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Efficiency of Educational Resource Allocation --- Taking a Local University in China as an Example

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Abstract **– The educational resource deployment of local university is the focus of social attention in China. Effective resource deployment is of great significance to the operation and management of local universities. Based on the data of different schools in a local university from 2017 to 2018, this paper employs the data envelope analysis and the total factor productivity analysis to evaluate the efficiency of educational resource deployment for different schools. Results indicate that four schools are not on the frontier of production and eight schools expose the problem of insufficient technical progress. The main factors affecting resource allocation are also given, accompanied by specific suggestions for improving resource deployment.**

Keywords **– Local University, Resource Deployment, DEA, Lingo.**

I. INTRODUCTION

The construction of effective educational resource deployment is a major strategy of higher education reform. Under this background, college education has put forward new requirements, new demands and new ideas for the deployment of resources in universities. The efficiency of higher education is often divided into two levels: internal efficiency and external efficiency [9]. The internal efficiency of higher education usually refers to the ratio of input to direct output within the higher education system or schools, that is, the relationship between input and output within the education system. In short, this efficiency is the effective allocation of resources within colleges and universities. The external efficiency of higher education refers to the comparison between the indirect output of higher education and the investment in education. It measures the degree of satisfaction of higher education with the labor market and with regard to economic growth and social development. Colleges and universities have three functions of teaching, scientific research and social services [4]. They are a multi-input and multi-output institution. Limited resources are allocated to these three activities, and all three activities have different outputs [6]. This brings the concept of Allocative Efficiency [7]. Allocation efficiency is used to measure the resource input and output of multiple types of production organizations, and refers to the reasonable allocation of the minimum cost to achieve the maximum output. If the indirect output is required to be measured, allocation efficiency focuses on external efficiency issues; if the direct output is required, allocation efficiency points to the internal efficiency [7]. In this paper, the output mainly refers to the direct output and the resource allocation efficiency of universities represents the internal efficiency.

At present, the Chinese government and many local administration pay more attention to the research on the efficiency of resource allocation in universities, and have made some progress in this aspect. Some from the perspective of institutional economics, cost control, competition mechanism, etc. based on the theory and combined with the reality of China's colleges and universities. Some studies have analyzed the efficiency of resource allocation in colleges and universities, which found that the efficiency of resource allocation in most colleges is relatively low [9]. There are also studies using statistical data to study the economies of scale and scope of higher education [8]. In this paper, we take the input and output data from 2017 to 2018 of a Chinese local university as a case to discuss microscopically the internal allocation of resources under certain circumstances. We employ the DEA method [1] to evaluate the input and output of internal resources of the university, subsequently accompanied an empirical analysis of efficiency, finding out the factors that affect the efficiency of university resource allocation. Then some suggestions are provided on reducing the waste and dissipation of educational resources.

II. Research Methods

A. *Research Design*

The evaluation methods of input-output efficiency mainly include qualitative evaluation method, quantitative evaluation method, and comprehensive evaluation method. With the continuous development of new evaluation tools, the comprehensive evaluation method has become the mainstream trend of input-output efficiency evaluation research. This paper makes use of the widely used data envelopment analysis (DEA) method in the comprehensive evaluation method. DEA is a relative efficiency evaluation method proposed by the famous American operations researcher Charnes et. al. [2]. It is suitable for decision-making units (DMU) with the multiple inputs (consumption of resources) and multiple outputs (efficiency after consumption of resources) to be evaluated so that the relative effectiveness of the DMU is essentially judged whether they are on the production frontier of the possible production set [3].

The C^2R model is one of the representative models in DEA, with the idea of analysing the input to output ratio to estimate the relative efficiency of DME. Specifically, given n DMU to be evaluate, let $X_j = [x_{1j}, x_{2j,...,} x_{mj}]$ and $Y_j = [y_{1j}, y_{2j,...,} y_{mj}]$ (j = 1,2,3, ..., n) be the jth DMU with m imput indexes and m output indexes, respectively, see Figure 1.

