Advances in Applied Economics and Finance
Vol. 1, No. 1, March 2012

www.worldsciencepublisher.org

The Regional Efficiency Differences Analysis of Education Expenditure in China based on DEA Model

[1]Man Qian, [2]Zhengming Li, [3]QingQing He

[*1] University of Shanghai for Science and Technology, Shanghai, China
[2] University of Shanghai for Science and Technology, Shanghai, China
[3] University of Shanghai for Science and Technology, Shanghai, China

Email: shauna0110@163.com

Abstract –This paper analyses the education expenditure efficiency of 31 provinces in 2009 with the method of DEA. The conclusion is: the highest efficiency is in central China; South China region is above the average; the technical efficiency is in North China and Northeast is among the best, but the total efficiency and scale efficiency is low. Scale efficiency in Northwest and Southwest region is higher, but the technical and total efficiency is low; the efficiency value in East China is in below average.

Keywords –DEA; Education Expenditure; Efficiency

1. Review of literatures

With the further enforcement of reforming and opening policy, go along with the fast developing of social economy, people pay more and more attention to the education. The level of education has become an important indicator to measure the development level and the civilization degree for a country or region. The strategy of rejuvenating the country through science and education was put forward definitely in 1995 *the Decision of the State Council of Central Committee of the Chinese Communist Party about speed up the progress of science and technology* .So far, the education has become a key project, and the education expenditure takes an important part in the government expenditure. So, in order to make full use of the limited financial resources, that is to say, to realize the maximize value of the government education finance capital, we need to calculate the expenditure precisely and search for a possible method to optimize the education expenditure efficiency.

This paper analyses education expenditure efficiency in 2009 with the method of DEA in 31 provinces. Under the background of promoting the development strategy of rejuvenating the country through science and education, finding out the diversity of the efficiency in different region will have theoretical and realistic significance. On one hand, it will help us accurately to estimate the current education situation; on the other hand, it will lead us to find out the right methods to improve efficiency in various areas.

With the booming of our education business, the enthusiasm of paying attention to the education and investing the education upsurges continually. The continued increasing input of the education will incur the attention and exploration.

First, for foreign scholars, Gupta and Verhoeven [1] estimated the government spending efficiency for education and medical treatment in 37 countries from 1984 to 1995 by FHD method which is investment orientation. The conclusion is: The efficiency of investment orientation and the scores negatively correlated to the public spending levels. Therefore, they thought that the way to improve the education and the medical treatment is the higher efficiency not more source investment. At the same year, Santiago Herrera and Gobo Pang[2]estimated the education expenditure efficiency in 140 developing countries from 1996 to 2002 by DEA and FDH method. The results show that: the country whose level of expenditure was very high, salary expenses took a large part in the government budget outlays, education input took a higher percentage in the government input and high degree of dependence on subsidiary got a low score in efficiency. Jarasuriya and Woodon[3]took the net enrollment for education in elementary school as the output index, and the per capita GDP, average education expenditure and the adult literacy rate as the input index, according built the function relationship between input and output to estimate the efficiency of some developing country's education supply by parameter method. The result: More investment not means better output. Alfonse and St. Aubyn[4]estimate the education expenditure efficiency by DAE and FDH. They choose different input index to estimate the education expenditure efficiency with the same output index. It suggested that: because of the resource (such as teacher) cost will be different in every country, if replace the monetary indices by the no monetary indices, the value of efficiency will change.

Second, for Chinese scholars, Xie youcai and Hu hanhui [5] took the education and research as the output ,and the number of teacher who had a senior professional title and research funds as input, to estimate the efficiency of 66 university's postgraduate according to DEA model by taking the university as the analysis unit. The result: the postgraduate of 31 universities had the technology effectively, 47 had pure technology effectively, and in the scale invalid university, the scale returns of 32 universities in a declining stage. There are 33 universities in the decreasing stage of the scale return from the view of quantity and 39 universities from the view of quality. So, the author points out that improving the management efficiency and eliminates the scale invalid is the urgent affair of improving the postgraduate education efficiency.

Han renyue and Chang shiwang [6] estimated the education expenditure of 31 province in 2006 based on the DEA model. The result: technology efficiency in East is higher than Midwest; however, the scale efficiency of the education expenditure in Midwest is higher than the East.

