{j-1}^{n}\omega_j^*E_{nj}^2} \tag{22}$$

$$H_e^*=\sum_{j=1}^{n}\omega_j^*H_{ej} \tag{23}$$

Get the comprehensive cloud parameters, the cloud parameters will be input into the MATLAB software, you can get the cloud map of the whole target, which can comprehensively reflect the results of the evaluation indicators on the whole.

(5) Determination of evaluation results

For the determination of evaluation results, there are two methods: similarity comparison and cloud diagram comparison. In order to make the evaluation results more real and reasonable, this paper synthesizes the above two methods to determine the evaluation level of asset management in public universities.

1) Similarity comparison

Input two evaluation clouds in the cloud forward generator, respectively, for comparing the comprehensive cloud and the standard cloud, and calculate the similarity between the two, which is accomplished with the help of MATLAB software, and the specific process is as follows:

(a)Generate random numbers $E_x^{'}\sim N(E_n,H_e^2)$ and $\chi_i\sim N(E_x,E_n^{'2})$ by using the software

(b) Calculate the certainty x_i of $\mu^{'}$:

$$\mu^{'}=e^{\frac{(x_i-E_x^2)^2}{2(E_n)^2}} \tag{24}$$

(c) Find the overall similarity μ :

$$\mu=\frac{1}{n}\sum_{i=1}^{n}\sigma^{'} \tag{25}$$

The similarity value μ is used to compare the two clouds, the larger the value the closer it is to the standard cloud.

2)Comparison of cloud diagrams

With the help of MATLAB software, the comprehensive cloud of each index is compared with the standard cloud in the same coordinate system to get the comparison cloud diagram of evaluation indexes. By observing the location of the comprehensive cloud in the comparison cloud diagram, the nearest standard cloud level is the specific evaluation level of asset management risk, i.e. the risk evaluation result.

Combining the advantages of the above two methods, combining the two, and calculating the similarity degree through the cloud diagram comparison pair, the evaluation level of asset management of public universities is determined more accurately, making the evaluation results more accurate.

III. Case studies

This chapter follows the steps of asset management assessment under the AHP-CRITIC Combined Empowerment Cloud Model to develop an asset management performance assessment for University A.

III. A. Determination of evaluation indicator weights

III. A. 1) AHP method for determining subjective weights

When determining the weights by AHP method, the opinion of experts is an indispensable part, because it is a comprehensive evaluation of the asset management of School A, this paper invites 15 experts who are involved in the construction, operation, application and management of the asset management of School A to rate the relative importance of the indicators in each layer respectively. Through calculation, the weights of all indicators relative to the previous layer were derived as shown in Table 2. The subjective evaluation of tangible asset performance has the greatest influence on the assessment of school asset management performance, accounting for 28.6%.

Table 2: Subjective weight

Secondary index	φ_j	Tertiary index	φ_j
B1	0.252	C11	0.247
		C12	0.217
		C13	0.293
		C14	0.243
B2	0.136	C21	0.282
		C22	0.345
		C23	0.198
		C24	0.175
B3	0.286	C31	0.211
		C32	0.216
		C33	0.289
		C34	0.284
B4	0.165	C41	0.158
		C42	0.23
		C43	0.356
		C44	0.256
B5	0.161	C51	0.226
		C52	0.194
		C53	0.215
		C54	0.365

III. A. 2) CRITIC determines objective weights

AHP determines the weights mainly by inviting the experts who are involved in the construction, operation, management and application of asset management in school A. There will be a certain degree of subjectivity when evaluating the relative importance of the indicators, so this paper invites industry experts to apply CRITIC to determine the objective weights. Combined with the overall requirements of university asset management and the expertise and work experience of experts, the importance of each indicator is scored, and the importance of the indicator is expressed as 1-10. The initial matrix is constructed according to the expert scoring data X. The target initial matrix, B1, B2, B3, B4, and B5 initial matrices are shown in Fig. 2~Fig. 7, respectively.

