Financial Performance Evaluation of Colleges and Universities
Based on DEA Model and Balanced Scorecard Method

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Abstract. In this paper, a DEA model is applied to the financial performance evaluation of colleges and universities. Six colleges in Guangxi are taken as the research objects, and their financial performances are ranked to determine the college with the best financial performance in the region. The college is used as the benchmarking unit to propose targeted management suggestions for the financial performance insufficiency of other colleges in Guangxi.

Keywords: DEA, Financial Performance, Colleges and Universities, Benchmarking Unit

1. Introduction
Most of the traditional financial performance studies in colleges and universities focus on the selection of evaluation indexes, and the evaluation method is relatively simple [1-2]. It fails to efficiently combine quantitative and qualitative methods to evaluate the financial performance of colleges and universities scientifically [3-4]. Envelopment analysis is a method based on the concept of relative efficiency to evaluate the relative effectiveness of the same type of department with multiple input and output indexes. In this method, a mathematical planning model is used to compare the relative effectiveness of the decision-making units (DMUs) and evaluate the performance of decision-making units. Since the data envelope analysis method was proposed, it has been widely used in the effectiveness evaluation of various industries [5-6].

However, the DEA model also has its insufficiency. As this method divides a large number of decision units into two categories, efficient and non-efficient, when using this method for effectiveness analysis, a large number of situations where all decision units are efficient are prone to occur. Using the DEA improvement method in the literature, a virtual ideal decision unit is introduced on the basis of the traditional DEA model, so that the DEA efficient decision units can be ranked, and the shortcoming of the “relative effectiveness” of the method is overcome. Subsequently, the improved method was applied to the financial performance evaluation of colleges and universities. Through empirical research on the financial performance of six colleges in Guangxi, useful exploration is performed on the application of the DEA model to the financial performance evaluation of colleges and universities.

2. DEA model
There are n companies or colleges, known as n decision units. Each unit has m inputs and p outputs, which are represented by different economic indexes, respectively. Hence, an evaluation system composed of n decision units with multi-index input and multi-index output can be obtained, as shown in Figure 1.

In Figure 1: $x_i$ and $y_j$ respectively the input amount of the i-th input index and the output amount of the r-th output index of the j-th decision unit, and $\nu_r$, $v_j$ > 0; $\nu_r$ and $v_j$ Represent the weight coefficients of the
i-th input index and the r-th output index, and $v_i, u_r \geq 0$.

The evaluation system shown in Figure 1 is used to establish an optimization model and performs its dual programming after Charnes-Cooper transformation. Meanwhile, the non-Archimedean infinitesimal $\varepsilon$ is introduced to obtain the DEA model (C²R):

$$
\begin{align*}
\min V_D &= \left[ \theta - \varepsilon \left( e^T s^- + e^T s^+ \right) \right] \\
\text{s.t.} &\sum_{j=1}^{n} x_j \lambda_j + s^- = \theta x_0 \\
&\sum_{j=1}^{n} x_j \lambda_j - s^+ = y_0 \\
&\lambda_j \geq 0 \ (j = 1, 2, \ldots, n), s^+, s^- \geq 0
\end{align*}
$$

(1)

Figure 1: input-output system

$e^T = (1,1,\cdots,1)$ represents an m-dimensional vector with elements 1, $x_i, y_j > 0$ is a p-dimensional vector with elements 1

To evaluate the technical effectiveness of production sectors better, it is generally necessary to use the C²GS² model with the structure as follows:

$$
\begin{align*}
\min V_D &= \left[ \varphi - \varepsilon \left( e^T s^- + e^T s^+ \right) \right] \\
\text{s.t.} &\sum_{j=1}^{n} x_j \lambda_j + s^- = \varphi x_0 \\
&\sum_{j=1}^{n} x_j \lambda_j - s^+ = y_0 \\
&\sum_{j=1}^{n} \lambda_j = 1 \\
&\lambda_j \geq 0 \ (j = 1, 2, \ldots, n), s^+, s^- \geq 0
\end{align*}
$$

(2)

Model (1) suggests that in the production possible set when the output $y_0$ remains unchanged, try to ensure that the input $x_0$ is reduced by the same proportion; if the input $x_0$ cannot be reduced by the same proportion $\theta$, solve model (1) to get the best value $\theta_0 = 1, s^+ = 0, s^- = 0$. We say that the evaluated decision-making unit is more efficient than other decision-making units. However, when $\theta_0 = 1$ but $s^+ = 0, s^- = 0$ is not met, the weak DEA is efficient, and its economic significance is: the evaluated decision unit is neither technically efficient nor scale efficient at the same time, then we need to use the model (2) for further calculations; if $\theta_0 < 1$, the evaluated decision unit is Non-DEA efficient.