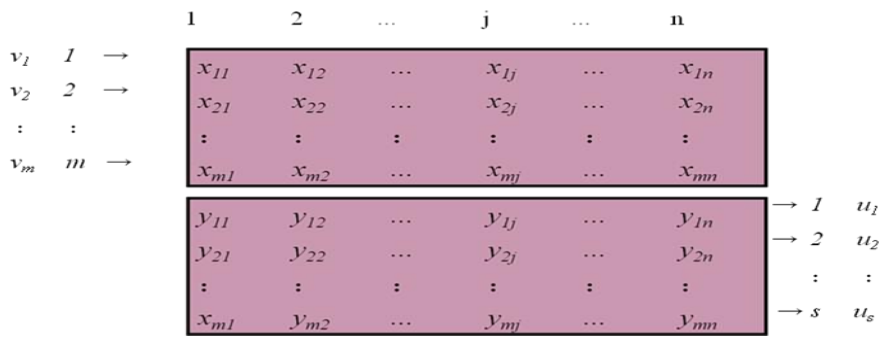

Fig. 1. Input and output indexes for m DMU.

The C^2R model requires to determine the weight coefficient vectors $v = [v_1, v_{2,...,} v_m]$ and $u = [u_1, u_{2,...,} u_m]$ appropriately to construct the input to output ratio of j-th DMU, i.e.

$$h_i = u^T Y_j / v^T X_j, \quad j = 1,2,3, ..., n,$$

to satisfy $h_j <= 1$. Under the weight coefficient vectors v and u, the meaning of the evaluation index of the j_0-th DMU is to find the maximum value as the optimal goal, that is, the fractional linear programming:

$$\text{Max } V_p = u^T Y_{j0} / v^T X_{j0}$$

$$s.t. \quad u^T Y_j / v^T X_j \leq 1, u \geq 0, v \geq 0, \quad j = 1.2....n$$

Obviously, the above model is a nonlinear programming and could be further simplifized as a linear model.

$$\text{Max } V_C{}^2{}_R = \mu^T Y_{j0}$$

$$s.t.\ \omega^T X_j - \mu^T Y_j \geq 0,\quad j=1, 2, ...,n;\ \omega^T X_{j0} = 1,\ \ \omega \geq 0, \mu \geq 0.$$

Definition 1: The j0-th DMU is DEA efficient if VC2R equal to 1.

Definition 2: The j0-th DMU is DEA strongly efficient if VC2R equal to 1 and ω>0, μ>0.

B. *Selection of Input and Output Indexes*

The input-output efficiency index can be divided into two groups: one for applied research and the other for basic research. The efficiency index for applied research focuses on the composition, organization, and implementation from a micro perspective. In the research of higher education resource allocation, the input indexes generally consist of human input indicators, financial input indicators, and physical input indicators. Output indexes include education service output indicators, scientific research output indicators, and social service output indicators. Therefore the following data indexes for a local university are selected to establish an input and output system.

Table 1. Input indexes and output indexes.

Index	Item	Unit	Specification
Input	Number of staff	Person	Professional staffs and part-time staffs
	School funding	Ten thousand RMB	Office expenses, business expenses, training fees, etc.
	Cost of Equipments and maintenance	Ten thousand RMB	Equipment purchase and maintenance fees, etc.
Output	Number of students	Person	Undergraduates and graduateed students
	Income	Ten thousand RMB	Tuition fees, accommodation fees, technical service fees, etc.
	Research Points	Point	Conversion points for research projects, articles and monographs

C. *Participants*

The selection of decision-making units must have the following characteristics: (1) all decision-making units must perform the same tasks and have similar goals; (2) all decision-making units are supposed to be operated under the same market conditions; (3) the number of input (or output) items of all decision-making units should be identical, but the input (or output) ranges can be different.

