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Zhiqian YU, Ning ZHU, Yuan ZHENG

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Editor of the Copenhagen Discussion Papers:
Associate Professor Michael Jacobsen

Asia Research Centre
Copenhagen Business School
Porcelænshaven 24B
DK-2000 Frederiksberg
Denmark

Tel.: (+45) 3815 3396
Email: mj.int@cbs.dk
www.cbs.dk/arc

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Zhiqian YU
PhD Student
School of Economics
Jinan University
yzq_8866@hotmail.com

Ning ZHU
PhD Student
School of Economics
Jinan University
znzy1986@163.com

Yuan ZHENG
PhD Student
Department of Food and Resource Economics
University of Copenhagen
yuanzheng@ifro.ku.dk

Abstract

The study investigates the efficiency of local public educational expenditure of 31 provinces in China during 2005-2010, using the Slack-based Measurement (SBM) directional distance function. The results show that public educational expenditure is the most efficient in eastern China, followed by middle and western areas. The inefficiency can be explained mostly by the number of master graduates, while the impacts of the number of undergraduates and graduates from secondary school are also significant. Additionally, bootstrap method is applied to explore the contextual factors influencing the efficiency. The results suggest that economic development and urbanization process increase the efficiency, while the state-owned industry obstructs the development.

Keywords: *Public Educational Expenditure; Efficiency, Slack-based Measurement Directional Distance Function; Bootstrap*
***JEL Classification**: H52, I22, D24*

1. Introduction

With the development of human society, knowledge and technological innovation have become the key competitiveness of a country. Education has important implications for economic growth and social welfare. In the field of research on public economics, education is treated as a public or quasi-public commodity. Public education refers to the service organized by the state, social groups or individuals, and the public educational expenditure refers to the expenses aimed at education of the public. The latter is regarded as governmental educational expenditure by the economists, the same as defined by United Nations Educational, Scientific and Cultural Organization (UNESCO) and Organization for Economic Co-operation and Development (OECD). However, the public educational expenditure refers to fiscal educational expenditure in China, including education funding in the fiscal budget and financial education funding which has not yet been counted in the budget.[1] The former element is equivalent to the public educational expenditure defined by UNESCO.

From 1992 to 2009, the fiscal educational expense grew 22 times from CNY 72.88 billion to CNY 1.65 trillion, and the percentage of budgetary educational expenses that accounts for Gross Domestic Product (GDP) increased from 2 percent to 3.35 percent. The substantial increase in public educational expense attracted widespread attention. The focus of the public is not only on the amount of investment in education, but also on how to mobilize more resources and use them effectively for education (Wang, 1989; Min, 2003). Currently, various undertakings developed rapidly while financial capital was relatively limited in China. What is the level of technical efficiency of such a huge amount of spending on education in this situation? The relevant departments have not been able to identify effective means to measure the public educational expenditure accurately for a long time, therefore, some aspects of public resources allocation is failing and the efficiency of fund usage remains low. How to improve the efficiency of educational expenditure and for effective use of limited educational resources is the problem that both the government and the

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[1] The public educational expenses in China including: the national budget in education, funding at all levels of government levied taxes for education, business school funding, school-run industries, work-study and social services revenue for education funding(Sun et al., 2002).

public pay close attention to.

Accounting efficiency of public educational expenditure has been a focus of research in the field of public economics (e.g., Grosskopf et al., 1997; Worthington, 2001; Kalyan et al., 2001; Clements, 2002; Blankenau and Nicole, 2004; Cong and Zhou, 2007; Wang, 2007; Lv and Wang, 2007; Laurens et al., 2010; Nabil et al., 2011 etc.). Currently, the frontier analysis mainly includes parametric and nonparametric models, where the non-parametric Data Envelopment Analysis (DEA) has been widely used in efficiency assessment of the public sector, since this model does not need market prices of inputs and outputs, which avoids the problem of public goods pricing.

There are two limitations in classic DEA models: oriented and radial problems. Chambers (1996) proposed the directional distance function which solved oriented problems successfully. Chung et al. (1997) firstly applied this new method in empirical research to account for undesirable output. The radial problem was not solved until Tone (2001) proposed SBM (Slack-based Measurement) analysis. Fukuyama and Weber (2009) incorporated Chamber's directional distance function and Tone's SBM model to construct the more general SBM directional distance function. This not only makes non-oriented and non-radial DEA model possible, and improves the accuracy of technical efficiency measures, but also enables decomposition of inefficiency values to trace the causes of inefficiency.

In addition, traditional DEA model focuses only on the internal management efficiency of the decision making units (DMU), including production technology, operational scale and efficiency and so forth, while it does not consider the external environment. Therefore, Timmer (1971) proposed the two-stage DEA method, which requires the traditional DEA model to estimate the technical efficiency in the first stage, and then regression in the second stage with technical efficiency as the dependent variable. Regarding the selection of econometrics models, the Tobit model is normally chosen due to the nature of technical efficiency value (between 0 and 1), while Hoff (2007) and McDonald (2009) considered that Ordinary Least Squares (OLS) method had a wider range of applications. However, neither of methods mentioned above takes into account the impact of serial correlation (Xue and Harker, 1999; Hirschberg and Lloyd, 2002; Simar and Wolson, 2007). To solve this problem, Bootstrap methods came into being.

In this paper, we aims to contribute to existing research by applying the SBM directional distance function to estimate the efficiency of public educational expenditure in 31 provinces of China, and explore in particular the influences of environmental factors on the efficiency.

The rest of the paper is organized as follows: literature review is provided in section two, followed by introduction to the methods in section three. The paper proceeds to data selection and analyses in sections four to six and ends with the conclusion.