Elements concentration and transfer payment is the mean reason in giving rise to the difference of the education expenditure efficiency among regions. Therefore, the East should pay more attention to optimize the education expenditure structure and improve the scale efficiency; the Midwest should still increase the education input and improve the technology efficiency. Kang Jianying and Zhang Hui [7] took the student personnel expenditure, public expenditure and capital construction funds as input index, and took the number of elementary school students and junior high school students as output index, and calculated the compulsory education expenditure efficiency of 31 province, city and autonomous region in 2005 with DEA method. The results show that: the difference of the education expenditure use efficiency among inter provincial is significant and the Middle West region is higher than that of the Eastern; Demographic transition and migration affect the use of compulsory education funds. The article suggest that we should continue to increase compulsory education investment in the Mid-west regions, and at the same time, should predict population and plan the education scientifically and reasonably, and improve the use efficiency of education funds. Zhang Maohua, Hu [8] based on SBM model, took the staff number, education funds and fixed assets of education as input index, and took the number of the specialized subject student, the patent license and graduate students as output index, to calculate the China's higher education efficiency of 31 province, city and autonomous region in 2007. The results show that China's higher education efficiency is commonly, the regional differences are outstanding. Therefore, we should strengthen higher education investment, especially in the Mid-west regions, and should also strengthen scientific research innovation fund management.

All of the above, no matter using the parameter analysis or the non parametric analysis, the research of all the foreign scholar indicate that: The more put in to the education is not means the higher output, even it leads to the lower. Most of the Chinese scholar focuses their research on the higher education expenditure and compulsory education expenditure efficiency; few of them research the total education expenditure of the 31 provinces. This paper will calculate the total education expenditure efficiency of our 31 provinces by DEA to check out the applicability of the foreign research result, and make up the insufficient of the domestic research.

2. Conception define

Efficiency is to emphasize the allocation efficiency when it appears in the economic, and its target is to achieve the Pareto Optimality. That is to say, under the fixed technology level, we should change the limited resource to the maximal value. Then the define has been expanded constantly, and finally it becomes that make use of the society resource effectively to satisfy the human's desire and needs.

The education expenditure efficiency (EE): make use of the education resource effectively to satisfy the human's desire and needs. In this paper, it is divided into technology efficiency (TE) and scale efficiency (SE).

The technology efficiency of the education expenditure is the rate of input and output. If the education system can get as much as output with as few as possible input, we call this system is technology effective. Conversely, with the same input, the output can be improved, or we can use less input to get the same output, that is, there exists the Pareto improvement, then we call it non-efficiency.

The scale efficiency of the education expenditure is that the change rate of output leaded by the input changing with the same rate. If the output increased more than the input, we call it increasing returns to scale; otherwise, we call it decreasing returns to scale. But both the two situations are scale failure. Only when input and output increase with the same pace, we can call it scale efficiency.

3. The introduce of the Research method and the Index selection

3.1 The introduce of DEA

DEA is the abbreviation of data envelopment analysis is a nonparametric method in operations research and economics for the estimation of production frontiers. It is used to empirically measure productive efficiency of decision making units (or DMUs). It was a nonparametric tests method which is based on relative concept and suggested by the famous operational research expert A.Charnes and W.W.Cooper in 1978. They called their first model as CCR. From the point of view of the production function, this model is a ideal method which is used in researching whether the production system with multiple input especially multiple output has technical efficiency and scale efficiency ideal or not. Utilizing the selected variables, such as unit cost and output, DEA software searches for the points with the lowest unit cost for any given output, connecting those points to form the efficiency frontier. Any decision making units not on the frontier is considered inefficient. Because BCC removed the assumptions of scale efficiency on the base of model CCR, the result will be suitable for the change of Returns to Scale. BCC can divide the total efficiency into technical efficiency and scale efficiency, that is total efficiency=radices efficiency * scale efficiency. According to BCC we can find out the reason of efficiency deficiency which is belongs to scale or technical. [9]

