



## Performance of Financial Expenditure in China's basic science and math education: Panel Data Analysis Based on CCR Model and BBC Model

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### ABSTRACT

Basic education plays the fundamental and leading role in the national education system. Strengthening and optimizing the allocation of resources in basic education and improving the performance of fiscal expenditure on basic education has always been the focus of academic attention. In this paper, the teacher-student ratio, per-student educational appropriations, per-student fixed assets are taken as the input indexes, graduation rate as the output index, data envelopment analysis (DEA) is used to analyze the performance of basic education expenditure from 2005 to 2014, obtaining the comprehensive technical efficiency, pure technical efficiency, scale efficiency, scale income and scale elasticity of the basic education expenditure. It is believed that in the input structure of basic education, raising the amount of input in junior middle school can improve the expenditure performance of the whole basic education better than the other three stages. At the same time, in the way of basic education input, improving the quality of resource allocation of input factors can improve the performance of basic education expenditure better than simply increasing the scale of input factors. Therefore, the performance of fiscal expenditure can be improved by optimizing the input structure of the financial expenditure and the matching quality of resources in the basic education stage.

**Keywords:** basic education, fiscal expenditure, performance evaluation, data envelopment analysis

### INTRODUCTION

Basic education plays the fundamental and leading role in the national education system. It is the education of a basic knowledge of the people, and plays a fundamental role in cultivating citizens' survival ability and cognitive ability. Its quality is directly related to the long-term development of the country. The basic education in this paper includes four stages: term education, primary education, junior high school education and high school education. It is proposed in the National Long-term Education Reform and Development Program (2010-2020) that improving the quality of education is the core task of the reform and development of education; a management system and working mechanism based on improving the quality of education should be established; the allocation of educational resources and school work should be focused on strengthening teaching links and improving the quality of education. It is pointed out by The Development of National Education Plan in the 13th Five-Year that

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#### **State of the literature**

- The existing research results for the evaluation of the performance of basic education financial expenditure has not yet established a more authoritative performance evaluation index system.
- At present, China's basic education expenditure performance has not been scientifically and reasonably evaluated, which restricts the efficiency of the use of education funds.
- Most of the current research results focus on improving the quality of basic education by strengthening the amount of fiscal expenditure, and neglecting to improve the overall expenditure performance by optimizing the resource investment structure.

#### **Contribution of this paper to the literature**

- This paper analyzes the performance of financial expenditure in four stages of basic education from the perspective of input orientation, and puts forward that in the input structure of basic education, raising the amount of input in junior middle school can improve the expenditure performance of the whole basic education better than the other three stages.
- Based on the comprehensive analysis of the five kinds of indexes, such as the comprehensive technical efficiency, the pure technical efficiency, the scale efficiency, the scale income and the scale elasticity of the basic education financial expenditure performance, this paper puts forward that in the way of basic education input, improving the quality of resource allocation of input factors can improve the performance of basic education expenditure better than simply increasing the scale of input factors.

since 2012 the national financial education funds accounted for 4% of GDP target for the first time, per-student appropriation system has been established gradually. Investigation Report on Basic Education Development in 2016 shows that in 2015, the national financial education funds reached 2 trillion and 900 billion yuan, and the country maintained a good growth in the amount of basic education input. However, in the entire education stage, the allocation of educational resources in basic education has been at a disadvantage. Therefore, it is of great significance to strengthen and optimize the resource allocation of basic education and improve the performance of basic education expenditure in order to improve the quality of education.

### **LITERATURE STUDY**

In the Interim Measures for the Management of Performance Evaluation of Financial Expenditure, the performance evaluation of financial expenditure (hereinafter referred to as performance evaluation) means that the financial department and the budget department (units) use the scientific and reasonable performance evaluation index, evaluation standard and evaluation method, make an objective and fair evaluation of the economic, efficiency and performance of financial expenditure according to the performance goals. Although education finance is a part of public finance, it also has its own characteristics. Scholars' research on the performance of educational expenditure mainly focuses on the performance evaluation indexes, evaluation methods and post evaluation inspiration of educational expenditure.