2. Literature Review

As a limited resource, public education can help the accumulation of human capital of the entire society, so as to enhance labor productivity and promote economic growth. Meanwhile, the externality which is endogenous from public education, can partly alleviate the negative impact of income inequality on education investment and optimize individual decisions. Therefore, it is important to measure the efficiency of public educational expenditure in order to ameliorate the usage of education funding and allocation of public education resources.

Early studies on evaluating the efficiency and equity of educational expenditure are mainly based on parametric methods. Levin (1974) applied non-random parameter linear programming model (Aigner and Chu, 1968) to estimate the production boundary coefficient and found that parameter estimation using OLS could not accurately reflect the relationship between the school input and output effectively. Using OLS, Klitgaard and Hall (1975) revealed that smaller teaching scale, higher payment and more experienced teachers contributed to improving the quality of teaching. The study further suggested that the results reflected an average, rather than individual, relationship between inputs and outputs. Wu and Li (2004) built a financial education expenditure performance evaluation model according to the performance evaluation principles and the theory of public educational expenditure, and also built a general index system based on five aspects, including the situation, the goal, the compliance, the direct and the indirect effects. Taking into consideration prevalent international, domestic, and theoretical perspectives on the makeup and composition of the education system, Cong and Zhou (2007) analyzed its efficiency, effectiveness, and comprehensiveness based on a simplified system which accounts for elementary, middle, and upper tier educational levels. The results show that public education performance in China has made progress in the past few years, but there is still room for improvement by adjusting the educational expenditure policy. Wang (2007) proposed the performance of fiscal expenditure on education can be divided into progress performance (including configuration performance and consumption performance), achievement performance and regulatory performance, with the achievement performance as the core of the performance evaluation of the entire fiscal expenditure on education. Lv and Wang (2007) built a set of multi-level index systems on the basis of the internal composition of the public educational expenses performance and the characteristics of educational expenses' progress. They carried out an empirical test on the index system using principal component analysis, and evaluated the public educational expenditure performance in each province. From the internal composition of performance evaluation, Cheng and Yuan (2007) built a more comprehensive and effective measure of the educational expenditure performance index system according to the particular characteristics of the education system. Shen (2009) proposed a performance evaluation index system for public educational expenditure to more accurately assess the realities of public educational expenditure, and used AHP method to determine the various weights of evaluating public educational expenditure. However, the drawback of the above methods does not consider the case of multi-input and multi-output, while non-parametric DEA method can solve this problem effectively. O'Donoghue et al. (1997), Bosker et al. (1999) and De Witte et al. (2008) compared the methods of parameters and nonparametric on educational efficiency.[2]

This paper focuses on the literature that studies the efficiency of public educational expenditure using the DEA method. Charnes et al. (1978) was the first to apply the DEA method in the field of public education. Bessent and Bessent (1980), Bessent et al. (1982) improved it and introduced the non-parametric production function to analyze the case of multi-outputs and

[2] Nonparametric model does not consider the impact of the residual, which does not require specific model, and has certain rationality. While the DEA as the most popular method in non-parametric model, this technology model has also selected in this paper.

identify the sources of inefficiency. Ray (1991), McCarty and Yaisawarg (1993) extended the previous studies and argued that the inputs and outputs which is controlled in the first stage of the DEA model are valid. However, the uncontrollable variables such as independent variables can be used in Tobit or OLS models in the second stage. Kalyan et al. (2001) tried to integrate parametric and nonparametric models and applied two-stage DEA method to estimate the technical efficiency of 40 school districts in Utah, United States. Laurens et al. (2010) discussed the efficiency and fairness in education based on DEA method, and accounted for the environmental influences. At present, researchers have started to pay attention and use the DEA method to evaluate the efficiency of public expenditure on education in China, but there were very limited papers. For instance, Liao et al. (2008) analyzed the efficiency of public educational expenditure in China during 2000-2007 using DEA method. They found that, the inputs did not produce enough outputs, and the educational expenditure did not have a significant impact on the economic growth during 2002-2006. Hu and Lu (2010) selected the net enrollment rate as an output, and the educational expenditure per student as an input, and applied the DEA method to analyze the efficiency of public educational expenditure in Guangdong province during 2000-2007. The results showed that the efficiency of public educational expenditure in Guangdong province was not high.

Regarding numerous published studies on the efficiency of public educational expenditure, there are some drawbacks. First, most researches in China employed qualitative methods and emphasize the design of index systems, like target-effect method, causing the results to be non-objective. Second, the use of a single variable to measure the efficiency of public sector may weaken the accuracy and credibility of the result, since the public sector is characterized by multi-inputs and multi-outputs. Third, the radial and oriented DEA, which can deal with multi-inputs and multi-outputs, may distort the measurement results. Fukuyama and Weber (2009) integrated methods of Chambers et al. (1996) and Tone (2001), and proposed a more general SBM directional distance function to solve the problems as mentioned above. Last but not least, the common Tobit or OLS models tend to ignore the impact of serial correlation, which may bias the results in the second stage of DEA. This paper aims to employ the SBM directional distance function and the Bootstrap model to analyze the efficiency of public educational expenditure in China, and contributes to existing research on public education in China.

3. Methods

The efficiencies of 31 Chinese provinces are estimated, and each province is considered as a DMU to constitute the best production frontier. The production possibility set proposed by Färe et al. (2007) is used, including desirable and undesirable outputs. Let N inputs, $x=(x_1,x_2,\cdots,x_N)\in R_N^+$, to produce M desirable outputs, $y=(y_1,y_2,\cdots,y_M)\in R_M^+$ and L undesirable outputs, $b=(b_1,b_2,\cdots,b_L)\in R_L^+$, and one DMU holds $(x^{k,t},y^{k,t},b^{k,t})$, where $t=1,\cdots,T$ indicates each time and $k=1,\cdots,K$ indicates each province. The production possibility set satisfies several assumptions that the set is closed and convex, both desirable outputs and inputs are strongly disposed and undesirable outputs are weakly disposed as well as null-jointness (Eq.1).

$$T=\{(x^t,y^t,b^t):\sum_{k=1}^{K}\lambda_k^t x_{kn}^t\le x_n^t,\forall n;\sum_{k=1}^{K}\lambda_k^t y_{km}^t\ge y_m^t,\forall m;\sum_{k=1}^{K}\lambda_k^t b_{kl}^t=b_l^t,\forall l \quad (1)$$

$$\sum_{k=1}^{K}\lambda_k^t=1,\lambda_k^t\ge 0,\forall k\}$$

Where λ_k^t indicates the weight of each cross section. The constraint $\sum_{k=1}^{K}\lambda_k^t=1$ indicates the technology frontier which is variable return to scale (VRS). If taking the scale efficiency into account, the constraint $\sum_{k=1}^{K}\lambda_k^t=1$ should be deleted and the frontier is then based on constant return to scale (CRS).

