Evaluation of Input Output Efficiency in Higher Education Based on Data Envelope Analysis

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Abstract

The level of development of higher education is a sign of a country's comprehensive national strength and the level of economic and social development. In this paper, the author makes comprehensive evaluation of the resource utilization efficiency in higher education, by using large scale network data, the result shows that the main reason lead to non DEA effective in colleges and universities is caused by the low scale efficiency and the low technical efficiency. Therefore, the university should pay special attention to the effective use of investment resources, gradually build effective performance appraisal system, and make implementation of the organic combination of teaching and scientific research. Also, reduce the cost of education investment, so as to effectively improve resources utilization and running benefits in colleges.

Keywords: Data envelope analysis; higher education; scale efficiency; education investment; analytic hierarchy process

1. Introduction

The level of development of higher education is a symbol of national comprehensive national strength and the level of economic and social development. Higher education bears the historical mission for the country to cultivate all kinds of special talents. In today's world, the competition of the surface is a trade war, which is behind the competition of science and technology, talent competition, and in the final analysis is the competition of higher education. Higher education to improve the quality of the people, the function of reserve personnel of science and technology, has become the focus of attention of all countries in the world. To this end, countries in the world generally expand the enrollment scale; increase the input of resources, higher education has been an unprecedented rapid development [1]. At the same time, the development of China's higher education has made remarkable achievements; the 90's is the rapid development of higher education in China f. The continuous expansion of the scale of higher education, but at the same time that the higher education of our country to take the road to the development of connotation, strengthen macro-control of the higher education, makes the scale of education more in line with the development of our national economy, further implement the strategy of rejuvenating the country through science and education, speed up the reform of higher education system, created more favorable conditions for the development of higher education, the quality and efficiency of higher education in our country has been greatly improved.

The development of higher education in China has been a common concern of all sectors of the community, because the financial resources of China's higher education mainly rely on the state's financial funding and tuition fees. Tens of millions of capital investment, what kind will benefits to the whole society. How to measure the school performance? What is the way out of the higher education in developing countries, which

are relatively weak in our country, the developing countries with weak educational foundation and the increasingly prominent contradiction between supply and demand? This is a realistic problem that the higher education system must face. Thus, for higher education input and output efficiency evaluation has a strong theoretical and practical significance [2]. It is not only established the evaluation method of the efficiency of education, more important is to promote the higher education management, policy makers think about how in the premise of ensuring the quality of education, reduce the cost of inputs, raise the input and output efficiency, and improve the benefit of running a school, to create a good environment for the development of higher education in China. Through the research on the resource use efficiency, can find out the main problems existing in the educational resources allocation and utilization, with its for decision makers in the management of colleges and universities and the education sector provides relevant suggestions, for future improvement of the management system, fully excavate educational resources utilization potential and efficient utilization of education resources to provide a basis.

2. Literature Review

2.1. Educational Efficiency

The large sample quantitative research in the late 1960s to the early 1970s, research on the efficiency of education is mainly of a large number of samples by regression analysis, the fundamental purpose is find between the input and output of the education system correlation, think to want to improve efficiency in the education of colleges and universities must pay attention to the rational use of the resources of the school, but about how to organize and use of resources, the research only a handful. Overemphasize the influence of student achievement and behavior difference on the efficiency of education in this period, most of the studies, as to whether there is a clear relationship between colleges and universities have the resources and the efficiency of education, did not give sufficient evidence [3]. Therefore, later some scholar's research ideas to broaden, not stick to the assessment of student achievement and behavior, but extend to the resources of the school in the class of transformation mechanism. And it is concluded that the some important conclusions: School of resources and the number of schools of education efficiency between no deterministic relationship / teachers and students are the main factors affecting the efficiency of education. The research on the efficiency of education was first started by foreign scholars. The most fundamental approach is to design a questionnaire, around the educational efficiency of what features to start. Questionnaire although able to collect a large number of first-hand information, but due to the preparation of the content, diversity and compiling them and concept of the anisotropy of the investigated, description of the nature of education efficiency is difficult to completely consistent approval [4]. To the late 70's, the research of educational efficiency is biased and case study, the case study mainly includes two aspects, one is the comparative case study, the other is the typical case study. But no matter which kind of existence has certain flaw, has been criticized by the academic community. End of fine, logical in the 1980s to the early 1990s, the efficiency of education research mainly focuses on the use of quantitative methods and accurate models of the construction, the purpose of which is to think through the hypothesis has been obtained breakthrough preliminary research methodology limitations. However, this research has also been a sharp criticism from the academic circles, they think of past research on the characteristics of the efficiency of education has produced mixed, study the efficiency of education in the 1990s seems to have been struggling, always thought, current education system and structure of education efficiency have great influence, but now it seems, this effect did not so important as people imagine. Investment in education and output efficiency calculation, most scholars

