Research of Universities' Input-Output Efficiency Basing on DEA

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Abstract

According to data envelopment analysis, coupling with the peculiarity of higher school in inputting and outputting, the paper constructs inputting and outputting index system which considered both the teaching and the science research in college and university all-round, and sets up the comprehensive evaluating model for higher school. Then in view of 12 universities' circumstance which subordinate to ministry of education, the paper evaluates their efficiency using frontier analyst soft, and find that the efficiency of the well-known colleges and universities is not as high as imagination. We should contrast of the output and input to assess university and colleges. Otherwise the result will be unfair. In this way, the universities with higher efficiency will get more resources and be further developed. The universities with lower efficiency should analyze carefully to looking for the way to improve input-output efficiency

Keywords: universities; efficiency evaluation; DEA

1. Introduction

Education efficiency is ported from the economics. It is the comparison of educational resources inputting and outputting[1]. The essence of educational input-output allocation is the effective allocation and utilization of educational resources[2]. Efficiency evaluation of higher education is a complex system. Under the situation of certain input, the approaches to improve the efficiency is to make full use of existing resources. From the microscopic, the problem of resource allocation and school management can be found by analysis of internal efficiency. This will induce the universities to improve management, develop the potential use of resources, and bring up more higher quality students.

2. Index System

When we evaluate the effectiveness of input and output for colleges and universities. The evaluation index system must be able to correctly reflect the basic task of colleges and universities. In this paper, students develop and academic research as two basic tasks are adopted as evaluation criteria. According to scientific principles, system optimization principle, general principles, practical principles and objectives-oriented principles, by analysis of the past evaluation index system, 19 input indexes and 26 output indexes are set at first. Then merger related indicators using cluster analysis to determine the final evaluation index system. （fig.1）

By operating the result of Actual indicators value divided by the maximum value of the corresponding index, the different dimensionless input-output indicators are converted into homogeneity evaluation value to describe higher education efficiency. The index value of different

spacing will be normalized into [0,1] interval[3]. Considering the importance of each indicator itself, simultaneously taking full account of raw indictors data variations, each index weight is calculated by using Analytic Hierarchy Process. (fig.2)

	Level indicators	Secondary indicators
Input Indicators	human input X_1	1.Number of teaching teachers X_{11} 2.Number of research teachers X_{12} 3.Number of teachers with doctorate X_{13} 4.Expert number X_{14} 5.Professor and ph.D number X_{15} 6.Administrate and support staff number X_{16}
	Level indicators	**Secondary indicators**
Input Indicators	material resources X_2	1.Fixed assets X_{21} 2.Libray holdings X_{22} 3.Teaching and research equipment worth X_{23} 4.Number of state key lavoratory and 5.disciplines X_{24} 6.Number of research sites X_2
	financial investment X_3	1.government funds X_{31} 2.tuition X_{32} 3.other financial income X_{33}
Output indicators	Students trainning y_1	**Training scale** 1.students number Y_{11} **training quality** 2.number of outstanding doctoral thesis Y_{12} 3.number of people getting nationa awards Y_{13} 4.the ratio of postgraduate getting degree Y_{14} 5.employent rate Y_{15} 6.number of outstanding teachers Y_{16}
	Academic and research achievements y_2	**Academic achievements:** 1.number of scientific papers recorded by SCI、EI、ISTP Y_{21} 2.number of social science papers recorded by SSCI、A &HHCI、ISSHPY$_{22}$ 3.number of papers recorded by CSSCI Y_{23} **research achievements:** 4.number of teachers awarded by the highest national science and technology Y_{24} 5.number of people getting china's top ten scientific and technological progress Y_{25} 6.number of people getting natural/invention/improement awards Y_{26} 7.number of authorized patents Y_{27} 8.number of outstanding research teachers Y_{28}

Fig.1: Input and output indexes for university

indicator	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}
weight	0.347	0.347	0.050	0.144	0.084
indicator	X_{16}	X_{21}	X_{22}	X_{23}	X_{24}
weight	0.029	0.293	0.293	0.293	0.077
indicator	X_{25}	X_{31}	X_{32}	X_{33}	Y_{11}
weight	0.043	0.460	0.221	0.319	0.067
indicator	Y_{12}	Y_{13}	Y_{14}	Y_{15}	Y_{16}
weight	0.133	0.133	0.266	0.357	0.044
indicator	Y_{21}	Y_{22}	Y_{23}	Y_{24}	Y_{25}
weight	0.195	0.195	0.070	0	0.311
indicator	Y_{26}	Y_{27}	Y_{28}		
weight	0.117	0.070	0.044		

Fig.2: The weight distribute of indicator

3. Model of Data Envelopment Analysis

Suppose there are n objects to be evaluated, called the decision-making units (DMU). Each DMU has m inputs and s types of output. X_{ij} means the numbers of DMU_i inputting to j. Y_{ik} means the numbers of DMU_i outputting to k. so , DMU_i input can be expressed as:

$$X_i = (x_{i1},\ x_{i2}...,\ x_{im})^T,\quad (i=1,2,\ \ldots,\ n)$$

DMU_i output can be expressed as:

$$Y_i = (y_{i1},\ y_{i2},...,\ y_{is})^T,\quad (i=1,2,\ \ldots n)$$

DMU_i efficiency can be expressed as:

$$E_i = \frac{u^T Y_i}{v^T X_i},\quad (i=1,2,\ \ldots n) \tag{1}$$

If we want to evaluate DMU_0, it inputs X_0, outputs of Y_0. Then the relative efficiency evaluation model of i_0 DMU is:

$$\max E_0 = \frac{u^T Y_0}{v^T X_0} \qquad u \geq 0,\ \ v \geq 0$$
$$\sum_{i=1}^{s} u_i = 1, \qquad \sum_{i=1}^{m} v_i = 1 \tag{2}$$
$$\frac{u^T Y_i}{v^T X_i} \leq 1,\quad i = 1,2,...,\quad n$$

