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The Sharing Benefit Evaluation Method of Large Instruments and Equipment in Colleges and Universities Based on Analytic Hierarchy Process

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ABSTRACT
As an important support platform for discipline construction, talent training, scientific research innovation and social service, large-scale precision instruments and equipment in colleges and universities have important strategic significance for supporting the development of national science and technology. In order to optimize the resource allocation of precision instrument and maximize the use benefit of precision instrument, it is necessary to establish a sharing benefit evaluation system for precision instrument. The weight of the evaluation index will have an important influence on the evaluation results. This paper presents a linear weight evaluation method for sharing benefits of large instruments and equipment in colleges and universities, and uses analytic hierarchy process (AHP) method to determine the index weight, so as to form a scientific evaluation system for sharing benefits of large instruments and equipment.
Keywords: *AHP, benefit evaluation, large-scale instruments and equipment, assets management*

1. INTRODUCTION

Large precision instruments and equipment in colleges and universities are characterized by high scientific and technological content, strong specialty and high operating cost, which are of great significance to teaching, scientific research and social scientific and technological innovation in colleges and universities [1]. Large instruments and equipment is the precious resources of colleges and universities teaching and scientific research [2]. How to give full play to the hardware support function of precision instrument and maximize the use benefit of precision instrument is an important subject of asset management in colleges and universities. At present, domestic colleges and universities have built open and shared information platforms for large instruments and equipment, open and reserve for use, and strengthened the open and shared management of large instruments and equipment by combining power monitoring, video monitoring and other scientific and technological means. However, there are still low utilization rates and low economic benefits [3], which are not conducive to the balanced allocation of resources. Therefore, colleges and universities should establish a reasonable and effective evaluation system for the use benefit of large instruments and equipment, and use benefit measurement as a lever to further stimulate the open sharing and improve the use benefit of large instruments and equipment.

In the evaluation process, the weight of the evaluation index will play a crucial role in the evaluation results.Most of the evaluation index weights are set artificially. It is a key problem to determine the weight of evaluation index scientifically and rationally [4]. Taking Harbin Institute of Technology at Weihai as an example, this paper calculates the weight of each index by using AHP based on the expert's scoring of each index.

2. CONSTRUCTION OF OPEN SHARING BENEFIT EVALUATION SYSTEM FOR LARGE INSTRUMENTS AND EQUIPMENT

According to relevant policies and the actual situation of domestic colleges and universities, the current evaluation indexes of the open and shared benefits of large-scale instruments and equipment are basically determined as operation period utilization, teaching and scientific research achievements, talent training, service income, service benefit and maintenance status and so on, and the benefit evaluation method basically adopts the linear weight method. However, due to the different management of large instruments and equipment in various universities, the setting of the weight of each index is not the same. In order to rationalize the weight system by combining qualitative and quantitative factors, linear evaluation weight will be established by AHP model after expert scoring.

2.1. Introduction of AHP

2.1.1. Introduction of AHP Model

The method combine quantitative analysis with qualitative analysis, using the experience of decision makers to judge the standard of each target realization between between the relative important degree, and give each decision reasonably plan for each of the standard weight, use of weighting the pros and cons of each solution sequence, is effectively applied to the subject that's hard to use quantitative methods to solve [5].

2.1.2. Algorithm Steps of AHP

Firstly, a hierarchical model need to be build. According to their mutual relations, the objectives, factors (decision criteria) and objects of decision are divided into the highest, middle and lowest levels, and a hierarchical structure is drawn.

The highest level is the purpose of the decision and the problem to be solved.The lowest level are alternatives when making a decision. The Middle level are considerations, criteria for decision making. For the two adjacent layers, the upper layer is called the target layer and the lower layer is called the factor layer.

Secondly, a judgment (pairwise comparison) matrix is constructed. The method of constructing the judgment matrix in analytic hierarchy process is the consistent matrix method, that is, instead of comparing all the factors together, two factors are compared with each other.The relative scale is used to reduce the difficulty of comparing different factors with each other as much as possible, so as to improve the accuracy. Table 1 shows the scale of judging matrix elements method.

Table 1 Scale table of judging matrix elements method

Scale	Meaning
1	The two factors are equally important
3	One factor is slightly more important than the other
5	One factor is more important than the other
7	One factor is strongly more important than the other
9	One factor is extremely more important than the other
2,4,6,8…	The median value of the above two adjacent judgments
reciprocal	The judgment value of factor i compared with factor j is recorded as a_{ij}, then the judgement value of factor j compared with factor i is $a_{ji} = 1/a_{ij}$

Finally, hierarchical single sort and its consistency check. The eigenvector corresponding to the maximum eigenvalue $\boldsymbol{\lambda_{max}}$ of the judgment matrix is written as W after normalization (the sum of all elements in the vector is 1) which is the sorting weight of the same level element to the relative importance of a factor in the next level. This process is called hierarchical single sorting.