cited economics with economics of / production efficiency evaluation methods on the efficiency of education evaluation, these methods on the condition of more stringent requirements, tighter restrictions applicable to single index or index is less, but in the comprehensive evaluation of the fusion of multi index does not apply. Especially with multi input and multi output complex system evaluation, the system of higher education is a complex system with multiple inputs and multiple outputs, which has many functions, it is not only to improve people's ability, but also to promote social development and increase economic benefits [5]. Therefore, the measure of higher education performance indicators are in many aspects, it is necessary to consider the quantitative indicators, but also consider the qualitative indicators, not only to consider the output but also to consider the input, including both human factors and includes the factors and so on. This requires us to use the method of multi index comprehensive evaluation to evaluate the efficiency of higher education. The multi index comprehensive evaluation of the higher education system, a lot of scholars draw lessons from the application and after the time test of some models and methods.

Linear programming is a method to solve the linear objective function in the condition of linear constraint. The goal of maximum profit and minimum cost) can also be represented by a linear function of the variables, and then such problems can use the method of linear programming to solve [6]. Although the simplex method for solving linear programming both in theory and algorithm are mature and with the development of computer technology, the corresponding solving linear programming software have long been popular, but due to the linear programming constraints limit requirements more stringent, to be individually analyzed verification, which in the establishment of large-scale linear programming problems with great difficulty. Dynamic programming model is a method to solve multi stage decision process optimization. It decomposes the difficult multi stage decision-making problem into a series of single stage decision problems which are easy to solve, and solves this problem by solving a series of single stage decision problems. The establishment process of this model is more complex, especially when the number of model variables is more than a long time, it is quite difficult to solve.

The analytic hierarchy process (AHP) is a multi-criteria decision making method of qualitative and quantitative analysis of the famous American operations researchers in 1970s combined. It is the thinking process of hierarchy, the number of people, and the use of mathematics analysis, decision making, and provide quantitative basis for forecasting or control. In particular, it is suitable for people to judge the main function of the decision, and it is difficult to directly and accurately measure the results of the occasion. The method of solving the problem has been no problem, there are a lot of ready-made software is very practical. But the use of the difficulty of this method is to construct the evaluation system of hierarchy, sometimes posing a question to the hierarchy between the various factors of the evaluation system is not clear, which to establish a hierarchy of brought no small difficulty; also the pairwise comparison matrix to establish evaluation to be assessed, things have enough understanding to more accurate measure of the degree of importance of each other between.

2.2. The Application of DEA in the Field of Higher Education

By using DEA model, to evaluate the relative efficiency of a foreign university 21 school running, the model to college operation expenditure and teacher salary as input indicators, to patent income, number of publications, graduate student number, and research project winning number as output indicators. Using DEA method of public universities and colleges in the United States relative efficiency evaluation and analysis, to establish the evaluation model of input indexes include: with PhD Title Teachers accounted for all the teachers, the percentage of teachers and students, student educational funds expenditure, average student enrollment scores, student learn five indicators, output indicators include: student graduation rate and freshmen enrollment rate of two indicators.

It is found that the DEA method is more effective than the traditional statistical method in evaluating the effectiveness of college education, and it is different from the ranking results of the DEA analysis and the American news and world weekly school. And scholars use DEA to evaluate the Australian 36 university school performance, put forward three modes of performance and overall performance, education service performance and registered performance analysis [7]. The study found that most schools have technology and economies of scale, but still in the registration performance need to strengthen, there are more schools are descending of economies of scale and need to adjust the scale, DEA can for inefficient school find learning reference object, and puts forward the target improvement suggestions. In addition, some scholars use the stochastic frontier approach to study the optimal allocation of higher education resources.