3.2 Index selection

Measuring the efficiency with DEA, the first we should do is to find out the decision making units and then the index. In this paper, we take the 31 provinces as the decision making units. Based on the data's availability, we select 6 indexes as the input indicators, such as per capita education expenditure , average education expenditure per student, and 12 indexes as the output indicators, such as average years of school attainment above six years old and the rate of casting off illiteracy above fifteen years old and

the number of all levels Internal Students and graduates to measure and calculate our thirty-one provinces in 2009. The international general concept of Public Expenditure on Education including the government departments at all levels of education expenditure according to the national constitution form. We can find the explanation on the statistics yearbook which edited by the United Nations science and technology education cultural organization. Because of the funds come from the nongovernmental takes a large percentage, in this article we regard the public expenditure on education as the total of State financial education funds, the investment by founder of the private schools , social donation funds, undertaking revenue and other revenue. According to the data of the public education expenditure and population, we can calculate the per capita education expenditure in various regions. Limited by the availability of the material, we simplify the education system as three parts including primary, secondary and tertiary education in this article. In order to get the data of the educated years per capita, we take the educated years per capita above six years old as the basic data. Then, the educated years for primary school, middle school, high middle school, and the higher education separately are 7 years, 10 years, 13 years, 17 years.

Let AE represent the educated years per capita above six years old, and I represent primary, secondary and tertiary education level, Ni represent the population of the education level of I, P represent the population above six years old in the sample survey. The formula is:

$$AE = \frac{\sum_{1=1}^{4} L_i N_i}{P} \quad (1)$$

Get the data of the rate of casting off illiteracy above fifteen years old still from the sample survey (the sampling ration is 0.0873%). Let R represent the total population above the fifteen years old, L represent the illiteracy above fifteen years old, T represent the total population above fifteen years old. We can get the other fifteen indexes from the yearbook directly. The formula is:

$$R = 1 - \frac{L}{T} \times 100\% \quad (2)$$

4. Model analysis

This paper estimates the result with DEAP2.1 software. According to the six input indicators(the public expenditure on education per capita) and twelve output indicators(the educated years per capita, the rate of casting off illiteracy), we can find the result by the input orientation analysis method under the variable scale returns in table1:

Table1. The education expenditure efficiency in various regions

Region	Total-e	Tech-e	Scale-e	Returns-s	Region	Total -e	Tech-e	Scale-e	Returns-s
Peking	0.330	1.000	0.329	DEC	Hubei	1.000	1.000	1.000	-
Tianjin	0.620	1.000	0.618	DEC	Hunan	0.840	0.989	0.848	DEC
Hebei	0.870	1.000	0.870	DEC	Guangdong	0.760	1.000	0.757	DEC
Shanxi	0.910	1.000	0.908	DEC	Guangxi	0.980	1.000	0.979	DEC
Nei Menggu	0.850	0.871	0.980	DEC	Hainan	0.860	0.870	0.992	DEC
Liaoning	0.650	1.000	0.653	DEC	Chongqing	0.730	0.731	0.999	-
Jilin	0.760	1.000	0.763	DEC	Sichuan	0.750	0.767	0.978	INC
Hei longjiang	0.700	0.953	0.732	DEC	Guizot	1.000	1.000	1.000	-
Shanghai	0.430	1.000	0.434	DEC	Yunnan	0.850	0.920	0.925	INC
Jiangsu	0.660	1.000	0.663	DEC	Xizang	0.310	0.470	0.649	INC
Zhejiang	0.480	0.475	1.000	-	Shanxi	0.870	0.973	0.891	INC
Anhui	0.910	0.967	0.936	INC	Gansu	0.780	0.864	0.903	INC
Fujian	0.640	0.645	0.998	INC	Qinghai	0.620	0.671	0.926	INC
Jiangxi	0.950	1.000	0.946	DEC	Ningxia	0.590	0.601	0.985	INC
Shandong	1.000	1.000	1.000	-	Xinjiang	0.940	1.000	0.940	DEC
Henan	1.000	1.000	1.000	-	Median	0.770	0.896	0.858	-

Note1: DEC: decrease INC: increase
Note2: Total efficiency=Technology efficiency * Scale efficiency
Data sources: *2010 China's population and employment statistics yearbook, China's education funds statistical yearbook 2009*