We take 12 schools as a research object in a university in Hunan Province, which locates the central area of China and could be regarded as a representative of the local universities. As most scientific research results require more than one year to yield outputs, two years of data are selected to reflect the scientific efficiency, that is, two years from 2017 to 2018 (the data could be obtained by sending request form at http://dag.hut.edu.cn/ fwzn/zhda.htm). At the same time, all 12 schools in the university are used as independent decision-making units and the descriptive statistics (the maximal, the minimal and the mean value of Number of staff, School funding, Cost of Equipment and maintenance, Number of students, Income, Research Points) are listed in Table 2.

Table 2. Descrptive statistics for inputs and outputs.

Item	I/O	Min	Max	Mean
Number of staff	input	51	183	73
School funding	input	20.34	640.12	92.54
Cost of equipments and maintenance	input	163.71	6652.37	848.48
Number of students	output	236	4045	1051
Income	output	320.25	8581.65	932.56
Research Points	output	386	5201	1205.43

As shown in Table 2, there is a big gap in various statistical items for different schools. For example, the most minimal values of input indexes and output indexes attribute to the School of Philosophy as it has the least number of staff and cost of equipment and maintenance. Also, the School of Foreign Language takes the smallest research points. As a comparison, the School of Civil Engineering and the School of Computer and Communication have the maximal values of input index and output index. In fact, the statistical data indicates that most schools of arts obtain the smaller inputs indexes while schools of engineering take bigger ones, showing that there is a problem of uneven development among various schools.

III. Analysis and Results

A. *DEA Efficiency Analysis*

Based on the input and output panel data of each school, we employ the software Lingo 11.0 [6] to compute the C^2R model and analyze the results. The codes for calculating the DEA efficiency of each school is given in Figure 2.

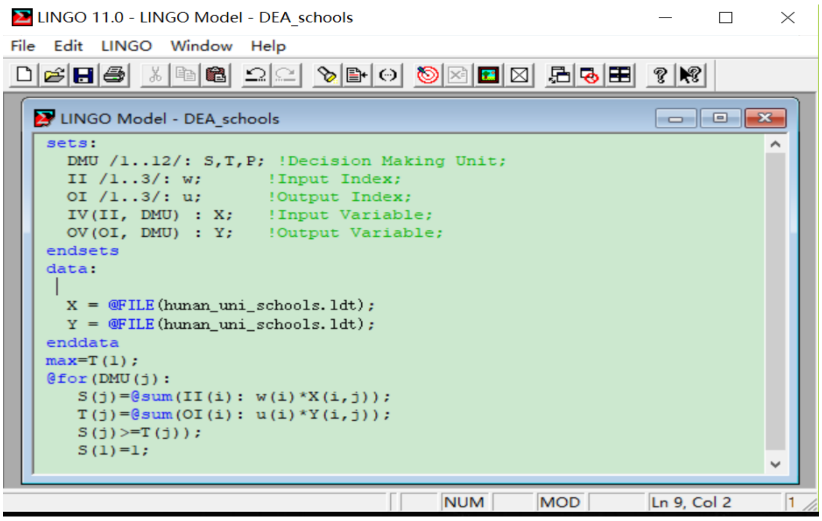

Fig. 2. Computation of DEA efficiency in Lingo 11.0.

The vectors w and u are the input and output index, X and Y respectively stands for the input data and output data of schools, being stored in Lingo data file “Hunan_uni_schools.ldt” and incorporated into Lingo 11 via the command “@FILE”. We compute the DEA efficiency for 12 schools one by one and list the obtained results in Table 3, where the DEA efficiency, Technical efficiency and Scale efficiency has the equality, DEA efficiency = Technical efficiency × Scale efficiency.

Table 3. DEA efficiency of various schools.