3.1 SBM directional distance function

SBM model proposed by Tone (2001) solves the radial problem in classical DEA model successfully, but not the oriented problem, so incorporating the directional distance function proposed by Chambers et al. (1996) and the SBM model is a good way to deal with the both problems.

According to the model employed by Fukuyama and Weber (2009), the SBM directional distance function is defined as:

$$\vec{S}_V^t(x^{t,k'}, y^{t,k'}, b^{t,k'}; g^x, g^y, g^b) = \underset{s^x, s^y, s^b}{Max} \frac{\frac{1}{N}\sum_{n=1}^{N}\frac{s_n^x}{g_n^x} + \frac{1}{M+L}\left(\sum_{m=1}^{M}\frac{s_m^y}{g_m^y} + \sum_{l=1}^{L}\frac{s_l^b}{g_l^b}\right)}{2} \quad (2)$$

s.t.

$$\sum_{k=1}^{K}\lambda_k^t x_{kn}^t + s_n^x = x_{k'n}^t, \forall n; \sum_{k=1}^{K}\lambda_k^t y_{km}^t - s_m^y = y_{k'm}^t, \forall m; \sum_{k=1}^{K}\lambda_k^t b_{kl}^t + s_l^b = b_{k'l}^t, \forall l;$$

$$\sum_{k=1}^{K}\lambda_k^t = 1, \lambda_k^t \geq 0, \forall k; s_n^x \geq 0, \forall n; s_m^y \geq 0, \forall m; s_l^b \geq 0, \forall l$$

In the linear programming function, $(x^{t,k'}, y^{t,k'}, b^{t,k'})$ illustrates inputs and outputs of the province k'. (g^x, g^y, g^b) is the positive directional vector with constriction of inputs, expansion of desirable outputs and constriction of undesirable outputs, and (s_n^x, s_m^y, s_l^b) illustrates the slacks of inputs and outputs. If the slack equals zero, the DUM is defined as efficient, otherwise it is inefficient, which means that inputs and undesirable outputs are exceeded, given outputs, or desirable outputs are expanded, given inputs and undesirable outputs. The slack is used to measure the deviated degree between actual and potential efficiency.

Following Cooper et al. (2007), the inefficiency can be decomposed:

Inefficiency of inputs: $IE_x = \frac{1}{2N}\sum_{n=1}^{N}\frac{s_n^x}{g_n^x}$ （3）

Inefficiency of desirable outputs: $IE_y = \frac{1}{2(M+L)}\sum_{m=1}^{M}\frac{s_m^y}{g_m^y}$ （4）

Inefficiency of undesirable outputs: $IE_b = \frac{1}{2(M+L)}\sum_{l=1}^{L}\frac{s_l^b}{g_l^b}$ (5)

3.2 Bootstrap method

Bootstrap was firstly proposed by Efron (1970), using original data to resample, rather than more new samples. Assume random sampling $\{x_1, x_2, \cdots, x_n\}$ from *F*， define the empirical distribution of *F*, F_n as follows：

$$F_n(x) = \frac{1}{n}\sum_{i=1}^{n} I(x_i \le x) \quad -\infty < x < \infty$$

Based on nonparametric bootstrap, namely empirical distribution bootstrap, assume that exist $r = 1, 2, \cdots, R$, and that samples $\{i_1^*, i_2^*, \cdots, i_n^*\}$ are drawn from $\{1, 2, \cdots, n\}$ randomly. Therefore, we can obtain $(y_1^*, x_1^*), (y_2^*, x_2^*), \cdots, (y_n^*, x_n^*)$ derived from $y_j^* = y_{i^*j}$ and $x_j^* = x_{i^*j}$ to estimate $\beta_{i,r}^*$, where $j = 1, 2, \cdots, n$.

4. Data Issue

2005 was a major turning point for China's public education. Issues such as compulsory education, vocational education, study loans for undergraduates, and modes of education were under heated debate. The implementation of a series of policies has led to changes and adjustments in the development of educational concepts and policies, and attracted widespread attention from the public. The study involves 31 provinces.[3] Data was sourced from the China Statistical Yearbook and China Education Statistics Yearbook of each province during 2005-2010. We used 2000 as the base year to eliminate the price impact. As for the missing data, we took a linear interpolation approach to obtain an estimated value.

This paper will use DEA method to measure the efficiency of public educational expenditure. Educational scale, educational quality, educational

[3] The east includes: Beijing, Tianjin, Liaoning, Hebei, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, Hainan; the west includes: Chongqing, Yunnan, Sichuan, Guizhou, Xizang, Guangxi, Xinjiang, Qinghai, Ningxia, Gansu, Shanxi, Neimeng; the rest is the middle. In order to maintain the consistency of the statistical standards, our selected sample period is 2005-2010. Because of statistical standards the proportion of illiterate and semiliterate were accounted for in the population aged 15 and above before 2005, while the proportion of illiterate was accounted for among the population aged 15 and above after 2005.

opportunity, educational products input (such as technology, social service and so on) and output data are to be put into the model of the efficiency of public educational expenditure to be analyzed according to previous research. However, there may be some restrictions due to data availability issues and caliber consistency. Therefore, according to data availability, we select budgetary educational expenses (BEE) as the input indicator and output indicators including illiterates and semi-illiterates accounting for the proportion of the population aged 15 and above (IR), school-age children enrollment rate (SCER), the number of graduates of secondary vocational education (SVE), the number of undergraduates (CE) and the number of graduates of graduate education (GE). While this may affect the results of the evaluation to some extent, it has no significant impact on the overall educational outcome.