From table 1 we can see that: only the Shandong, Henan, Hubei and Guizhou provinces whose total efficiency get to the optimum ; more than half of the provinces' efficiency is lower than the average level ; Even Beijing and Shanghai only close to the 43% and 56% of the average level. For the technology efficiency, Beijing, Tianjin, Hebei, Shanxi, Liaoning, Jilin, Shanghai, Jiangsu, Jiangxi, Shandong, Henan, Hubei, Guangdong, Guangxi, Guizhou and so on is effective, other provinces is non-effectve more or less. Take Hunan province as an

example, its technology efficiency is 0.989, that means if the government cut down the 1.1% input, it shuold have reached the same output. To the scale efficiency, only Zhejiang, Shandong, Henan, Hubei, Guizhou is effective, and in the above province which are technology effective, their scale efficiency are far less than the national average level. The last rank of table 1 is the level of every province at present: Zhejiang, Shandong, Henan, Hubei, Chongqing and Guizhou is at the optimal stage of the scale return; Anhui, Fujian, Sichuan, Yunnan, Xizang, Gansu, Qinghai, Ningxia is at the increasing stage of the scale return; the other regions is at the decreasing stage of the scale return.

For further, we can discover that from the table 1: Almost half of the regions' education expenditure exist the technology efficiency loosing. According to the definition of technology efficiency, we can divide the region which has the technology efficiency lose into two type: the first is the input at present is more than the effective input, but it not exists the output slack; the second is opposite. In this paper, all technology efficiency lose regions have the output slack in different degree, so it belongs to the second type. As seen in table 2 and table 3:

Table2. The output of various regions' slack results

Region	slack variable											
	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12
Nei Monggol	0.010		85.584	22.287	109.780	32.820	125.590	43.030	331.900	114.380	756.190	116.780
Hei longjiang		0.135	11.410	3.535	15.145	7.170	13.715	5.735	28.715	6.100	133.810	17.185
Zhejiang	0.010		50.230	11.590	100.990	26.040	115.650	41.590	297.530	104.030	726.890	108.510
Anhui	0.060	0.825	48.472	12.809	74.372	18.330	66.823	23.930	164.340	57.883	528.780	62.074
Fujian	0.010		71.531	17.939	104.240	30.030	122.980	42.900	321.130	110.910	786.010	118.000
Hunan		0.032		1.154	18.390	2.244	16.672	1.402	46.312	22.548	62.395	15.726
Hainan	0.010		116.228	28.913	143.090	42.030	176.150	61.510	406.020	139.940	910.020	140.400
Chongqing		0.461	88.096	21.901	120.250	34.200	140.800	53.620	338.040	121.300	834.900	121.320
Sichuan	0.020	0.720	33.290	8.190	43.440	18.040	57.650	25.200	118.800	50.9800	434.980	49.090
Younan	0.070	1.540	97.520	24.820	116.570	34.970	140.050	51.790	270.430	101.100	607.890	92.440
Xizang	0.310	3.702	95.516	23.385	107.470	30.180	134.530	45.690	323.010	110.350	680.010	110.680
Shanxi	0.010		36.363	9.449	75.437	21.330	78.858	27.850	220.940	71.894	602.160	83.655
Gansu	0.090	1.180	100.730	25.000	129.770	38.280	138.130	50.940	333.150	116.840	799.430	116.480
Qinghai	0.060	0.584	98.962	23.908	116.910	32.700	145.570	49.920	370.320	124.750	812.100	130.580
Ningxia	0.020		113.589	27.801	135.730	38.990	166.100	57.860	405.690	138.910	897.450	141.800

Note1. Let X1 represent the proportion of the cast off illiteracy above fifteen years old, x2 represent the educated years per capita above six years old，x3、x4 separately represent the number of internal student and graduate in the higher education, x5、x6 separately represent the number of internal student and graduate in secondary vocational school，x7、x8 separately represent the number of internal student and graduate in high middle school, x9、x10 separately represent the number of internal student and graduate in middle school ,x11、x12 separately represent the number of internal student and graduate in primary school.

