Performance Evaluation of Key Laboratory Operation Based on Data Envelopment Analysis

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Abstract: DEA (Data Envelopment Analysis) model is applied to evaluate the index system of key laboratory in this paper, aiming at measuring the comprehensive level of the laboratory. Firstly, based on the establishment of key laboratory evaluation index system, the weight coefficient of each index is given. Then the CCR model and the efficiency values of several key laboratories are analyzed. The experiment results show that about 50% of the sample key laboratories in DEA are non-technical effective state, the basic amount of effective state is between 0.6-1 and presents the fluctuation condition, which needs to be improved continuously.

1. Introduction

As the platform and carrier of innovation research, the key laboratory can improve the quality of schooling and the mode of personnel training. The evaluation of key laboratory is an important part of college teaching research assessment, which not only promote the construction of laboratories in colleges and universities but also improve the level of laboratory work and education quality of teaching [1]. Evaluation index system research is the core elements of laboratory assessment activity and important basis. Therefore, it is necessary to establish a scientific and reasonable evaluation index system.

The commonly used methods in the laboratory evaluation system more include the analytic hierarchy process, fuzzy comprehensive evaluation method and neural network evaluation method, etc, but these methods are involved to determine the weight of index factors [2]. The evaluation index was set up in the basic course teaching experiment of local universities, and the weight of each index was determined by the analytic hierarchy process in reference [3]. According to the characteristics of multi-level, multi-factor and qualitative indicators, the application of fuzzy extension analytic hierarchy process is proposed to evaluate the level of laboratory construction. Although these methods can represent the relative importance of each index, the subjective judgment is ignored.

DEA (Data Envelopment Analysis) is a non-parametric method to evaluate the relative efficiency of multiple input and decision making unit (DMU). The first DEA model was established as the CCR model when the DEA method was proposed by Charnes, Cooper, and Rhodes [4,5]. The BCC, CCWH, ST and NCN-I-C and NIRS models are developed after CCR model, but the application of the CCR model is the most common model. Therefore, this paper firstly selects the

DEA evaluation method, and uses the CCR output guidance model to analyze and evaluate the efficiency of the management of scientific research funds in universities.

2. Evaluation Index System

Comprehensive, scientific and reasonable evaluation indicators should cover all aspects of the laboratory management, through the research of each link of experiment teaching, embody the laboratory construction characteristic. The evaluation index system is set to the level of indicators. According to the ministry of education key laboratory evaluation rules, evaluation indicators of key laboratory include four aspects: research level and contribution, research team construction, subject development and talents training, open communication and operation management. Each index has different standard requirements [6]. Among them, the research level and contribution account for 40%, and the other three indexes account for 60%. These four indicators are set to the secondary indicators. According to the weight and standard of the index, it is further refined, and 15 three-level indexes are obtained, which is used as the index collection of evaluation system. Evaluation index system of key laboratory is shown in figure 1.

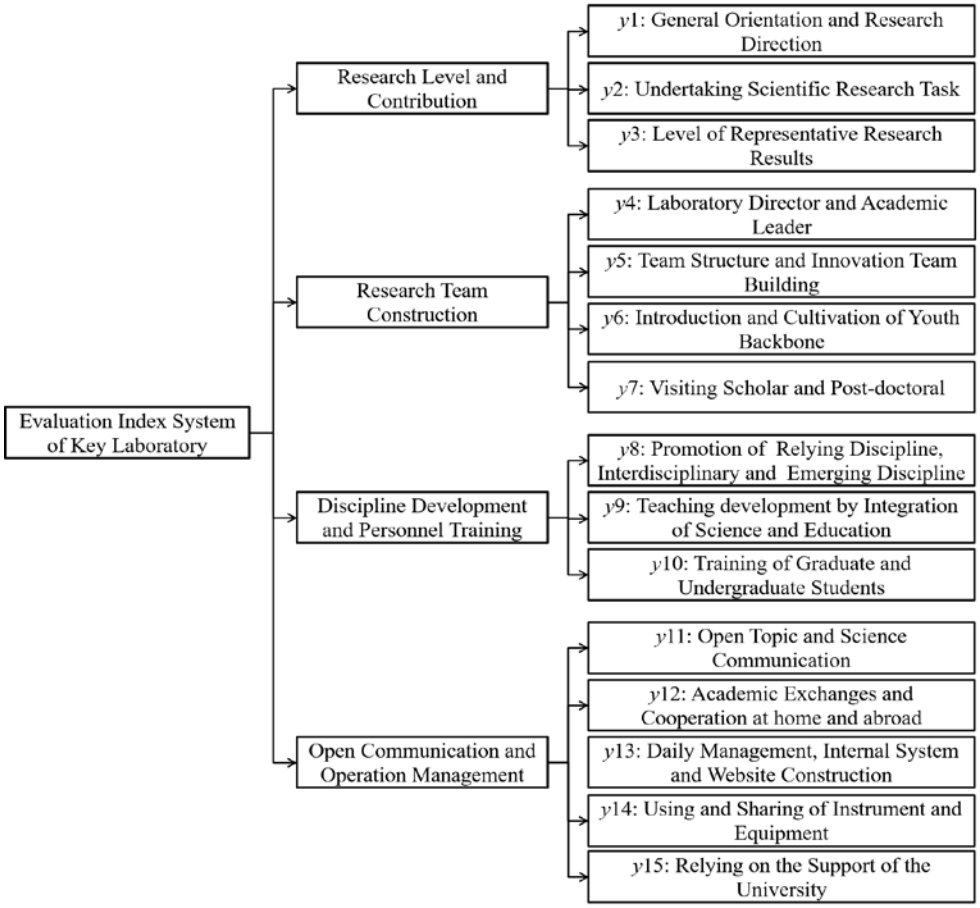

Fig.1 Evaluation Index System of Key Laboratory

3. DEA-CCR Control Model

DEA method can be used for the performance evaluation of complex decision unit system with multiple inputs and outputs, and the evaluation results are the relative number, which is not affected by the index dimension. It does not need to set the corresponding weight of input and output