Schools	DEA Efficiency	Technical Efficiency	Scale Efficiency
Transportation & Rail	1.000	1.000	1.000
Civil Engineering*	1.000	1.000	1.000
Computer & Communication	0.9853	0.9931	0.9921
Mechanical Engineering	1.000	1.000	1.000
Metallurgical Engineering	1.000	1.000	1.000
School of Materials*	1.000	1.000	1.000
Life & Chemistry*	1.000	1.000	1.000
Management	0.9624	0.9751	0.9869
Science	1.000	1.000	1.000
Foreign Language	0.9585	0.9721	0.9860
Philosophy	1.000	1.000	1.000
News & Literature	0.9938	0.9987	0.9950
Average	0.9916	0.9949	0.9966

Some observations could be made from Table 3:

(1) Except for 4 schools (Computer & Communication, Management, Foreign Language, News & Literature), other schools are DEA efficient. Especially, the derived results show that the weighted vectors u and w are greater than 0 for 3 schools (labeled with "*", Civil Engineering, Materials, Life & Chemistry), indicating that these schools are strongly DEA efficient. Also, it is seen from the results that most schools of engineering have limited adjustment space in the input indicators, and the overall gap is small.

(2) The technical efficiency and scale efficiency of eight DEA efficient schools are all 1, constituting the production frontier of the input-output efficiency of schools. This shows that the scale returns are optimal and the current scale is supposed to be maintained.

(3) The input-output efficiency of four DEA inefficient schools has not reached the frontier of production, indicating that there exists room to improve the input-output efficiency.

(4) As stated in the last section, the school of Philosophy has the least number of staff and the cost of equipment and maintenance. However its research points are not the least and it has a relatively higher DEA efficiency, although not the strongly DEA efficient one, via seeing from Table 3.

B. *Analysis of DEA Inefficient Schools*

As shown in Table 3, four schools (Computer & Communication, Management, Foreign Language, News & Literature) are not DEA efficient. In other words, they have not reached the frontier of production and the input-output efficiency should be further improved. Here we take the school of the smallest DEA efficiency, i.e. the School of Foreign Language, as an example to show the specification. The Lingo computes the DEA efficiency in Figure 3 and the derived results on redundant inputs and insufficient outputs are listed in Table 4.

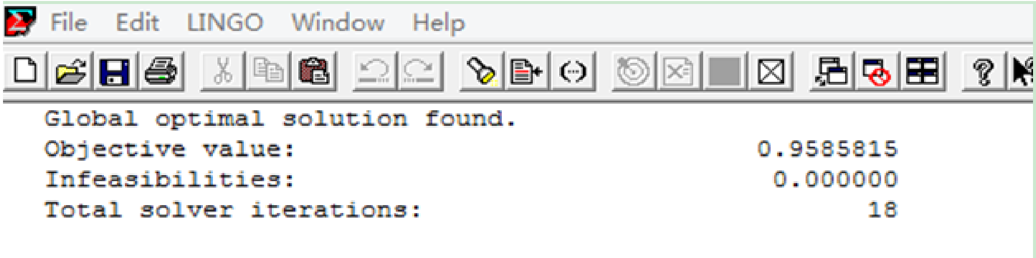

Fig. 3. DEA efficiency of the School of Foreign Language in Lingo. 11.

As shown in Table 4, the redundant input and insufficient output of the School of Foreign Language are specifically manifested in the number of staff, school funding, equipment purchase and maintenance costs, etc., and the amount of redundancy is 23.4, 4.86, 85.65, respectively. Especially, the redundancy of maintenance fees is more prominent. On the other hand, the insufficient output mainly lies in the research points, owing to 213.

Table 4. Redundant input and insufficient output of School of Foreign Language.

	Item	Original value	Redundant Input	Inefficient Output
Input	Number of staff	96	23.4	0
	School funding	66.67	4.86	0
	Cost of Equipments & maintenance	634.42	85.65	0
Output	Number of students	2012	0	0
	Income	812.54	0	0
	Research Points	386	0	213

To achieve the best state of input-output efficiency, it is necessary to reduce input and increase output. After optimization, the target values of input and output of the School of Foreign Language, the number of staff, school funding, cost of equipments & maintenance, and research points reached 72.6, 61.81, 548.77, 599, respectively.