Model (2) shows the further analysis based on the calculation of model (1) to determine whether it is technically efficient. Due to the comprehensive effectiveness, it is the intersection of technically efficient and scale efficient, that is, $\theta = \varphi \sigma$, $\sigma$ represents the scale validity value, according to the characteristics of the DEA model, $\theta, \varphi, \sigma \leq 1$. According to this equation and model (1) (2), the scale validity value $\sigma$ can be
obtained.

For the case where non-DEA is efficient, the “projection” of the evaluated decision unit on DEA efficient frontier (new decision unit) is obtained through analysis and adjustment. The new decision unit is a valid DEA conversion of the original decision unit. The equation is as follows:

\[
\begin{align*}
  x'_0 &= \theta^0 x_0 - x^0 - \\
  y'_0 &= y_0 + \delta^0
\end{align*}
\]

\( (x'_0, y'_0) \) decision unit corresponding \((x_0, y_0)\) “Projection” on DEA efficient frontier.

According to equation (3), it is possible to obtain the adjustment amount for the correction of various input indexes by non-DEA efficient sectors on the premise of keeping the output unchanged.

3. Construction of the financial performance evaluation index system of colleges and universities

Traditional performance assessments are mostly based on financial indexes of colleges and universities, and performance assessments of this model are no longer applicable to current science and technology universities. Therefore, a model that integrates multiple indexes for performance evaluation is urgently needed. The most commonly used method is the DuPont financial analysis method. In this method, the operating performance of colleges and universities are evaluated comprehensively through the internal relationship between multiple financial indexes. For the industrial economy era, the application of this performance appraisal system is consistent with the current economic development with capital as the main body. However, in the current market competition of informatization, the use of this performance evaluation model can no longer meet the needs of economic development, mainly because the traditional university performance evaluation model cannot be implemented, and it has intangible assets and knowledge assets in the operation of some universities. In addition to practical evaluation, such performance appraisal systems usually focus only on the operating results within the university, while insufficient attention is paid to external environmental factors with a significant impact on the university and the current operating results of the university. The traditional college performance evaluation method is more important.

In this paper, with reference to the evaluation index system adopted by the research project “Comprehensive Evaluation of University Finance” from the research project of the Ministry of Education and Nanjing University, the characteristics of the DEA model are combined to design the university financial performance evaluation index system, as shown in Table 1.

Among them, \(X_3\), \(X_4\), and \(X_5\) represent teaching input, \(X_1\) represents scientific research input, \(X_2\) represents school-run business input; \(Y_3\), \(Y_4\) represent teaching output, \(Y_1\) represents scientific research output, and \(Y_2\), \(Y_5\) represent school-run operating output.

### Table 1. University financial performance index system

| Index name            | Index variable                        | Index name                                      |
|-----------------------|---------------------------------------|------------------------------------------------|
| Input index           | \(X_1\) Teachers' research funding per capita |
|                       | \(X_2\) Proportion of self-raised infrastructure funds to infrastructure funds |
|                       | \(X_3\) Expenditure per faculty       |
|                       | \(X_4\) Equipment cost per student    |
|                       | \(X_5\) Expenditure per student       |
|                       | \(Y_1\) Rate of return on scientific research achievements |
|                       | \(Y_2\) Ratio of self-financing income to total income |
| Output index          | \(Y_3\) Student-teacher ratio         |
|                       | \(Y_4\) Student Employment Rate       |
|                       | \(Y_5\) Annual increase in school property delivery and operating income |

4. Empirical analysis

(1) Data source

The purpose of this study is to provide an evaluation method for the financial performance of domestic colleges and universities. Given the availability of data and the applicability of the model, six colleges in Guangxi are selected as the research sample. The data of the evaluation indexes mainly come from various “Annual Institutional Analysis of Universities” from 2004 to 2006 and relevant information from relevant departments such as the Finance Office, Asset Management Office, School Office, and Academic Affairs
Office.

