Statistical Appraisal of the Allocation Efficiency of Higher Education Resources in Ningbo City

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Abstract. This paper used data envelopment analysis (DEA) method to analyze the allocation efficiency of higher education resources in the city of Ningbo. The estimate results of technical efficiency and scale efficiency consistently show that allocation efficiency of higher education resources in the city of Ningbo are lower, and the allocation efficiency of higher education resources in the north and south higher education campus of Ningbo city is conspicuous difference, which shows that there exists ecological imbalance in the allocation of higher education resources in the city of Ningbo.

Introduction

With the popular development of higher education, the enrollment number of college students in the city of Ningbo increases from 2.37 million in 1999 to 19.00 million in 2010, but almost all of colleges and universities face the actual difficulties in the process of management and operation. On the one hand, colleges and universities are short of financial assistance and teachers; on the other hand, the graduates confront a great variety of difficulty to get a satisfied job. To a certain extent, the gap between supply and demand means a serious waste of human life means, a huge waste of resources for higher education, which has become a serious constraint of the continuing and harmonious development in the higher education field in the city of Ningbo. Under this circumstance, this study indicates very importantly practical significance for the allocation efficiency analysis of higher educational resources and putting out the suited measurements for improvement the allocation efficiency of higher education resources in the city of Ningbo.

Literature Review

The so-called higher education resources are certain social and historical conditions exist, can be exploited for the development of higher education, through processing and creation of the higher education system to produce all elements of the outcome of higher education, including human resources, material resources and cultural resources (Peng Bo, 2008) [1]. The main two ways of higher education resources is a market mechanism and planning mechanisms, the two complement each other conducive to the rational allocation of resources for higher education.

Since the late 20th century, Researchers are increasingly paying attention to the allocation efficiency of higher educational resources. Breu & Raab (1994)[1]used data envelopment analysis (DEA) method to analyze the relative efficiency of public universities in the United State. Sinuany and Stern (1994) [2] also used DEA method to build a model to evaluate the relative efficiency of the 21 colleges of the Negev Ben-Gurion University in Israel. Hooshan Izadi et al (2002)[3] used the stochastic frontier analysis method to analyze the allocation efficiency of higher educational resources. John F.Ryan (2004) [4] used the least squares method to analyze the relationship among graduation rates, entry requirements, ethnicity, gender, age, teaching expenditure, schools, public administration

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expenditure. William R. Johnson & Sarah Turner (2009) [5] focused on the serious imbalance of teacher-student ratio in different disciplines of the university.

In recent years, scholars began to pay attention to the allocation efficiency of educational resources in China. Zhang Yue(2002)[6]constructed a comprehensively analytical model for the evaluation of allocation efficiency of human resources. Shao Zhengyan (2006)[7] used DEA model to analyze allocation efficiency of regional higher education resources in China. Kang Ning(2010)[8] designed a comprehensive index system to evaluate the transformation degree of higher education resource allocation in China.

In a word, the existing literatures provide important reference material for further study the allocation efficiency of educational resources, but these studies don't pay attention to the allocation efficiency of higher education in the city of Ningbo. Therefore, this paper intends to take the city of Ningbo as the research object, and uses the DEA method to objectively analyze the allocation efficiency of higher educational resources in the city of Ningbo.

Models, Indicators and Data

In this study, the samples include 14 colleges and universities in the city of Ningbo, which is named decision making unit (DMU) A, DMU B, DMU C, DMU D, DMU E, DMU F, DMU G, DMU H, DMU I, DMU J, DMU K, DMU L, DMU M, DMU N respectively. The following is a brief description of the basic analytical models, variables and data issues[1].

3.1 Models.

In this study, we regard the each college or universities as a DMU and build the DEA model to estimate their technical efficiency (TE), pure technical efficiency(PTE), scale efficiency(SE). According to the definition of efficiency of Farrell (1957)[9], the efficiency of the individual colleges or universities can be divided into two parts: TE and price efficiency, the former reflects the individual colleges or universities in the circumstances of a given input for maximum output abilities, the latter reflects a given input prices, the capability for using all kinds of investments of the individual colleges or universities. Supposing variable returns to scale (VRS), the TE of individual colleges or universities can be decomposed into PTE and SE. PTE measure the distance between the colleges or universities and its production frontier; SE measures the distance between the frontier of product in constant returns to scale (CRS) and the frontier of product in VRS.