Note2. The number of the table 2 in the following region is empty: Peking, Tianjing, Hebei, Shanxi, Liaoning, Jilin, Shanghai, Jiangsu, Jiangxi, Shandong, Henan, Hubei, Guangdong, Guangxi, Guizhou, Xinjiang

Table 3 shows that: take themselves as consult, the education expenditure of Beijing, Tianjin, Hebei, Shanxi, Liaoning, Jilin, Shanghai, Jiangsu, Jiangxi, Shandong, Henan, Hubei, Guangdong, Guangxi, Guizhou, Xinjing is technology effective; We order the provinces which have the technology efficiency wastage by region weight decrease on the second row. Take Hunan province as an example, it refers to Hebei, Guangdong, Jiangxi, and Henan. Because the output relaxation of casting off illiteracy above fifteen years old and the number of internal student and graduate in the higher education is zero, we should adjust the output of the ten indexes. The education expenditure of higher school, high school, middle school, primary school, secondary vocational school reaching 13.119、 5.006、 3.86、 3.006、 5.963(thousand Yuan) can be realized on the condition of: first, the rate of casting off illiteracy is 94.96%; second, the number of internal student and graduate in the higher education is 1,026,800; third, the year being educated will be increasing from 9.41 to 9.44; the number of secondary vocational school , high school, middle school and primary school internal student will be increasing from808,700、 1,064,300、 2,143,500、 4,691,500 to 265,800、295,600、429,700、918,800、867,500. Take the education expenditure per capita as an example, that is 0.831 =0.547*0.81（the education expenditure per capita of Hebei）+0.093*1.26（the education expenditure per capita of Guangdong） +0.313*0.76 （the education expenditure per capita of Jiangxi）+0.047*0.69 （the education expenditure per capita of Henan） (U. thousand yuan). The actual education expenditure per capita is 0.84 thousand yuan in 2009, we can infer others in this way. According to the above analysis, we can sure that there must be some region exist technology efficiency wastage.

Table3. The valid input and the consult object of each region

Region	Consult region	Valid input(thousand yuan）

		y1	y2	y3	y4	y5	y6
Peking	Peking	5.040	39.700	21.610	19.690	13.650	18.810
Tianjing	Tianjing	1.920	19.180	12.720	9.120	7.760	9.250
Hebei	Hebei	0.810	13.030	5.000	4.240	3.500	5.830
Shanxi	Shanxi	0.970	11.650	6.070	4.080	3.140	7.460
Nei Monggol	Henan[0.804]，Shanxi [0.196]	0.745	10.348	4.261	3.180	2.167	5.177
Liaoning	Liaoning	1.20	18.790	6.400	5.800	4.750	9.000
Jilin	Jilin	1.100	13.910	6.210	5.400	5.050	9.010
Hei longjiang	Jiangxi[0.5]，Liaoning[0.5]	0.980	14.970	5.350	4.495	3.475	7.240
Shanghai	Shanghai	3.070	28.780	27.640	18.710	15.740	20.390
Jiangsu	Jiangsu	1.410	20.690	8.510	6.130	5.400	8.470
Zhejiang	Henan	0.690	10.030	3.820	2.960	1.930	4.620
Anhui	Henan[0.948]，Sichuan[0.052]	0.705	10.357	3.859	2.998	1.974	4.593
Fujian	Henan[0.956]，Guizhou[0.044]	0.691	10.011	3.843	2.947	1.934	4.625
Jiangxi	Jiangxi	0.760	11.150	4.300	3.190	2.200	5.480
Shandong	Shandong	0.860	13.500	6.070	5.010	3.250	6.920
Henan	Henan	0.690	10.030	3.820	2.960	1.930	4.620
Hubei	Hubei	0.980	16.250	4.560	3.680	2.770	4.110
Hunan	Henbei[0.547]，Guangdong[0.093]，Jiangxi[0.313]，Henan[0.047]	0.831	13.119	5.006	3.860	3.006	5.963
Guangdong	Guangdong	1.260	21.790	8.000	4.330	3.360	9.030
Guangxi	Guangxi	0.72	10.68	4.630	3.490	2.590	6.000
Hainan	Henan[0.922]，Shanxi[0.078]	0.712	10.157	3.996	3.048	2.025	4.843
Chongqing	Henan [0.987]，Sichuan[0.009]，Jiangxi[0.004]	0.693	10.091	3.829	2.967	1.939	4.619
Sichuan	Henan [1]	0.690	10.030	3.820	2.960	1.930	4.620
Guizhou	Guizhou	0.720	9.610	4.350	2.660	2.020	4.730
Younan	Henan [1]	0.690	10.030	3.820	2.960	1.930	4.620
Xizang	Henan [0.46]，Guizhou [0.335]，Sichuan[0.205]	0.759	11.163	4.149	3.007	2.132	4.552
Shanxi	Henan [0.784]，Liaoning [0.216]	0.800	11.921	4.377	3.573	2.539	5.566
Gansu	Henan [1]	0.690	10.030	3.820	2.960	1.930	4.620
Qinghai	Henan [0.686]，Guizhou [0.314]	0.699	9.898	3.986	2.866	1.958	4.654
Ningxia	Henan [0.853]，Guizhou [0.147]	0.694	9.968	3.898	2.916	1.943	4.636
Xinjiang	Xinjiang	1.330	11.130	7.350	6.280	4.630	9.510