Besides DEA applications in the field of higher education involves many aspects, both between the comparison of the overall service efficiency of the allocation of resources, the university also has a function of the university of, such as scientific research performance measure, and internal departments or a department of university, such as performance evaluation of the library. DEA method applied in China's higher education in the late time, the number is less. Some scholars have carried on the quantitative analysis to the efficiency of the graduate education in our country; take the University as the analysis unit, the education and the research as the output of the graduate education. Will digital tutors, with the title of senior teachers and research funding as input, the study found: 66 University, 31 university graduate education is overall technical efficiency, 47 university is pure technical efficiency, and scale inefficient University have 32 in decreasing return to scale stage; from the number of efficiency, there are 33 University in decreasing return to scale stage; from the quality and efficiency, there are 39 University return to scale in the decline stage. In addition, the relative effectiveness of higher education input and output in the western region is discussed. The results show that most of the western universities are in the stage of non DEA effective and scale returns increasing. Through the DEA method from four aspects of efficiency, quality, scale, structure, the current situation of the allocation of resources in China's regional higher education is analyzed.

2.3 Education Input Output

In educational economics, educational investment is also regarded as productive investment, which can calculate the input and output, as well as the cost and benefit. As a result, the input and output of education is the most basic expression of the relationship between education and economic, and it is the embodiment of economic activities in the field of education. In the transition from planned economy to market economy, the shortage of investment in education has become an important reason for restricting the development of education in China. The original investment system of education cannot meet the needs of the development of education. With the increasing demand for talent in market economy, China's increasing investment in education, colleges and universities scale growth is very fast, but it also caused new problems, a large number of inputs are produced expected results, more scholars pay more attention to the investment output efficiency. Under the existing conditions, how to improve the efficiency of output has an important influence on the economic efficiency and the reform and development of higher education in our country [8]. In terms of investment in education, qualitative research can basically form a consensus. It is generally believed that with the enterprise input as, investment in education including human, financial, and material inputs, human input such as teachers, support staff, has the famous professors and scholars, experts and other: financial resources including government funding; tuition; enterprise of higher education investment, individual investment of higher education, social groups, overseas Chinese compatriots from Hong Kong, Macao and other donations to institutions of higher learning, school oneself income, schools to raise funds; schools and other funds and

income. The investment of the material mainly includes the investment of fixed assets and equipment. However, there are some differences in the quality of the output of higher education. Some scholars think that students are the products, the output is the talent, colleges and universities only adapt to the talent market needs to adapt to market needs; some scholars think talent but not the products, the output of higher education is a service, should serve the society; the scholar in front of the two views that output of higher education is a very complex system, teaching is not only a student product and services. Students products refers to the increase of students in physical strength, intelligence, skills, adapt to the improvement of social competence, namely human capital increase; education service mainly includes knowledge and its processing and teaching activities and students learning to provide other services and so on. In this paper, due to the efficiency of the input and output of higher education is to study, so the higher education service is divided into two aspects: service process and service effect, education service process inside as the education unit of resources by conversion to process of the intermediate outputs, we will not consider; the effect of education services as education outcomes were analyzed. Therefore, in this paper the output of education mainly refers to the University in operation, the education, the teaching process, in the talent training results, in terms of academic and scientific research obtained rewards and achievements.

3. DEA Evaluation Index System

3.1 Index System

Because of higher education resources use efficiency comprehensive evaluation is a complicated system engineering, which is mainly higher education itself is a complex dynamic feedback system "any system from the narrow perspective of understanding is a conversion mechanism, coming from the outside environment to receive a variety of material energy and information in the system of internal processing, processing or transformation, the conversion into another form of material energy and information, and output to the environment, while the environment has a certain degree of influence. The main purpose is to through the output to external environment have a certain role, or said to be on the outside environment and make a contribution.