Table 1 descriptive statistic of inputs and outputs: 2005-2010

District	Indicator	Min	Max	Mean	Std	C.V.
East	BEE	199,132.57	7,340,173.60	2,572,294.19	1,471,015.11	0.5719
	IR	1.70	12.92	6.07	2.99	0.4923
	SCER	99.38	100.00	99.85	0.15	0.0015
	SVE	12598.00	439337.00	169129.02	119908.18	0.7090
	CE	11788.00	478868.00	187969.18	110489.35	0.5878
	GE	143.00	59818.00	15704.74	14089.10	0.8971
Middle	BEE	739880.36	4343620.06	1734149.88	764409.22	0.4408
	IR	1.92	19.24	6.99	3.92	0.5608
	SCER	98.40	99.93	99.62	0.35	0.0035
	SVE	52454.00	526333.00	199068.75	111258.07	0.5589
	CE	83982.00	382486.00	194232.81	76554.78	0.3941
	GE	1772.00	25709.00	9489.40	6345.47	0.6687
West	BEE	166023.84	4449431.75	1195114.86	821946.04	0.6878
	IR	2.36	45.65	13.38	9.41	0.7030
	SCER	95.90	99.99	99.01	0.95	0.0096
	SVE	2197.00	314065.00	86901.56	70612.00	0.8126
	CE	3172.00	278577.00	80224.94	68228.03	0.8505
	GE	17.00	21709.00	5071.71	5727.83	1.1294
Country	BEE	166023.84	7340173.60	1822897.21	1234421.35	0.6772
	IR	1.70	45.65	9.14	7.25	0.7932
	SCER	95.90	100.00	99.47	0.73	0.0073
	SVE	2197.00	526333.00	145025.41	111310.19	0.7675

CE	3172.00	478868.00	147878.16	102356.95	0.6922
GE	17.00	59818.00	9984.77	10662.80	1.0679

The results show that mean BEE of the east is significantly higher than those of middle and western China, while IR indicates the opposite distribution (Table 1). The middle area has the highest mean SVE and CE, followed by the eastern and western areas, whereas higher mean SCER and GE are observed in the east rather than the west. In the terms of the coefficient of variable, the input and output variables fluctuate slightly in the middle area. GE in the east and the middle regions fluctuate evidently and the other variables do not fluctuate significantly. Besides, SCER in the three regions led to minimal changes.

5. Empirical analysis

This paper estimates the inefficiency of public educational expenditure based on CRS and VRS respectively, and decomposes the total inefficiency to explore its determinants. When different efficiencies are estimated using these two resumptions, the results based on VRS should be the priority (Zheng et al., 1998). Therefore, we analyze the inefficiency of public educational expenditure based on VRS in this paper, and compare it with that obtained by employing CRS.

Table 2 Inefficiency and its determinants based on CRS

Province	CRS						
	Inefficiency	BEE	IR	SCER	SCE	CE	GE
Beijing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Guangdong	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hubei	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Liaoning	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tianjin	0.0069	0.0000	0.0000	0.0000	0.0060	0.0010	0.0000
Hunan	0.0383	0.0274	0.0000	0.0020	0.0000	0.0000	0.0089
Henan	0.0448	0.0000	0.0000	0.0087	0.0000	0.0031	0.0330
Hebei	0.0507	0.0000	0.0000	0.0037	0.0000	0.0003	0.0467
Jilin	0.0858	0.0308	0.0000	0.0000	0.0182	0.0084	0.0285
Shandong	0.0913	0.0000	0.0000	0.0392	0.0005	0.0000	0.0517
Heilongjiang	0.1049	0.0336	0.0000	0.0000	0.0494	0.0005	0.0215

Shaanxi	0.1061	0.0815	0.0000	0.0000	0.0026	0.0071	0.0150
Shanxi	0.1285	0.0000	0.0000	0.0000	0.0000	0.0066	0.1219
Jiangsu	0.1589	0.0880	0.0000	0.0463	0.0015	0.0005	0.0227
Jiangxi	0.2068	0.0000	0.0000	0.0000	0.0000	0.0000	0.2067
Chongqing	0.2535	0.0007	0.0000	0.0000	0.0282	0.0859	0.1386
Shanghai	0.2804	0.0508	0.0000	0.0008	0.1621	0.0516	0.0151
Sichuan	0.3023	0.0743	0.0011	0.0409	0.0034	0.0491	0.1335
Hainan	0.5000	0.0000	0.0000	0.0000	0.0412	0.0490	0.4098
Anhui	0.5061	0.0000	0.0203	0.0353	0.0113	0.0815	0.3579
Ningxia	0.5372	0.0000	0.0016	0.0000	0.0622	0.1417	0.3318
Fujian	0.6150	0.0000	0.0035	0.0179	0.0514	0.1381	0.4040
Gansu	0.6249	0.0000	0.0409	0.0070	0.1109	0.1740	0.2921
Guangxi	0.6296	0.0000	0.0000	0.0011	0.0016	0.0746	0.5523
Zhejiang	0.7284	0.0257	0.0000	0.0587	0.0014	0.0626	0.5800
Xinjiang	0.9472	0.0000	0.0000	0.0000	0.0809	0.1468	0.7196
Neimenggu	1.1190	0.0000	0.0017	0.0015	0.0911	0.1703	0.8544
Qinghai	1.1273	0.0000	0.0000	0.0000	0.1331	0.2997	0.6946
Yunnan	1.1700	0.0000	0.0213	0.0293	0.1165	0.3141	0.6889
Guizhou	1.5007	0.0000	0.0323	0.0135	0.1594	0.2818	1.0138
Xizang	6.5923	0.0000	0.0404	0.0000	0.9339	0.6538	4.9642
East	0.2211	0.0150	0.0003	0.0151	0.0240	0.0276	0.1391
Middle	0.1394	0.0115	0.0025	0.0057	0.0099	0.0125	0.0973
West	1.2425	0.0130	0.0116	0.0078	0.1437	0.1999	0.8666
Country	0.5954	0.0133	0.0053	0.0099	0.0667	0.0904	0.4099