Note. Result from DEAP2.1 software. Let y1 represent per capita education expenditure, y2 represent higher school education expenditure per student，y3 represent education expenditure per student in high school，y4 represent student education expenditure in high middle school per，y5 represent education expenditure per student at primary school, y6 represent education expenditure per student in secondary vocational school.

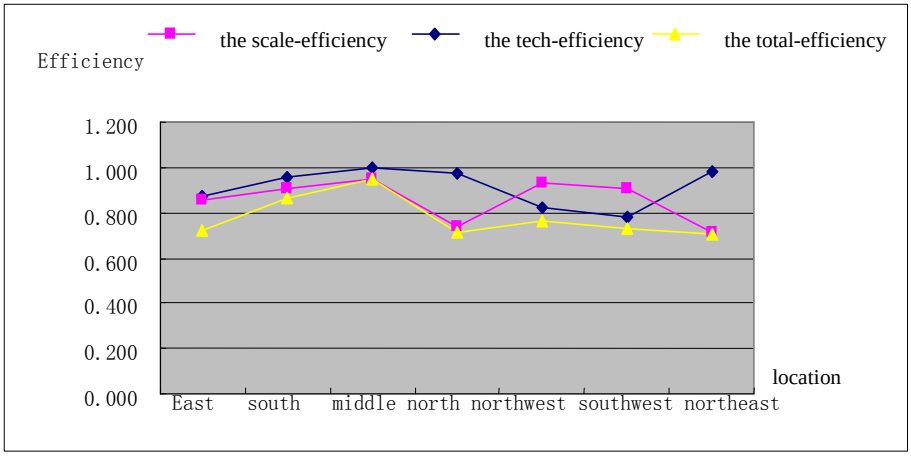

Figure 1. The average comparison of efficiency in each region

5. Conclusion

According to the administrative division, we can divide our mainland into seven regions, such as: the east(Shandong, Jiangsu, Anhui, Jiangxi, Zhejiang, Fujian, Shanghai),the south(Guangdong, Guangxi, Hebei, Shanxi, Nei Menggu), the northwest(Ningxia, Xinjiang, Qinghai, Shanxi, Gansu), the southwest(Sichuan, Yunnan, Guizhou, Xizang, Chongqing), the northeast(Liaoning, Jilin, Hei Longjiang).Give every province the same weight now, then we can get the per capita technology efficiency and the per capita scale efficiency of each region. We can see the result from picture 1:

From the figure1, we can see that: to the total efficiency, the middle and the south are the highest, while the north and northeast is the lowest, besides these two regions, the east, northwest and the southwest all of them are below the average. We also can find out from picture 1: the middle and the east are better than the west in the technology efficiency, but worse in the scale efficiency; No matter the technology efficiency or the scale efficiency is on the first place in the country; the south is on the average; the north and the northeast is among the best of candidates in the technology efficiency, but lowest in the scale efficiency; the northwest and the southwest just on the contrary; the east is locate behind the middle.

Therefore, in order to improve the education of our country, we should pay more attention on improving the scale efficiency of the north and the northeast, but the technology efficiency of the southwest and the northwest.

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