(2) Data analysis

The collected raw data of 6 colleges were introduced into the model (1), and the linear programming software Lindo was used to perform the linear programming. The results show that in addition to the comprehensive effectiveness of $A_6 \theta = 0.0925$, the performance is non-DEA efficient, and the rest 5 All institutions are efficient for DEA. Obviously, the results obtained with the traditional DEA model cannot provide much management information for decision-makers. Here we use the DEA improvement method mentioned in to introduce a virtual ideal sample university. The value of each input index takes the minimum of its corresponding input in the 6 institutions, and the value of each output index takes the maximum of its corresponding output. Therefore, it must be the most efficient in the selected sample. ranking results of each sample university, as shown in Table 2.

Table 2. Comprehensive efficient values and ranking results of various colleges

| College | A₁ | A₂ | A₃ | A₄ | A₅ | A₆ | Ideal college |
|---------|----|----|----|----|----|----|---------------|
| 0.3138  | 0.1899 | 0.8143 | 0.3238 | 0.5718 | 0.0256 | 1 |
| Sorting results | 4 | 5 | 1 | 3 | 2 | 6 |

Table 2 shows the financial performance rankings of various colleges and universities. To obtain efficient management decision information, we also need to know how much investment value should be maintained by each investment index of each college to ensure its optimal financial operation performance level. If we use the ideal sample colleges as the standard to adjust the input levels of the other sample colleges and make them relatively efficient, it will have no practical significance. Therefore, in further analysis, we remove the ideal sample colleges, and the college with the highest efficiency value among the sample colleges is college A3. The college is taken as a benchmarking unit; the efficiency value of each sample college is divided by its efficiency value 0.8143 and standardized to obtain the following:

$\theta_1 = 0.3854$, $\theta_2 = 0.2332$, $\theta_3 = 1$, $\theta_4 = 0.3976$, $\theta_5 = 0.7022$, $\theta_6 = 0.0314$.

Obviously, in the above decision-making units, decision-making unit 3, that is, institution A3 is DEA efficient, and the other sample institutions are non-DEA efficient.

The following are adjustments and improvements to non-DEA efficient decision units.

Substitute the model as a known number (1), and solve the relaxation variable of decision unit $i: s^0 = (s^1_i, s^2_i, \ldots, s^m_i); s^0_u = (s^1_u, s^2_u, \ldots, s^p_u)$. According to formula (3), as long as the input-output index value is adjusted to the level, the financial performance of the sample institution is said to reach the financial performance level of the benchmark institution.

We can obtain the specific values to be improved in various indexes of financial input and output (such as institution A₅) for six best benchmarking institutions in Guangxi. For example, the combination of input indexes of college A₅ can be adjusted as follows: Research funding per teacher decreased to 1368, the proportion of self-raised infrastructure funding to infrastructure funding increased to 0.695, the expenditure per faculty decreased to 7898, the equipment cost per student decreased to 498, and business expenditure per student decreased to 39. The output level will change accordingly to the following: The ratio of teachers to students will remain the same, the rate of return on scientific research results will increase to 0.95, the ratio of self-funded income to total income will decrease to 0.61, and the student employment rate will increase to 0.82, and the annual growth rate of school property delivery and operating income increased to 0.18. At this time, it can be said that the financial performance of the college A₅ has reached the optimal level in the region, with capital utilization efficiency improved to a growth stage.

5. Conclusions

In this paper, the DEA model is introduced to the financial performance evaluation of various colleges in the same region. On the one hand, it has overcome the difficulties of other evaluation methods in setting artificial weights and identifying accurate and complex functional relationships. The evaluation results are objective and conducive to the comparison between similar colleges and universities, which can even be extended to the comparison between different types of institutions. On the other hand, the introduction of ideal decision-making units can implement proper ranking of the financial performance of various institutions, which has overcome the insufficiency of the “efficiency” in the traditional DEA model. At the
same time, through the selection of the benchmarking institution, specific improvement values are provided for the financial input factors of the colleges and universities with relatively low financial performance, which has provided efficient decision-making data for colleges and universities to adjust their financial management further. The results of this study are in line with the actual situation, suggesting the practicality of the method.

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