Note: The results obtained from SBM directional distance function are similar to those of traditional directional distance function. The larger the value is, the lower the efficiency is.

The inefficiency of public educational expenditure of the country is 59.54 percent, which is largely attributed to the higher inefficiency in the west (Table 2). The results indicate that to achieve efficiency, BEE and IR need to increase by 1.33 percent and 0.53 percent respectively while SCER, SVE, CE and GE each needs to be reduced by 0.99 percent, 6.67 percent, 9.04 percent and 40.99 percent on the country scale. Moreover, GE accounts for the largest inefficiency with 68.85 percent, followed by CE and SVE. It is also notable that inefficiency of public educational expenditure varies significantly among regions, with the highest and lowest efficiency found correspondingly in middle and western area.

These differences can be explained by the inefficiency of GE. Although the inefficiency of IR in the east is lower than that of the middle area, the overall efficiency of public educational expenditure of the latter is superior. This contrasts the results based on VRS (Table 3), which suggests a higher efficiency of public education expenditure in the east relative to the middle area. Results based on VRS are more practical, since the scale efficiency is not taken into VRS. In VRS, Henan and Jiangsu are the best, but not in CRS. Besides, due to the scale efficiency, the inefficiency of Anhui, Fujian, Shanghai and Zhejiang based on VRS is lower than that based on CRS.

Table 3 Inefficiency and decomposition based on VRS: 2005 - 2010

Province	VRS						
	inefficiency	BEE	IR	SCER	SCE	CE	GE
Beijing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Guangdong	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Henan	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hubei	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Jiangsu	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Liaoning	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Shandong	0.0025	0.0000	0.0025	0.0000	0.0000	0.0000	0.0000
Tianjin	0.0069	0.0000	0.0000	0.0000	0.0060	0.0010	0.0000
Shanghai	0.0131	0.0000	0.0000	0.0000	0.0118	0.0013	0.0000
Hebei	0.0348	0.0000	0.0000	0.0001	0.0000	0.0009	0.0339
Hunan	0.0360	0.0340	0.0000	0.0000	0.0000	0.0000	0.0020
Jilin	0.0854	0.0301	0.0000	0.0002	0.0184	0.0085	0.0283
Heilongjiang	0.0893	0.0323	0.0000	0.0005	0.0359	0.0005	0.0201
Zhejiang	0.0902	0.0706	0.0073	0.0000	0.0008	0.0018	0.0096
Shaanxi	0.1058	0.0810	0.0000	0.0002	0.0026	0.0071	0.0150
Shanxi	0.1118	0.0000	0.0000	0.0000	0.0000	0.0061	0.1057
Chongqing	0.1256	0.0158	0.0091	0.0000	0.0103	0.0402	0.0502
Jiangxi	0.1324	0.0000	0.0002	0.0000	0.0000	0.0005	0.1317
Sichuan	0.2228	0.1361	0.0198	0.0003	0.0000	0.0313	0.0355
Fujian	0.3090	0.0590	0.0331	0.0000	0.0000	0.0473	0.1697
Anhui	0.3340	0.0617	0.0384	0.0000	0.0000	0.0535	0.1805
Hainan	0.4721	0.0000	0.0006	0.0000	0.0386	0.0464	0.3866
Ningxia	0.5323	0.0000	0.0079	0.0000	0.0626	0.1401	0.3217
Gansu	0.5478	0.0365	0.0486	0.0007	0.0921	0.1508	0.2193

Guangxi	0.6266	0.0008	0.0000	0.0004	0.0015	0.0744	0.5496
Xinjiang	0.9423	0.0000	0.0000	0.0004	0.0800	0.1463	0.7156
Neimenggu	0.9603	0.0000	0.0060	0.0001	0.0814	0.1560	0.7168
Yunnan	0.9626	0.0535	0.0432	0.0020	0.0543	0.2171	0.5926
Qinghai	1.1079	0.0000	0.0092	0.0001	0.1381	0.2920	0.6685
Guizhou	1.4059	0.0000	0.0493	0.0016	0.1020	0.2038	1.0493
Xizang	6.4300	0.0000	0.0469	0.0003	0.9961	0.6201	4.7666
East	0.0844	0.0118	0.0040	0.0000	0.0052	0.0090	0.0545
Middle	0.0986	0.0198	0.0048	0.0001	0.0068	0.0086	0.0585
West	1.1641	0.0270	0.0200	0.0005	0.1351	0.1733	0.8084
Country	0.5060	0.0197	0.0104	0.0002	0.0559	0.0725	0.3474

Note: The SBM directional distance function is the similar as traditional directional distance function, which the more the value is, the lower the efficiency is.

Table 3 is the inefficiency and decomposition of the public educational expenditure based on VRS. In the VRS, the inefficiency of public educational expenditure in the county is 50.6 percent, and it indicates that the public educational expenditure in the country should decline 1.97 percent BEE, 1.04 percent IR, and increase 0.02 percent SCER, 5.59 percent SVE, 7.25 percent CE, 34.74 percent GE to eliminate the inefficiency. Like the CRS, the result is that the west remains the major source of inefficiency in country.