The objectives of the construction of the evaluation index system is a part of the output efficiency evaluation work is very important in higher education investment, scientific and reasonable degree in a large extent determines the authenticity and objectivity of the evaluation of the efficiency of the system of higher education, the evaluation index system is composed of a plurality of single evaluation index, it reflects to solve the problem of "index system to practical, reasonable and scientific, to relevant leaders and Ministry of higher education system, the basic acceptance must be to reflect the purpose of colleges and universities, it is necessary to combine the practical and to look to the future. Therefore, we should consider the following basic principles.

1) Objective principle: evaluation index system design should be comprehensively, truly reflect the higher education essence and evaluation system, from the overall consideration, neither omission, does not repeat, tightly around the target decomposition, rejection and to evaluate the independent or unrelated index.

2) Systematic principle: the design of evaluation index system to starting from the system point of view, will be evaluation of the object as a subsystem of open to understand and analysis of indicators to include all aspects involved in the target system, from the system input, output, internal structure, system state and the external environment perspective should be designed, and the qualitative problem to have appropriate evaluation index, in order to avoid one sidedness of evaluation.

3) Operating principle: the established evaluation index system under realistic conditions to put into practice to ensure the evaluation work smoothly, and

sufficient accuracy and requires that the selected indicators can be measured, has a clear physical meaning, clear connotation, without ambiguity. In addition, the rating price index should be easy to investigate and collect, as far as possible obtained from statistics.

4) Comparability principle: more evaluation index system design with particular attention to, any of the alternatives in to ensure the realization of the system's basic functions to ratio and uniformity, outstanding individual function or program content, only that the relevant aspects, not a substitute for other, thus losing the true meaning of evaluation "

5) Scientific principle: we should use the scientific classification method, for different influence factors are classified, scientifically and rationally define the efficiency of education evaluation system. In addition, scientific principle also requires the coupling between evaluation index relationship to reduce as much as possible, the structure of the model to be as much as possible clear, index weight distribution should as far as possible scientific, in line with the actual situation .

Data envelopment analysis is a tool to evaluate the relative effectiveness of the same type of decision making units (DMU). To make clear the basic idea of DEA evaluation, the concept of validity of DMU must be quantitatively explained. Through an example, intuitively gives a method to judge the DMU is effective measure method, and then the specific method as the theoretical, and a measure of multi input multi output effective DMU of linear programming model. The process of measuring the effectiveness of DMU is the basic idea of the original DEA method. Hypothesis has four primary schools, through actual investigation and study, get a reference set, which decision making unit (DMU) into four, input for the number of staff and the construction area, with X; output is the number of the students in the school, with y said as shown in Table 1.

Table 1. DMU Input and Output Indicators

DMU	S1	S2	S3	S4
X1	15	45	30	25
X2	1600	1600	1600	2000
Y	1200	1200	1700	1500

3.2. Correlation Analysis

According to the index system, we can estimate the correlation between each index. And the DEA evaluation model requires that the indexes should be linear independent, so as to avoid the cross of the index information, which leads to inaccurate evaluation results. Therefore, it is necessary to make a judgment on the correlation between each index, and provide the basis for the selection of appropriate evaluation methods in the future. In this paper, the statistical software SPSS to 9 input indicators and eight output indicators for the Kaiser Meyer Olkin Measure of sampling Adequacy and Bartlett test of Spherieity, judge basis and test results are shown in Table 2-4. Results show that there is a correlation between the standard, so the DEA method is used to pre evaluation should be to eliminate the correlation and principal component analysis (PCA) just can be used to solve this kind of problem.

Table 2. Judgment Basis of Correlation between KMO-BTS Test

KMO	(0.8 ,1)	(0.7 ,0.9)	(0.7,0.8)	(0.7 ,0.8)	(0.6,0.7)
	Very strong	high correlated	strong	general	not strong
BTS	Bartlett Test of Spheroid				

Table 3. Input Test of KMO and Bartlett

Kaiser Meyer Olkin Measure of Sampling Adequacy.		.743
Bartlett Test of Sphericity	Approx. Chi-Square	287.673
	df	34
	Sig.	.000

Table 4. Output Test of KMO and Bartlett

Kaiser Meyer Olkin Measure of Sampling Adequacy.		.773
Bartlett Test of Sphericity	Approx. Chi-Square	61.319
	df	27
	Sig.	.000

4. Experimental Researches

In this paper, we choose 10 undergraduate colleges from Sichuan province, related to investment in 2014, output indicators, in this paper, all the data processing and operation are using deap2.1 software SPSS and. Use SPSS software to the original input indicator data processing can be obtained by principal component extraction and analysis table and initial factor loading matrix as shown in Table 5 and Table 6.