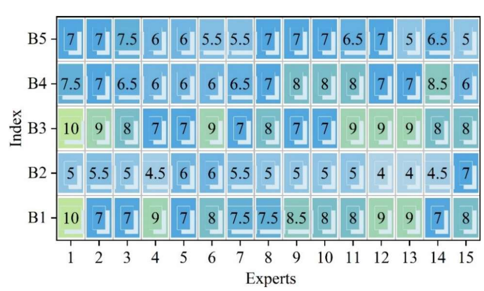

Figure 2: Target initial matrix

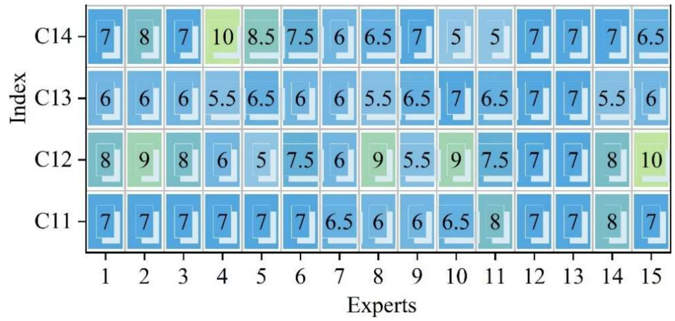

Figure 3: B1 Initial matrix

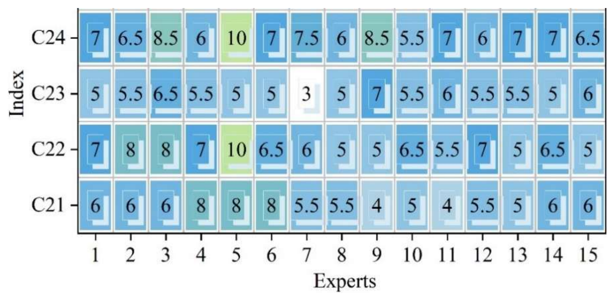

Figure 4: B2 Initial matrix

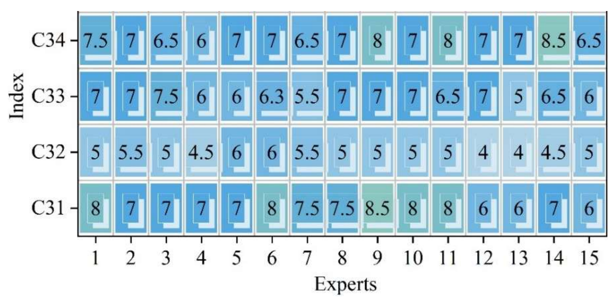

Figure 5: B3 Initial matrix

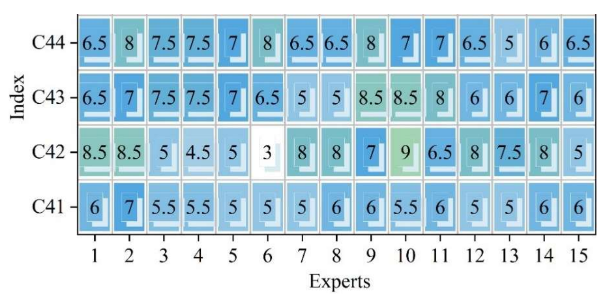

Figure 6: B4 Initial matrix

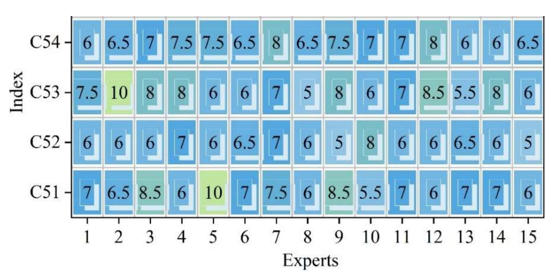

Figure 7: B5 Initial matrix

The objective weights were calculated according to formula (3). The calculation results are shown in Table 3. Talent training performance in the objective evaluation has the greatest influence on the assessment of school asset management performance, accounting for 26.8%.

Table 3: Objective weight

Secondary index	σ_j	Tertiary index	σ_j
B1	26.8	C11	27.2
		C12	23.7
		C13	22.5
		C14	26.6
B2	14.4	C21	20.8
		C22	30
		C23	26
		C24	23.2
B3	23.1	C31	25.8
		C32	24.1
		C33	26.6
		C34	23.5
B4	18.2	C41	23.1
		C42	28.7
		C43	27.1
		C44	21.1
B5	17.5	C51	25.9
		C52	30.4
		C53	21.9
		C54	21.8