C. *Total Factor Efficiency Analysis*

If the rank of all schools is required, the analysis of Total Factor Productivity (TFP) with the relation Total factor productivity = technical efficiency × technical progress, has to be calculated. We listed the derived results in Table 5.

Table 5. Total Factor Productivity of twelve schools.

Schools	DEA Efficiency	Technical Progress	TFP	Rank
Transportation and Rail	1.000	1.025	1.025	4
Civil Engineering	1.000	1.043	1.043	3
Computer and Communication	0.985	0.956	0.941	10
Mechanical Engineering	1.000	0.998	0.998	5
Metallurgical Engineering	1.000	0.980	0.980	7
School of Materials	1.000	1.101	1.101	1

Schools	DEA Efficiency	Technical Progress	TFP	Rank
Life and Chemistry	1.000	1.087	1.087	2
Management	0.962	0.932	0.896	11
Science	1.000	0.993	0.993	6
Foreign Language	0.958	0.904	0.867	12
Philosophy	1.000	0.975	0.975	8
News and Literature	0.993	0.971	0.965	9

It is seen from Table 5 that Technical progress points of four schools (i.e. Transportation and Rail, Civil Engineering, School of Materials, Life and Chemistry) are greater than 1, reflecting their performances in this statistical period are better than that of last period. As a result, the TFP points of the four schools are greater than 1 and they take the first four ranks. On the other hand, Technical progress points of six schools (Mechanical Engineering, Metallurgical Engineering, Science, Philosophy, News and Literature, Computer and Communication) are greater than 0.95, indicating that there is no obvious difference among these schools and they take 5-10 in the rank. Note that schools of Computer & Communication and Management are DEA inefficient. Finally, the TFP points of Foreign Language and Management are below 0.9 mainly due to the low DEA efficiency and technical progress points, resulting in the last two ranks in Table 5.

IV. Conclusions

The DEA efficiency of twelve schools in a Chinese local university has been analysed. Derived results show that the input-output efficiency of four schools (Computer & Communication, Management, Foreign Language, News & Literature) is not on the frontier of production. Besides, the analysis of Total Factor Productivity shows that eight schools expose the problem of insufficient technical progress. As mentioned before, problems faced by various schools are that the gap between them is still very large, and the imbalanced resource allocation and low utilization efficiency is common. To remedy these problems, it is possible to take some measures to promote output efficiency via several suggestions below.

1. The school is supposed to rationally determine the size to improve structural efficiency. Starting from the administrative departments and the interior of the university, all staff should clearly make out the position of the university, rationally determine the scale of running the school, gradually improve the development mode and the structural efficiency, carefully leapfrog the marginal trap of scale development and continuously enhance the performance of the school.

2. The university is suggested establishing a system of paid occupation of resources within schools and the university to achieve resource sharing. First of all, it is necessary to accelerate the construction of informatization. This requires the joint efforts of universities in the whole province and even the whole country, using science and technology to develop a comprehensive teaching system so that students are able to learn the knowledge wherever they are. Secondly, by introducing a market mechanism to revitalize the school's assets, schools and the university can provide laboratories, libraries, gymnasiums, and other teaching resources to off-campus people in the same area for a fee, strengthening the awareness of resource cost and efficiency. Finally, the administration of the university should also coordinate the interests of vari-

-ous schools and dilute self-awareness.

3. The university should effectively construct the cost accounting system, and promote the transformation of university management from an extensive way to a refined way. By advancing the cost accounting system and other methods, schools and the university are encouraged to pay attention to costs, with refined management as the guide and cost accounting as the means to rationally determine the cost and expenses, so to improve the performance of resource allocation and the enhance the level of running schools.

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