CRS model was put out by Charnes, Cooper and Rhodes in 1978[10]. We assume that there exist N colleges and universities, each of them uses the K kinds of inputs to produce the M kinds of outputs, the inputs and output are named X and Y respectively, X is a K×N dimensional input matrix, Y is a M×N dimensional output matrix. Under the conditions of CRS, TE can be calculated by the following linear programming model:

$$\begin{aligned} &\mathrm{Min}_{\theta,\lambda}\,\theta; \\ &\text{s.t. } -y_i + Y\lambda \geq 0; \\ &\theta x_i - X\lambda \geq 0; \\ &\lambda \geq 0; \\ &i = 1,2,3...,N \end{aligned} \tag{1}$$

In which, λ is a N×l dimensional constant vector, and θ is the efficiency value of the i-th DMU. When the inputs of the I-the colleges or universities remains unchanged, θ value represents the proportion of the actual output to the efficiency of the cutting-edge surface of the standard sample. Generally speaking, θ is ≤ 1. if $\theta = 1$, it means that the university is in the frontier surface of efficiency; if $\theta < 1$, it means that the college or university is in the state of the technical inefficiency.

The assumption of CRS doesn't agree with the reality. What's more, in the condition of the hypothesis of CRS, we can't separate the TE and SE. In order to solve the above problem, Banker,

[1] In order to avoid being misunderstood, we don't show clearly the name of colleges or universities.

Charnes &Cooper [11] proposed the improvement model of the CRS model in 1984. A constraint the conditions $N1T\lambda = 1$ is added in the CRS model, we can construct the VRS model as follows:

$$\begin{aligned} &\mathrm{Min}_{\theta,\lambda}\,\theta; \\ &\text{s.t. } -y_i + Y\lambda \geq 0; \\ &\theta x_i - X\lambda \geq 0; \\ &N1^T\lambda = 1; \\ &\lambda \geq 0; \\ &i = 1,2,3...,N \end{aligned} \tag{2}$$

Using model (2), we can get the θ value, which is PTE. Furthermore, SE value can be obtained for each of colleges and universities if we combined with the equation "SE=TE÷PTE". If SE=1, it means that college or university in a state of scale efficiency; if SE≠1, it indicates that the college or university is in a state of scale inefficiency. In this situation, scale inefficacy can be divided into two cases, which are increasing returns to scale (IRS) and decreasing returns to scale (DRS).

In order to discriminate the cases between IRS and DRS, another model named non-increasing returns to scale (NIRS) needs to be introduced. NIRS model was put out by Coelli (1995) [12]. If we substitute the constraint condition of $N1T\lambda \leq 1$ for $N1T\lambda = 1$ in VRS model, we get the NIRS model as the following:

$$\begin{aligned} &\mathrm{Min}_{\theta,\lambda}\,\theta; \\ &\text{s.t. } -y_i + Y\lambda \geq 0; \\ &\theta x_i - X\lambda \geq 0; \\ &N1^T\lambda \leq 1; \\ &\lambda \geq 0; \\ &i = 1,2,3...,N \end{aligned} \tag{3}$$

And we also can discrimination of the DRS or IRS state of the colleges and universities by the efficiency value derived by NIRS and VRS model. If TENIRS=TEVRS, it shows that the object is in the state of DRS, the scale of college or university is too large to lead to inefficient state; If TENIRS ≠TEVRS, it means that the object is in the state of IRS, the size of college or university is too small to lead to inefficient state.

3.2 Indicators and Data.

Taking into account scientificity and representation of the selected indicators and the availability of sample data, we use the input indicators, including the number of teaching staffs, the covering acre of the schools, the construction area of the schools, the library collection et al and the output indicators including the number of students and the published papers et al to evaluate the efficiency of resource allocation in the colleges and universities in the city of Ningbo.

The data come from the released data from internet and the survey data from interviews. In which, the library collection includes paper books and electronic publications; the number of students refers to the enrollments of colleges and universities; the number of articles comes from the National Knowledge Infrastructure (CNKI) in China.

Empirical Results and Analysis

According to the basic principles of the input-oriented DEA model, this paper uses the special software named Deap2.1 to simulate the allocation efficiency of higher education resources in the city of Ningbo, combined with data coming from 14 colleges and universities of the city of Ningbo in 2010. The TE and SE value of higher education al resources in the city of Ningbo is shown in Table 1.