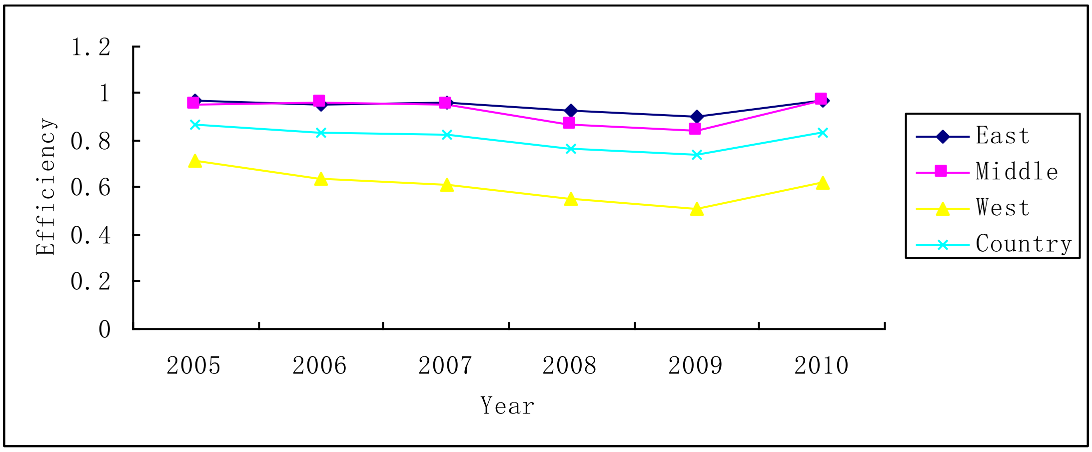

Figure 1 the efficiency of each province during 2005-2010

The efficiency of public education expenditure exhibits similar trends of changes regionally and country-wide (Figure 1). The lowest point is identified in

2009, when reforms of education policies in China have brought forward remarkable success. It is quite discernible that the efficiency of the west area is far below the country level and other regions, while the difference in efficiency of the east and middle areas is next to negligible, except for the period of 2005-2007. During this time, the efficiency of the east had a slightly better performance compared with that of the middle area.

As is indicated in Table 3, GE is still the most important factor affecting the efficiency of public educational expenses, in which inefficient contribution to the proportion is up to 68.64 percent. SVE and CE are also main factors. If compared to the inefficiency of public educational expenditure among regions, it can be seen that the efficiency of public educational expenditure in the east is the highest, the middle is lower than the east, and the west is the lowest. The trend of the efficiency of all indicators except for CE is higher in the east regions and the lower in the west areas, while efficiency in the middle regions is a little higher than that in the east. The efficiency of public educational expenses in the west is significantly lower than the east and the middle regions, and the reason is mainly reflected in GE. While SVE and CE cannot be ignored in inefficiency contribution, so it can be seen that there is a distinct disadvantage in secondary and higher education in the west. In terms of province, Beijing, Guangdong, Henan, Hubei, Jiangsu and Liaoning are the provinces with higher efficiency of public educational expenditure, which are all at the technical boundary, and Xizang is the province with the lowest efficiency of public educational expenditure. Sichuan has the lowest efficiency in the indicator of BEE, and the inefficiency value is 13.61 percent, taking up 61.06 percent of the total value, which is higher than the average in country. The inefficiency value of IR is ranked highest in Guizhou, Gansu, Xizang and Yunnan, which are all western provinces. The inefficiency value of SCER is relatively low, and the average in the country is only 0.02 percent, accounting for 0.04 percent of the total inefficiency of public educational expenses, which shows that enrollment education of school-age children in China has been effectively guaranteed and the spread of primary education is in good condition. The lowest efficiency of SVE is in Xizang, which has an inefficiency value of up to 99.61 percent, beyond the western average of 86.11 percent and higher than the national average of 94.03 percent. The east and the middle regions in secondary vocational education have a good output. The inefficiency value of CE and GE is still high in the west. There are 592 poverty-stricken counties in China and the west account for 307 of them, These regions have food security and clothing provision problems and severely low levels of education. In the two indicators, Xizang is still the most inefficient province. The inefficiency value of CE is up to 62.01 percent, which exceed the western average of 44.68 percent and beyond the national average of 54.76 percent. The inefficiency value of GE is up to 476.67 percent, which exceeds the western average of 395.82 percent and beyond the national average of 441.92 percent. The trend of these two indicators almost remains the same in most provinces. It is noteworthy that in the Hainan province, the inefficiency value of GE in Hainan is 38.66 percent, which exceeds the national average 3.92 percent. However, the inefficiency value of CE is less than 2.61 percent of the national average. Ningxia is just the opposite. The inefficiency value of GE in Ningxia is 32.17 percent, which less than 2.57 percent of the national average, but the inefficiency value of CE is higher than 6.76 percent of the national average.

6. Macroeconomic environment test

There are many factors that affect the efficiency of public educational expenditure. Some from internal factors like the government financial educational expenditure scale, and others are influenced by external environmental factors. Section 5 analyzes the efficiency only from the internal aspect for each province, yet lack research from the external environmental point of view needs to be accounted for. Wang and Yang（2008）deemed that there are some existing evident blanks on the research of public educational finance in China. The most important challenge being how to evaluate the overall scale of public expenditure for education and how to disaggregate its various components of which is the public educational expenditure scale in a country or a local government. A more accurate assessment is needed to investigate what factors can explain the regional differences of the relative efficiency of public educational expenditure. This paper will use the Bootstrap model for regression testing to analyze the impact of external environmental factors on the efficiency of public educational expenditure. Specifically, indicators which represent the level of economic development, ownership structure, industry structure, population size and structure, and the degree of urbanization are selected. The data is sourced from the China Statistical Yearbook. Specific indicators are as follows:

(1) The level of regional economic development (AGRP) represents the regional per capita GDP index. Per capita indicators were chosen since that they provide more objective measurements of people's living standard, and can reflect macroeconomic performance of the region.