Using the Charness-Cooper transformation and dual programming theory, And introducing of slack variables s+, s- and Non-Archimedean infinitesimal ε ,the above model can be transformed into a linear programming model.

$$\begin{aligned} &\min\left[\theta-\varepsilon\left(\hat{e}^{T} S^{-}+e^{T} S^{+}\right)\right], \\ &\text{s.t.} \quad \sum_{i=1}^{n} X_i \lambda_i + S^{-} = \theta X_0, \\ &\sum_{I=1}^{N} Y_i \lambda_i - S^{+} = Y_0, \\ &\lambda_i \geq 0, \quad i=1,2,\ldots, \quad n \\ &S^{-} \geq 0, \quad S^{+} \geq 0 \end{aligned} \tag{3}$$

Among them, ε is the Non-Archimedean infinitesimal, $\hat{e}^{T}=(1,1, \ldots 1) \in E_m$, $e^{T}=(1,1, \ldots,1) \in E_s$. S^{-} is vector corresponding to input, $S^{-}=(S_1^{-}, S_2^{-}, \ldots S_m^{-})^{T}$. S^{+} is the vector corresponding to output, $S^{+}=(S_1^{+}, S_2^{+}, \ldots, S_s^{+})^{T}$.

The results and analysis of model parameters:

(1) DMU_0 is DEA efficient

When $\theta=1$ and $S^{-}=S^{+}=0$, DMU_0 is DEA efficiency. That is among n evaluation objects, on the basis of input X_0, Y_0 achieve the optimal output.

(2) DMU_0 is non-efficient of DEA

When $\theta<1$, DMU_0 is DEA non-efficient. That is the DMU_0 input can be reduced to θX_0 as well as original Y_0 unchanged.

4. Empirical Analysis

4.1. the Original Data Source

In this paper, the original input and output data of 12 key universities in 2003 comes from the compilation of basic statistics of ministry of education under 2003, and the university website and related official websites.

4.2. Evaluation Results of Overall Efficiency

According to the provision of samples and indicators numbers in DEA evaluation model, the sample size is at least twice the number of indicators[4]. Or the sample size is greater or equal to the number of input-output multiplied[5]. This index system calculate five-level indicators including of the human input, material resources and financial input, student training, academic research basing on the standardized data of indicators and corresponding weights. The overall efficiency of 12 colleges and universities are calculated using frontier analyst soft as fig.3.

university	Tsinghua university	Zhejiang university	Peking university
efficiency	1	0.6719	0.9572
university	Shandong university	Jilin university	Huazhong university of science and technology
efficiency	0.58	0.3997	0.6176
university	nanjing university	Shanghai Jiaotong university	Fudan university
efficiency	1	0.6493	0.6941
university	Tianjin university	xi'an jiaotong university	dalian university of technology
efficiency	0.8852	1	1

Fig.3: university efficiency

4.3. Evaluation Results

Overall, the efficiency of the well-known colleges and universities directly under the ministry of education is not as high as the imagination. Of the 12 universities, the efficiency of tsinghua university, nanjing university, xi'an jiaotong university, dalian university of technology is the highest. Among them, tsinghua university and nanjing university are high input,

high output type, xi'an jiaotong university, dalian university of technology are low input, low output type. Minimum input-output efficiency of jilin university for 39.97%, Shandong university is 58%. Remaining colleges are in the middle position. Of course, this only reflects a relative number. But we can see that it's very important to raising efficiency of resource in current lack of investment.

5. Results

Based on past evaluation of university, whether wangda or the guangdong branch of china academy of management, their ranking are very different, mainly because the different evaluation ideas. In their index system, inputs and outputs , together as the elements of university strength[6]. In short, the "input+output" value is as the basis of university strength. Thus some college less investment is in the position behind. Such as xi'an jiaotong university and dalian university of technology, their inputs in human, material and financial resource are much less than the inputs of peking university and jilin university. In this article, the "outputs/inputs" value is taken as the basis for evaluation. Evaluation results are certainly different. In addition, in the past university ranking, a large weight is set to the index of students number, so that some university with large number of students rank much earlier. In this paper, the weight of student number is only 6.7%, the student cultivate value is more measure from the quality of students, which is a major cause of the different measurement results.

We should contrast of the output and input to assess university and colleges. Otherwise the result will be unfair. Measuring input-output efficiency will guide the higher education to the correct target of making full use of resources. Especially in present situation that educational investment inadequate and the quality of education needs to be improved, we should evaluate the university development potential based on education efficiency. Then determining how much investment to university according to the university potential. In this way, the universities with higher efficiency of resource use will get more resources and be further developed. The universities with lower efficiency will analyze carefully to looking for the way to improve input-output efficiency.

6. References

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