Table 4: Asset management index combination weight

Secondary index	φ_j	σ_j	w_i	Tertiary index	φ_j	σ_j	w_i
B1	0.252	0.268	0.316	C11	0.247	0.272	0.268
				C12	0.217	0.237	0.226
				C13	0.293	0.225	0.261
				C14	0.243	0.266	0.24
B2	0.136	0.144	0.116	C21	0.282	0.208	0.211
				C22	0.345	0.3	0.315
				C23	0.198	0.26	0.243
				C24	0.175	0.232	0.204
B3	0.286	0.231	0.309	C31	0.211	0.258	0.25
				C32	0.216	0.241	0.235
				C33	0.289	0.266	0.273
				C34	0.284	0.235	0.239
B4	0.165	0.182	0.154	C41	0.158	0.231	0.203
				C42	0.23	0.287	0.262
				C43	0.356	0.271	0.322
				C44	0.256	0.211	0.221
B5	0.161	0.175	0.105	C51	0.226	0.259	0.237
				C52	0.194	0.304	0.255
				C53	0.215	0.219	0.231
				C54	0.365	0.218	0.304

III. A. 3) Determination of portfolio weights

The previous section has completed the subjective weight and objective weight calculation of various indicators of asset management in school A. According to the formula (10), the combined weights of the indicators are calculated, and the units are converted to different ones, as shown in Table 4. Comprehensive evaluation of the weight of the indicators from large to small in order of talent training performance (0.316), tangible asset performance (0.309), intangible asset performance (0.154), tangible asset performance (0.116), the school-run industry performance (0.105).

According to the hierarchical logical relationship between the second-level indicators and the third-level indicators, in this way, the weight of the third-level indicators relative to the first-level indicators can be calculated and ranked, and through the calculation, the weight of all indicators relative to the target and the ranking is shown in Table 5.

Table 5: The solution layer is relative to the weight and sort of the target

Secondary index	w_i	Tertiary index	W	Sort
B1	0.316	C11	0.085	1
		C12	0.071	8
		C13	0.082	3
		C14	0.076	5
B2	0.116	C21	0.024	18
		C22	0.037	11
		C23	0.028	15
		C24	0.024	19
B3	0.309	C31	0.077	4
		C32	0.073	7
		C33	0.084	2
		C34	0.074	6
B4	0.154	C41	0.031	14
		C42	0.04	10
		C43	0.05	9
		C44	0.034	12
B5	0.105	C51	0.025	17
		C52	0.027	16
		C53	0.025	20
		C54	0.033	13

III. B. Evaluation of asset management

Combining the actual situation of asset management in School A and referring to relevant asset management research, the evaluation level of asset management in School A is categorized into five levels: low risk [90, 100], lower risk [75, 90), medium risk [55, 75), higher risk [30, 55) and high risk [0, 30). Where [90, 100] indicates safety and an acceptable level of risk. [75, 90) indicates safer and the risk is within the acceptable range, but needs to be strengthened. [55, 75) indicates generally safe, with a high level of risk and the need for appropriate measures. [30, 55) indicates that it is more dangerous, the risk is at a high level and measures need to be taken to control it. [0, 30) indicates dangerous, unacceptable risk, requiring immediate measures for elimination.

The cloud model parameters were calculated for each corresponding level, and the cloud model parameters for each level were (95, 1.7, 0.5), (83, 2.5, 0.5), (65, 3.3, 0.5), (42.5, 4.2, 0.5), and (15, 5, 0.5) in that order. The forward cloud generator is applied to generate the risk level standard cloud and the standard cloud map is plotted as shown in Fig. 8.

The experts were invited to score the evaluation indicators according to the above criteria, and the scored values were input into the inverse cloud generator to obtain the cloud model characteristic parameters of the three-level indicators as shown in Table 6.

Based on Eqs. (21) to (23) and the characteristic parameters of the cloud model for the third-level indicators, the characteristic parameters of the second-level indicators are calculated as shown in Table 7.