(2)Ownership structure: SYZ is the proportion of the investment in fixed assets of the state-owned economy to the total social fixed assets investment. Given the substantial impact of ownership structure on productivity, SYZ is considered as an independent indicator of macroeconomic factors. The state-owned economy consists of publicly owned sectors, collective sectors and so on, including provincial and local governments, institutions, and enterprises invested by state-owned assets as well as community groups and so on. Because of their leading force, it is reasonable to use SYZ to reflect the ownership structure of the regions.

(3)Industry structure: IOP. IOP is the proportion of output earned from the secondary sector in the region' GDP. As secondary sector leads the development of the national economy and provides the basis for developing other industry sectors, we choose IOP to represent industry structures for all regions.

(4)Population size: POP refers to the size of the total population. It has a direct impact on socio-economic development, and hence is one of the indispensable contextual variables that need to be considered.

(5)Population structure: POG stands for the dependency ratio; that is the ratio of the population aged 0-14 years relative to those aged 15-64 years. Population structure can affect the distribution of consumption and savings derived from national income revenues, thus influencing macroeconomic growth. The indicator is chosen to reflect the population structure because it can effectively reveal the burden of people.

(6)The degree of urbanization: CSH is the proportion of the urban population which accounts for the total population. Urbanization describes a process where people migrate to the city and shift their lifestyles from farm to non-farm work as a result of socio-economic changes.

The statistics indicated that AGRP remained relatively stable at about 112 percent in each region during 2005-2010 (Table 4). SYZ averaged around 0.3 percent and varied little across regions. IOP was at about 47 percent. There was a big variance in the mean of IOP within the eastern region, despite the subtle difference in mean IOP across regions. POP fluctuated largely, especially in the east. Mean POG was found higher in the west and lower in the east while CSH displayed the opposite.

Table 4 Descriptive statistics of contextual variables

District	Indicator	Min	Max	Mean	Std.	C.V.
East	AGRP	102.40	115.00	111.02	2.69	0.0242
	SYZ	0.14	0.47	0.27	0.08	0.2819
	IOP	0.80	60.10	47.14	11.94	0.2534
	POP	828.00	10441.00	4802.58	3148.43	0.6556
	POG	9.64	34.96	19.52	6.07	0.3110
	CSH	37.69	89.09	60.81	15.41	0.2535
Middle	AGRP	104.90	118.80	112.75	2.08	0.0185
	SYZ	0.01	0.46	0.32	0.09	0.2705
	IOP	39.90	61.50	49.65	5.52	0.1111
	POP	2716.00	9487.00	5246.92	2021.68	0.3853
	POG	15.00	37.76	24.55	6.22	0.2535
	CSH	30.65	55.60	44.19	6.66	0.1508
West	AGRP	106.50	123.40	112.76	2.77	0.0246
	SYZ	0.01	0.81	0.43	0.12	0.2738
	IOP	25.30	56.10	45.64	6.94	0.1520
	POP	277.00	8212.00	3009.88	2118.62	0.7039
	POG	17.98	44.65	29.88	5.71	0.1912
	CSH	22.61	55.09	38.15	7.79	0.2042
Country	AGRP	102.40	123.40	112.14	2.70	0.0241
	SYZ	0.01	0.81	0.34	0.12	0.3497
	IOP	0.80	61.50	47.21	8.88	0.1881
	POP	277.00	10441.00	4223.30	2684.85	0.6357
	POG	9.64	44.65	24.83	7.44	0.2996
	CSH	22.61	89.09	47.75	14.77	0.3093

Bootstrap analysis was operated in the STATA 11.0, and the results are as follows.

Table 5 Results of bootstrapping analysis

Technology		East		Middle		West		Country	
		Coef.	Prob.	Coef.	Prob.	Coef.	Prob.	Coef.	Prob.
CRS	C	-2.3928	0.1220	0.7106	0.7460	-0.0604	0.9380	-0.0585	0.9330
	AGRP	0.0275	0.0400	0.0080	0.6140	-0.0130	0.0890	0.0039	0.5050
	SYZ	-0.1092	0.8480	0.3199	0.4130	0.6163	0.1070	-0.2306	0.2440
	IOP	-0.0035	0.3530	0.0028	0.4100	0.0116	0.0220	0.0022	0.2360
	POP	0.0000	0.0770	0.0000	0.8560	0.0001	0.0000	0.0000	0.0000
	POG	-0.0034	0.6570	-0.0149	0.0550	0.0125	0.0280	-0.0023	0.4960
	CSH	0.0057	0.0670	-0.0129	0.1600	0.0198	0.0130	0.0061	0.0000
	OBS	66	—	48	—	72	—	186	—
VRS	C	-0.8993	0.3330	0.1417	0.9340	0.3274	0.6840	0.4001	0.5050
	AGRP	0.0158	0.0550	0.0092	0.4500	-0.0136	0.0890	0.0003	0.9560
	SYZ	0.0745	0.8220	0.2001	0.4950	0.4006	0.2460	-0.3562	0.0300
	IOP	-0.0013	0.3800	0.0036	0.1810	0.0089	0.0920	0.0027	0.1010
	POP	0.0000	0.0040	0.0000	0.7160	0.0001	0.0000	0.0000	0.0000
	POG	-0.0086	0.0660	-0.0089	0.1970	0.0097	0.0740	-0.0030	0.3200
	CSH	0.0031	0.0350	-0.0070	0.3760	0.0198	0.0130	0.0067	0.0000
	OBS	66	—	48	—	72	—	186	—

Note：The repeated sampling time in Bootstrap method is set to 999.