Table 5. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulati8ve%	Total	% of Variance	Cumulative%
1	3.991	47.223	47.223	3.977	47.223	47.223
2	1.772	21.243	71.445	1.770	21.145	70.257
3	1.035	11.975	73.233	1.027	10.963	82.235
4	.517	8.826	91.170	.611	7.637	89.697
5	.366	4.544	95.693	.362	5.149	97.556
6	.147	1.785	98.512	.143	1.773	98.335
7	.054	.687	97.314	.162	.753	98.215
8	8.1gE-005	.001	100.00	8.1gE-005	.001	100.00
9	1.28E-008	1.42E-007	100.00			

Table 6. Component Matrs(a)

Component	1	2	3	4	5	6	7	8
Zscore:(X1)	0.949	-0.174	-0.243	0.006	0.094	0.011	0.019	-0.007
Zscore:(X2)	0.932	-0.195	-0.278	0.048	0.010	0.105	0.059	0.004
Zscore:(X3)	0.903	-0.002	-0.245	0.218	-0.270	-0.047	-0.030	0.000
Zscore:(X4)	0.549	-0.313	0.683	0.361	0.053	0.011	0.003	-6.36E-005
Zscore:(X5)	0.939	-0.156	-0.205	-0.020	0.205	-0.084	-0.052	0.003
Zscore:(X6)	0.079	0.974	-0.031	0.143	0.044	-0.140	0.047	0.000
Zscore:(X7)	0.039	0.969	-0.091	0.156	0.058	0.149	-0.038	0.000
Zscore:(X8)	0.852	0.325	0.314	-0.261	-0.049	0.007	-0.001	0.000
Zscore:(X9)	0.852	0.325	0.314	-0.261	-0.049	0.007	-0.001	4.02E-005

According to Table 5-6, the cumulative variance contribution rate is more than 90% of the principle known input for three other initial factor loading matrix expressions of principal component cannot yet be drawn, you also need to list the number of principal components. In the first three columns of coefficient divided by the corresponding eigenvalues of square to get the principal component coefficients vector and principal components and their function of expression:

$$F_1 = 0.415ZX_1 + 0.408ZX_2 + 0.395ZX_3 + 0.24ZX_4 + 0.411ZX_5$$
$$+ 0.035ZX_6 + 0.017ZX_7 + 0.373ZX_8 + 0.373ZX_9$$

$$F_2 = -0.115ZX_1 - 0.129ZX_2 - 0.001ZX_3 - 0.207ZX_4 - 0.103ZX_5$$
$$+ 0.644ZX_6 + 0.64ZX_7 + 0.215ZX_8 + 0.215ZX_9$$

$$F_3 = -0.255ZX_1 - 0.291ZX_2 - 0.257ZX_3 + 0.716ZX_4 - 0.215ZX_5$$
$$- 0.032ZX_6 - 0.095ZX_7 + 0.329ZX_8 + 0.329ZX_9$$

The evaluation results of DEA effectiveness are calculated as shown in Table 7:

Table 7. Effectiveness Evaluation Results of DEA

	θ^*	C	S	scale revenue	reference set	S_1^{*-}	S_2^{*-}	S_1^{*+}	S_2^{*+}
DMU1	1	1	1	-	1	0	0	0	0
DMU2	1			drs	2	0	0	0	0
DMU3	1	1	1	-	3	0	0	0	0
DMU4	1	1	1	-	4	0	0	0	0
DMU5	1	1	1	-	5	0	0	0	0
DMU6	1	1	1	-	6	0	0	0	0
DMU7	0.817	0.815	0.998	drs	4,7	0	0.167	0	0.062
DMU8	0.808	0.758	0.914	drs	8	0.024	0.027	0.023	0
DMU9	1	1	1	-	9	0	0	0	0
DMU10	1	1	1	-	10	0	0	0	0