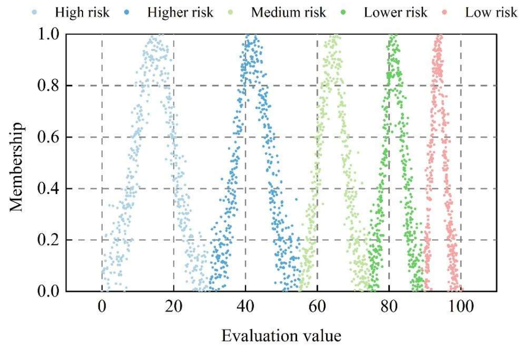

Figure 8: Standard cloud map

Table 6: Cloud model characteristic parameters of tertiary indexes

Tertiary index	Characteristic parameter (E_x^*, E_n^*, H_e^*)
C11	(50.7,1.3755,0.2113)
C12	(83.6,2.3061,0.9261)
C13	(72.9,3.7563,0.4853)
C14	(74.7,2.8045,0.8747)
C21	(81.2,1.5055,0.1363)
C22	(84.9,3.1048,1.0247)
C23	(61.6,2.2536,0.1525)
C24	(73.7,2.7558,1.3636)
C31	(54.3,2.5047,0.3174)
C32	(57.9,3.2556,1.4558)
C33	(68.8,2.9078,0.9636)
C34	(73.7,3.8136,1.7055)
C41	(70.2,1.9348,0.3675)
C42	(66.7,3.2635,1.4636)
C43	(74.1,2.6578,0.3635)
C44	(74.1,2.6326,0.8341)
C51	(69.1,2.4058,0.5016)
C52	(53.6,2.2547,0.0454)
C53	(68.1,1.9063,0.1372)
C54	(71.0,3.0055,1.2431)

Table 7: Cloud model characteristic parameters of primary and secondary indexes

Secondary index	Characteristic parameter (E_x^*, E_n^*, H_e^*)
B1	(70.8563,1.6563,0.545)
B2	(73.6344,2.375,0.663)
B3	(72.624,3.1523,0.4274)
B4	(70.322,2.715,0.8124)
B5	(75.314,1.4175,0.4036)

Substituting the cloud model characteristic parameters of the three-level indicators into Eqs. (21) to (23), the risk evaluation cloud model characteristic parameters of the asset management of school A are obtained as (71.2563, 1.3652, 0.2365). Using Matlab software, the comprehensive evaluation cloud is plotted in the same coordinate system with the standard cloud, and the comprehensive evaluation cloud is obtained as shown in Figure 9. The comprehensive evaluation cloud is distributed on the medium-risk comment cloud droplets, therefore, the result of the risk evaluation of the actual asset management of School A is medium risk, and measures should be taken to reduce the management risk. In addition, according to the fogging nature of the normal cloud model, the hyperentropy of the comprehensive evaluation cloud is 0.2365 (less than 1.2142/3), indicating that the evaluation results have a certain degree of reliability. The evaluation results are consistent with the actual asset management situation of School A, indicating that the constructed evaluation model is reasonable and feasible.

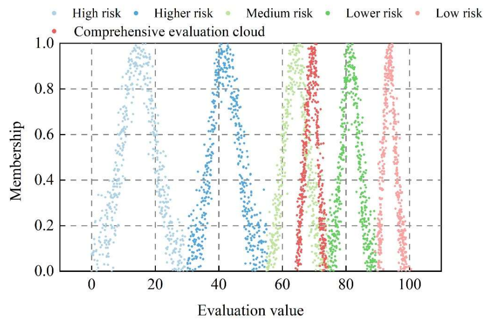

Figure 9: Comprehensive evaluation cloud map

In order to more deeply analyze the specific situation of the asset management risk of School A, identify the relative weaknesses, and put forward targeted improvement measures and recommendations, the three-level indicators were analyzed separately. As can be seen from Table 6, the expected values of indicators C11, C31 and C42 are all within [30, 55], and the evaluation result is "higher risk". The expected values of indicators C12, C22 and C21 are all within [75, 90], and the evaluation result is "low risk". The expectations of the remaining indicators are all within [55, 75], and the result is "medium risk". Therefore, University A should focus on academic learning (C11), utilization of equipment (C31), and external recognition (C42) to promote the improvement of asset management performance.

IV. Optimization of the asset management appraisal process

Based on the results of the above analysis, this paper puts forward targeted recommendations to optimize the working mechanism of asset management assessment.

IV. A. Strengthening dynamic monitoring of the appraisal process

For the assessment of asset management, it is more important to assess the daily asset management. How to get the traces of daily asset management of each department and make reasonable judgment on them is the focus of asset management assessment. At present, universities and colleges mainly carry out relevant asset management work through the state-owned asset management system, which can record in real time the whole life cycle management process of assets used by each faculty member from registration to disposal, but it is difficult to record the asset management work outside the system, such as the efficiency of the use of assets and the effect of asset operation. Part of the asset management situation can be recorded through the asset management system, but what cannot be recorded by the system needs to be dynamically monitored offline by the Asset Management Office and the Asset Appraisal Working Group and reacted in a quantitative way. Strengthening the dynamic monitoring of the appraisal process not only greatly improves the efficiency of the appraisal, but also makes the results of the performance appraisal of state-owned asset management more objective. Strengthening the dynamic monitoring of performance appraisal can effectively avoid the phenomenon of "temporary surprise" and reflect the real management situation of each department.