Regardless of the assumptions of CRS or VRS, both of the coefficients of AGRP are significant in the east and west (Table 5). The east is significant at the 5 percent level based on CRS, and the east based on VRS as well as the west based on the two assumptions is significant at the 10 percent level. The positive value of the east suggests that the efficiency of public educational expenses increases with higher levels of economic development, in stark contrast with the west. The coefficient of AGRP for the middle region is not significant, indicating no impact of economic development on the efficiency.

Based on VRS, SYZ is significantly negative at the country level, showing negative effects of ownership structure on the efficiency of public educational expenditure. A larger proportion of state-owned economy means a greater amount of funds needed to be invested by the government. While the total government expenditure is limited, it is bound to affect its input in education, and hence the efficiency of public educational expenses. At the same time, lower returns to the investments directed to state-owned enterprises are expected reflecting its low efficiency of operation. Thus the inputs that would have been placed in public education are not likely to be compensated in the coming years. Our finding points to the possibility to improve the efficiency of public educational expenditure by reducing the proportion of the state-owned economy in the overall composition of the economy.

IOP is significantly positive in western regions, and is significant at the 5 percent level based on CRS and significant at the 10 percent level based on VRS, which shows that the industry structure has positive effects on the efficiency of public educational expenditure in the west. It means that the bigger the proportion of secondary sector output, the higher the efficiency of public educational expenditure under the premise that other conditions remain unchanged. This suggests that development of secondary sector holds promises to promote efficiency of public education expenditure in western China, by stimulating rapid growth of the overall economy. The strategy makes particular sense in this part of the country, considering its poor economic performance.

POP is significant in all regions except for the middle region regardless of the assumptions of CRS or VRS. Specifically, the variable is significantly positive in the western provinces, while the coefficient is zero in other regions. It shows that the population size has positive effects on the efficiency of public educational expenses in the west where the population is unevenly distributed. But its coefficient value is very small, indicating a low impact. Population size has no significant impact on public education in the eastern and middle regions, due perhaps since population size has reached the saturation point. Human capital has thereby been put to its optimal use to enhance public education.

The POG sign is significant in both the middle and the western areas based on CRS. It is significantly negative at the 10 percent level in the middle, while the west is positive at the 5 percent level. However, the result mentioned above is not the same as that based on VRS, where the eastern region is negative at the 10 percent level, while the western region is positive at the 10 percent level. The main reason behind the difference between VRS and CRS sources arises due to the scale efficiency. The coefficient for the west is significantly positive based on both CRS and VRS Higher POG requires more education expenditure from the government to increase its efficiency. However, due to widespread achievement of compulsory education in the east and middle regions where resource for education is abundant, extra investments would have led to inefficiency.

The CSH based on CRS and VRS is positive in the east, the west and overall country, which is significant at the 5 percent level test except for the east which is significant at the 10 percent. The middle area is not significant in the test, meaning that urbanization held positive effect to the public education expenditure in areas except the middle. It may be interpreted that the better the urbanization is, the higher the educational level is, which is interrelated to the development of public education, and reflects the public education expenditure efficiency to a certain extent.

7. Conclusion

This paper applies SBM directional distance function to estimate the efficiency of public education expenditure in 31 provinces from 2005-2010 in China, and explores its relationship with environmental factors. We found a higher efficiency level in middle parts of China compared with the eastern and western regions based on CRS, while the efficiency becomes higher in the east than the middle region when removing the scale efficiency based on VRS. Based on CRS, Beijing, Guangdong, Hubei and Liaoning are efficient, while based on VRS, in addition to the four provinces mentioned above, Henan and Jiangsu are efficient as well.Furthermore, the efficiency of Xizang is the worst based on both CRS and VRS. Considering each variable, inefficiency of GE, which accounts for 68.64 percent of the total inefficiency, is the main contributing factor to the gap between the west and other regions. Moreover, SVE and CE also play important roles in the public education expenditure efficiency, where the proportion of inefficiency of SVE is 11.04 percent, and that of CE is 14.32 percent.

We use the bootstrap method to test the relationship between public education expenditure efficiency and environmental factors. Based on CRS and VRS, the sign of AGRP in the eastern region is positive, but significantly negative in the west. The SYZ is negative in the country based on VRS. The IOP is positive in the west. The POP in the west is also positive, and the rest is 0, but the middle region did not yield significantly results. The POG in the middle region is negative, but the western region is positive based on CRS, while the eastern region is negative based on VRS. The CSH based on both CRS and VRS, the east, the west and the entire country are positively significantly, except for the middle region.

In sum, the efficiencies of the east and the middle are better than that of the west. In order to promote the development of public education in China, we propose the following policies:

(1) Accelerate the education development, particularly of the minority people. Put more resources into basic education to bridge the gap between the east and the west. Moreover, rich areas may help poor areas such as the western development plans, and the government should encourage qualified persons to work in the west.

(2) Allocate public education resources effectively. Bridging the education gap between different areas will achieve education fairness. More educational resources should be dedicated to the western and poor areas to improve the development process among the eastern, middle and western areas.

(3) Focus on the development of secondary vocational education based on employment orientation. Local government should take secondary vocational education into account in their relevant development plans. Educational sectors should use different types of educational resources, and arrange the admission and employment through school-enterprise collaboration to improve the efficiency of secondary vocational education.

(4) Optimize inputs and outputs in higher education and improve the educational quality to increase the efficiency. Focus on the improvement of teaching quality, and match all levels of teachers. Make an effective incentive mechanism to encourage teacher to improve their research and teaching capacity. Reasonable arrangements should be made to improve the quality of postgraduate education such as enhancing the ratio of researchers to graduate students.

Due to data availability, we were not able to analyze the convergence of public education expenditure efficiency. Future research could take this into account and collect data from a longer time series. To improve the study, productivity analysis can be performed. The research could also be extended to compare the efficiency of public education expenditure of China with that of other countries.

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