According to the analysis of the empirical results, it can be known that the main reason for the non DEA effective is the scale efficiency and the low technical efficiency. So all colleges and universities in improving the input and output efficiency, besides should broaden sources of income and reduce expenditure on education resources use, should pay special attention to the effective use of the various resources. In this way, in order to enhance the school overall resource utilization, the teacher is the subject of the school, its own quality and ability, determines the quality of higher education. Therefore, colleges and universities should be based on teachers, strengthen management, scientific management, gradually perfect and effective performance appraisal system, the implementation of the organic combination of teaching and scientific research, construction of a reasonable structure of high quality teachers team, reduce the proportion of teachers and other personnel, reduce the cost of education investment, so as to effectively improve college of resources utilization efficiency and benefit of running a school.

5. Conclusions

In this paper, we test input-output efficiency for the colleges in Sichuan province, the specific research methods using principal component analysis (PCA) and data envelopment analysis (DEA) method, using the software mainly is excel, SPSS and Deap.

Although the DEA is used for higher education investment output efficiency of research are not uncommon, but the specific for a provincial universities and colleges of undergraduate course studies are still rare, hope it can play a valuable role. Now full are summarized as follows: through the analysis of existing, can check to the literature, starting from the input and output of the colleges and universities extract can reflect the index system of efficiency of higher education resources utilization; through login university campus network and letters and other forms, collected a certain number of original data, provided the necessary means for the input-output efficiency of a certain extent objective evaluation in Colleges and universities. Through principal component analysis (PCA) method using Excel and SPSS software on the original data of index calculation and dimensionality reduction, three inputs and three output indices, so as to ensure the index between linear independence requirements, and meet the use of DEA method on the sample number and the number of indicators, namely the number of samples is at least 2 times the number of indicators, or the number of samples is greater than or equal to the input index number and output index number of product. The commonly used CZR model and BCZ model are selected, and the DEAP2.1 software is used to calculate the input and output efficiency of each university. A h to colleges and universities, the technical efficiency is 1, accounted for 85% of all decision making units, and a total of 13 universities average efficiency reached 0.971, show that the overall resources of Anhui Provincial Colleges and universities use efficiency is satisfactory. Colleges and universities and the non DEA effective, quantitatively give the school specific to each input and output indicators improved value for reference. The evaluation and research of the utilization efficiency of higher education resources is a complicated systematic project, involving many factors. The through DEA method, from the multi input and multi output angle by cross-sectional data for the empirical analysis, overall there are still many shortcomings and need to be further studied, mainly displays in:

The establishment of index system is based on the reference of the relevant documents, and its scientific and comprehensive nature has yet to be further studied. Also due to the universities and website statistics inconsistencies and part of the data is not available (including qualitative index is quantified), to the writing of the thesis brought certain difficulties. Therefore, the study of the accuracy of the results and the actual situation has certain deviation. The requirements in the future research, to define a unified statistical data, on the basis of collected data were calculated at the same time, through questionnaire survey to obtain qualitative information, to make up for the lack of quantitative data. Principal component analysis (PCA) method has some disadvantages in the application. This paper use the DEA method to calculate and input output data is through the PCA transform, the limitations of PCA method performance after transformation of the data, the economic significance of new index data difficult to explain, because new data are a comprehensive reflection of the original data. The practice of this paper is to use the factor load matrix as the name of the principal component, but this approach cannot fully reflect the economic meaning of the main component. Therefore, the next step is to choose a method, which cans not only comprehensive index information, but also extract the impact degree of each index on the efficiency of the university. The model established in this paper is a plurality of DMU in the same time period horizontal comparative study, in fact, the efficiency of colleges and universities is changing, a time period may be non DEA effective, but along with the time development, probably in another time period to reach the DEA effective. This paper due to the shortage of the energy and ability to the further analysis, therefore, it is necessary in further study, to the same colleges and universities in multiple time periods on efficiency do in-depth discussion.

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