Define consistency metrics $\boldsymbol{CI} = \frac{\boldsymbol{\lambda - n}}{\boldsymbol{n-1}}$; if $\boldsymbol{CI = 0}$, there is complete consistency; if $\boldsymbol{CI}$ is close to 0, there is satisfactory consistency. The larger $\boldsymbol{CI}$ is, the more inconsistent there will be. In order to measure the size of $\boldsymbol{CI}$, the random consistency index $\boldsymbol{RI}$ is introduced showing as table 2. Define the consistency ratio $CR = CI/RI$, generally it is considered that the inconsistency degree of the judgment matrix is within the allowable range, and there is satisfactory consistency when $CR < 0.1$.

Table 2 Random Consistency Index

n	1	2	3	4	5	6
RI	0	0	0.58	0.9	1.12	1.24

2.2. Weight Calculation of Benefit Evaluation Index of Large Instruments and Equipment

2.2.1. Expert scoring

Established linear weighting method is used to build large-scale instruments and equipment efficiency evaluation system, corresponding to the AHP model. The goal is the formation of a set of reasonable weight index including machine utilization, scientific research achievements, talent training, service revenue, service revenue, maintenance condition

To construct judgment matrix, combining with the target optimization matrix, please each unit expert for several index scores of grading method is not in proportion scale table for the guidelines, but combined with proportional scale and target optimization matrix model, with expert thinks of large instruments and equipment operation efficiency is extremely important indicators for nine points, according to the proportion of reduced scale table. Taking our school district as an example, the scoring results are as follows.

Table 3 Expert Scoring Scale

Operation period utilization (opu)	teaching and scientific research achievements (sra)	talent training (tt)	service income (si)	service benefit (sb)	maintenance status (ms)
7	3	5	5	3	1
9	5	3	5	3	1
7	5	3	3	5	1
9	5	5	7	5	3
5	3	3	3	3	3
7	5	3	3	5	1

Based on this scoring results, a 6-order judgment matrix could be constructed as follows:

$$A = \begin{bmatrix} 1 & 1.692 & 2 & 1.692 & 1.833 & 4.4 \\ 0.591 & 1 & 1.182 & 1 & 1.083 & 2.6 \\ 0.5 & 0.846 & 1 & 0.846 & 0.917 & 2.2 \\ 0.591 & 1 & 1.182 & 1 & 1.083 & 2.6 \\ 0.545 & 0.923 & 1.091 & 0.923 & 1 & 2.4 \\ 0.227 & 0.385 & 0.455 & 0.385 & 0.417 & 1 \end{bmatrix}$$

The analytic results obtained by substituting analytic hierarchy process are as follows:

Table 4 AHP Results

Factor	Feature Vctor	Weight	λ_{max}	CI
opu	1.737	28.947%		
sra	1.026	17.105%		
tt	0.868	14.474%	6	0
si	1.026	17.105%		
sb	0.947	15.789%		
ms	0.395	6.579%		

After using AHP to calculate the weight of benefit evaluation index of large-scale instrument and equipment, the approximate value can be taken as figure 1 shows, the calculation system of large-scale instrument and equipment could be established. Set X as the benefit evaluation result of instrument and equipment, and P as each evaluation index:

$$X = \sum (0.3P_1, 0.2P_2, 0.1P_3, 0.2P_4, 0.15P_5, 0.05P_6)$$

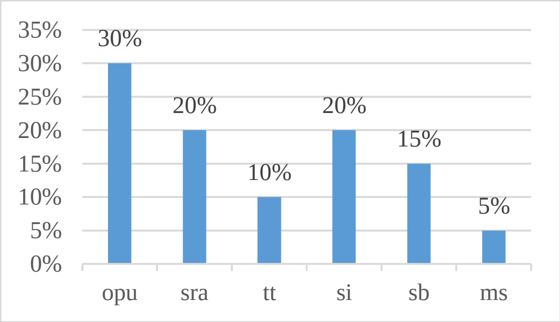

Figure 1 Weight of Benefit Evaluation Index

3. CONCLUSION

In the asset sharing evaluation system, the index weight will have a great influence on the evaluation results. This paper provides a method for determining weights. In this paper, combining with the actual situation of large-scale instruments and equipment in colleges and universities, based on the expert scoring, the analytic hierarchy process is used to carry out quantitative calculation of each index and determine the weight of each index, so as to obtain a more fair, scientific and reasonable evaluation system. This method can effectively avoid subjective factors. This qualitative and quantitative calculation method can provide reference for other universities to establish evaluation standards for large instruments and equipment.

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