Firstly, we examine the PTE base on VRS model. The results coming from Table 1 shows that the average PTE of 14 DMU in the city of Ningbo is 0.762, it suggests that higher education resources in the city of Ningbo are in a state of technical inefficacy. Furthermore, from the perspective of the single DMU, the PTE value of DMU A, DMU C, DMU D, DMU F, DMU G, DMU I and DMU K, which

indicate that these seven schools are in the frontier surface of the higher education resources production and the allocation of educational resources is in a state of relatively effective; the PTE of the several other schools is lower than 0.9, such as DMU B, DMU E, DMU H, DMU J, DMU L, DMU M and DMU N, which show that these DMU is far from the production frontier surface of higher education and the PTE of resources allocation is relatively low.

Table 1 Allocation efficiency of higher education resource in Ningbo city

No.	Colleges and Universities	TEcrs	TEvrs	SE	State
1	DMU A	0.204	1	0.204	DRS
2	DMU B	0.397	0.474	0.837	IRS
3	DMU C	0.490	1	0.490	DRS
4	DMUD	0.655	1	0.655	DRS
5	DMU E	0.304	0.343	0.888	DRS
6	DMU F	1	1	1	-
7	DMU G	0.733	1	0.733	DRS
8	DMUH	0.604	0.676	0.893	DRS
9	DMU I	0.852	1	0.852	DRS
10	DMU J	0.560	0.855	0.654	DRS
11	DMU K	1	1	1	-
12	DMU L	0.530	0.672	0.789	DRS
13	DMU M	0.256	0.29	0.880	IRS
14	DMUN	0.055	0.361	0.154	IRS
	Mean	0.546	0.762	0.716	

Note: TECRS=the technology efficiency based on CRS model; TEVRS=the pure technical efficiency based on VRS model; TENIRS=technical efficiency based on NIRS model; SE=TECRS÷TEVRS.

Secondly, we examine the SE of higher education resources in the city of Ningbo. As a whole, the scale efficiency value of Ningbo city is 0.716, which indicates that the allocation of higher education resources is in the state of scale inefficiency. Further comparison one of the DMU with the others, we find that the scale efficiency of DMU F and DMU K equals to 1, while the SE of the remaining 12 DMUs don't equal to 1, which indicate that the input and output of corresponding 12 university education haven't reached in the state of scale efficiency. What's more, DMU A, C, D, E, G, H, J, L are in the state of DRS, accounting for the proportion of 85.71%; while the other two DMU M,N are in the stage of IRS, accounting for the proportion of 14.29%, which means that the scale of expanding inputs will improve the allocation efficiency of higher education resources.

In order to analyze the difference among the different colleges and universities in the city of Ningbo, we further calculate the average TE, standard deviation and coefficient of variation of the DUM located at the north higher education park and the average TE of the DUM located at the south higher education park and average TE of the whole DMUs located at the city of Ningbo. The results are shown in Table 2. The significant difference we can see from Table 2, the allocation efficiency of entire higher education resource the city of Ningbo are lower, and the variation coefficient reflects the different allocation efficiency of higher education resources. Further comparison the average TE of the north higher education park with the average TE of the south higher education park, we find that there is no strikingly different between the TE of higher education resource in the north higher education park and the TE of higher education resource in the south higher education park. But in the perspective of the coefficient of variation, there exists significantly different in the inner of the north higher education park , and the different extent of the TE is bigger than that in the south higher education park.

Table 2 The difference in allocation efficiency of higher education resource in Ningbo city.

North Higher Education Park	average TE	0.665
	standard deviation	0.338
	coefficient of variation	0.509
South Higher Education Park	average TE	0.699
	standard deviation	0.169
	coefficient of variation	0.242
The Whole City of Ningbo	average TE	0.762
	standard deviation	0.286
	coefficient of variation	0.375

Note: The coefficient of variation=standard deviation ÷ average technical efficiency; the selected sample including 14 colleges and universities in the city of Ningbo. In which, North Higher Education Park includes unit A,B, H,E; South Higher Education Park includes unit C, D, L, M, N.

Conclusions

This paper constructs the input-output model about the higher education system, and uses the DEA method to analyze the allocation efficiency of higher educational resources in the city of Ningbo. The results show that the allocation efficiency of higher education resources in the city of Ningbo is in the state of inefficiency, what's more, there exists conspicuous differences between the TE of North Higher Education Park and the TE of South Higher Education Park. The above empirical results tell us that the limited resources of higher education system in the city of Ningbo are not allocated at the appropriate place. To some extent, the results also show that his ecological balance of the higher education system in the city of Ningbo is destroyed affected, which hinders the harmonious development of the higher education system the city of Ningbo.

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