correlation variables before data analysis. The production function equation of input and output should not be set before data analysis [7,8]. The essence of DEA is that linear programming method is used to estimate the boundary of the production frontier through a set of input and output data.

If the number of DMU is n, the number of input index is m, the output index is s [9]. $X_j = (x_{1j}, x_{2j}, \cdots, x_{mj})^T$ is the input data set, and $Y_j = (y_{1j}, y_{2j}, \cdots, y_{sj})^T$ is the output data set, $j = 1,2,\cdots,n$. Establish input data set $X_j = (1,1,\cdots,1)_{1\times n}$, that is $m = 1$ and $x_{mj} = 1$, $j = 1,2,\cdots,n$; the output data set is $Y_j = (y_{1j}, y_{2j}, \cdots, y_{sj})^T$, y_{sj} is the s quality indicator corresponding index system, in which, $s = 17$, $j = 1,2,\cdots,n$, the data structure is as follows:

The Output-CCR model is in equation (1), the optimal solution is λ^*, σ^*, in which σ^* is efficiency value of Output-CCR and $\sigma^* \geq 1$.

$$(D^O CCR)\begin{cases} \max \sigma \\ \sum_{j=1}^{n} X_j \lambda_j \leq X_0, \ \sum_{j=1}^{n} Y_j \lambda_j \geq \sigma Y_0 \\ \lambda_j \geq 0, \ j = 1,2,\cdots,n \end{cases} \tag{1}$$

To get the optimal solution of the model just make the output index of radial improvement information, Y_0 translate to the expanded output σ^* to achieve the optimal, for the efficient Output-CCR DMU.

4. Example of Application

Table 1 Evaluation indicator data of key laboratory

DMUj	*DMU1*	*DMU2*	*DMU3*	*DMU4*	*DMU5*	*DMU6*	*DMU7*	*DMU8*	*DMU9*	*DMU10*
x1	1	1	1	1	1	1	1	1	1	1
y1	8	7	6	9	9	9	8	9	6	7
y2	9	9	7	7	8	7	9	6	8	8
y3	7	5	6	8	7	6	8	8	8	9
y4	7	6	6	9	7	6	8	8	9	6
y5	8	8	7	7	9	8	9	7	8	8
y6	8	7	7	8	8	7	9	6	7	8
y7	6	6	8	7	9	8	9	8	7	9
y8	8	6	6	7	7	6	8	8	8	8
y9	9	7	8	8	8	8	9	7	6	5
y10	7	6	7	7	7	6	8	9	7	8
y11	8	8	9	8	8	8	8	9	6	8
y12	6	9	7	9	7	8	8	6	7	8
y13	9	8	8	7	9	7	8	8	8	5
y14	8	5	7	7	8	6	9	8	9	8
y15	6	7	7	8	9	8	8	7	8	7
σ^*	1	0.668	0.812	1	1	0.924	1	1	0.798	0.725

In this paper, 10 key laboratories in Nanjing are selected as evaluation objects, and the resource

utilization efficiency of these 10 key laboratories is evaluated and ranked to judge the quality of laboratory construction management. In order to facilitate the description, X and Y represent each input and output index respectively, which is substituted into the CCR model and calculated by computer, as the input indexes $X_j = (1, 1, \cdots, 1)_{1\times 10}$, output indicators basis for quality assessment of 15 indicators data, as shown in table 1.

From the table 1, we can judge the construction level of key laboratories in Nanjing city according to the evaluation index. The 17th line of the table is the result of the efficiency of the solution of CCR model with DEAP2.1 software, which reflects the overall efficiency of each laboratory. '1' indicates that the relative efficiency value is the maximum, and the remaining efficiency value is less than '1', which indicates that the overall efficiency of the laboratory is invalid. The output evaluation efficiency values of DMU1, DMU4, DMU5, DMU7, DMU8 are '1', indicating the five laboratories have a good comprehensive level. The output evaluation efficiency values of DMU2, DMU3, DMU6, DMU9, DMU10 are less than '1', indicating the five laboratories need to improve.

5. Conclusion

On the basis of the key laboratory index system, the DEA-CCR model is established to evaluate several key laboratories in this paper. When the index system for CCR model of efficiency value is 1, and the Output-CCR is effective. Under the DEA-CCR model estimates, about 30% of the key laboratory in DEA are non-technical effective state, the basic amount of effective between 0.6-1, and presents the fluctuation condition. The results show that the subjectivity of data and the selection of indicators of laboratory input and output may only reflect some level of the laboratory. How to select indicators and how to measure the overall input and output of key laboratory construction is still the key to evaluation, and high-quality data sources are still needed.

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