IV. B. Establishment of open channels of complaint and communication

For an appraisal process, the provision of complaint and communication channels for appraisees is also a key link. For the appraisees, a perfect complaint and communication channel not only provides protection for their own rights and interests, but also establishes a communication "bridge" between them and the appraisal department. The complaint mechanism lies in the fact that the teaching staff can reflect to the relevant departments and put forward their demands in time if they have objections to the appraisal results. It is the responsibility of the relevant departments to verify the evaluation results and feedback the results to the complainant. After investigation, if the problems reflected by the complainant do exist, then the review procedure should be initiated to review the appraisal process and give the complainant a fair and objective appraisal result again. Performance appraisal activities are often highly subjective, and cannot completely eliminate the impact of subjectivity on the appraisal results, but the establishment of a complaint system can to a large extent attenuate the impact of subjectivity, to protect the reasonable rights and interests of the appraisee. The communication mechanism is conducive to the feedback of the appraisal results, which is divided into two ways: individual communication and collective communication.

Individual communication is mainly for the appraisal results of the poorer faculty and staff, and its individual conversation, pointing out its mistakes in asset management, in order to help him make faster and better progress [18]. For the common problems that are widespread, feedback is provided through collective communication, for example, it can be publicly emphasized and released in the form of semester asset management appraisal work feedback meeting or semester asset management appraisal work report, so as to draw everyone's attention to avoid the recurrence of this kind of problems in the future work. The establishment of a long-term mechanism for complaints and communication can not only greatly improve the assessment culture, but also obtain better assessment results.

IV. C. Establishment of a sound accountability mechanism for assessment results

The performance appraisal accountability mechanism is also a way of applying the appraisal results, which can effectively motivate faculty and staff to improve their enthusiasm for asset management. At present, colleges and universities lack the relevant performance appraisal accountability mechanism, and the level of performance of each department's asset management can not have a substantial impact on the departments and asset users, so even if the annual assessment of asset management, it is still unable to improve the enthusiasm and initiative of asset management. Therefore, colleges and universities need to establish an accountability mechanism for appraisal results, linking the results of asset appraisal with the interests of individuals and departments. For the departments, the departments with excellent appraisal results are provided with priority in asset allocation, and the departments with poorer appraisal results are given less departmental incentive performance, and the reduced performance is sent to the departments with excellent appraisal results. For individuals, if the loss of state-owned assets is caused by personal reasons, the less serious ones will be warned and criticized within the university, and the more serious ones will be compensated, and the annual assessment of the current year will be recorded as “basically qualified”, and the appraisal of titles will be restricted within two years.

V. Conclusion

This study constructed a performance evaluation and assessment method for asset management in public universities based on the weighted least squares method, and verified the feasibility and effectiveness of the method through case studies. The study draws the following conclusions:

The constructed asset management assessment index system comprehensively reflects the multidimensional characteristics of asset management in public universities, containing five dimensions of talent cultivation performance, scientific research and education performance, tangible asset performance, intangible asset performance and university-run industry performance, covering 20 three-level indexes, which provides a scientific framework for comprehensive assessment.

The assessment method based on AHP-CRITIC combination assignment effectively integrates subjective weights and objective weights, making the assessment results more objective and reasonable. The case analysis shows that the top three weights of the comprehensive evaluation indicators are talent training performance (0.316), tangible assets performance (0.309) and intangible assets performance (0.154). Among the three-level indicators, academic learning (0.085), asset return (0.084) and cultural quality (0.082) ranked the highest in weight, reflecting the importance of these factors in asset management.

The cloud model evaluation method realizes the effective conversion of qualitative concepts and quantitative data, which improves the accuracy of the assessment.A The characteristic parameters of the cloud model for the evaluation of the risk of asset management in colleges and universities are (71.2563, 1.3652, 0.2365), with a hyperentropy value of less than 1.2142/3, which indicates that the results of the evaluation are reliable. The indicators of academic learning, instrument and equipment utilization and external recognition are rated as “higher risk”, which provides a clear direction for management improvement.

With regard to the assessment mechanism of asset management, optimization suggestions such as strengthening the dynamic monitoring of the assessment process, establishing a smooth channel for complaints and communication, and establishing a sound accountability mechanism for the assessment results are proposed, which provide practical guidance for improving the level of asset management in colleges and universities.

The assessment methods and assessment mechanism optimization suggestions in this study are of great theoretical and practical significance for improving the asset management performance and resource allocation efficiency of public universities.

Funding

This work was supported by Research on the Current Situation and Countermeasures of Service-oriented Manufacturing Industry Development: A Case Study of Changzhou City (Grant No. CZKSL-2023C085).

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