Generally speaking, the performance evaluation system of educational expenditure should meet the following three principles: adequate supply of education, effective allocation of educational resources and fair allocation of educational resources. Castano (2010) used the Malmquist index to evaluate the educational performance of 30 private educational institutions in Philippines between 1999 and 2003, and proposed that the staff's age, institutional nature and institutional autonomy have important impacts on performance. Huang Jinzhi (2010) and Zhu et al. (2017) gave play to the guiding role of performance evaluation results, directly constructed the performance evaluation index of compulsory education financial expenditure according to input-output. Aristovnik (2011) used data envelopment analysis (DEA) to evaluate the relative technical efficiency of higher education in various countries. The portfolio of students' public expenditure was used as input indexes, and higher education enrollment rates were used as indicators of output. Including input, process, output and effectiveness

these four indicators in the structure, schedule, and performance (SSP) analysis paradigm, according to the efficacy, efficiency and effectiveness (3E) standard, with the government departments, education departments and schools as the object, Luo Lin (2011) and Liu (2017) constructed the performance evaluation indicator system of compulsory education financial expenditure. Fan Yan (2013) established the performance evaluation model based on the CIP model, and evaluated the performance of compulsory education expenditure in China. The empirical analysis mainly focused on three factors: environment, input and output. The evaluation results showed that the performance progress of China's compulsory education financial expenditure was only from the additional input of financial funds instead of Pareto improvement. Chen Xiaoyan (2013) established panel data of China's 31 provinces (municipalities and autonomous regions) from 2000 to 2010, evaluated the financial efficiency of compulsory education between China and the provinces respectively through the Malmquist Index- data envelopment analysis (Malmquist-DEA). The evaluation results showed that the overall efficiency of compulsory education finance in China was low.

Using data envelopment analysis (DEA), taking number of academic staff and labor costs as two inputs, number of students and the number of graduates as outputs, Jablonsky (2016) made an evaluation of educational performance in Czech during 2009-2012. Nam (2016) evaluated the educational and financial performance through the local education financial evaluation system, and believed that the proportion of staff expenses to total expenditure had been decreasing, and the budget implementation plan had been greatly improved, but the composition of financial resources had not improved, and proposed to focus on the budget execution efficiency of financial resources and educational financial data. Yan Haina (2017) pointed out that, for the same evaluation object, the performance evaluation index system will be different because of the different evaluation subjects. Liu Xiaojie (2017) constructed a general index system of performance evaluation according to the three aspects of project decision-making, project management and project performance.

The present educational performance evaluation index system includes the quality of education, the conditions for running schools and the process of education. As a whole, the educational performance evaluation indexes can be classified into four categories: basic indicators, common development indicators, personality development indicators and educational efficiency indicators. In performance evaluation methods, there are mainly input-output method, AHP method, benchmarking method, balanced scorecard, Tobit model, exact method and income equation method, total factor productivity index method, stochastic frontier regression and data envelopment analysis method. In particular, the latter two methods are the most commonly used methods for scholars to study educational performance evaluation, and the combination of two or more methods has become a new trend of performance evaluation. Many scholars have made some exploration on the evaluation of educational performance, but there has not yet been a more authoritative and unified performance evaluation index system, which has influenced the establishment and perfection of the system of performance evaluation of educational expenditure in our country. The performance of educational expenditure has not been evaluated scientifically and rationally, which restricts the efficiency of educational expenditure.

## METHODOLOGY

### DEA Evaluation Model

DEA is a linear programming model that represents the ratio of output to input. The DEA model can be divided into three types: input oriented, output oriented and non-oriented. The meaning of input oriented type refers to the extent to which the inefficient measurement output can be reduced in proportion to input. Based on the evaluation of the performance of educational expenditure, in order to better improve the efficiency of resource allocation and utilization under the existing resource output, the input oriented DEA model is used. If production technology is variable return to scale, the efficiency value obtained by CCR model is not purely technical efficiency, it is called Technical Efficiency (TE), and contains the component of scale efficiency. The BCC model is based on variable yield of scale, which excludes the impact of scale and hence is called Pure Technical Efficiency (PTE).

The input oriented CCR model and BCC model are shown in equations (1) (2):

**Table 1.** Basic education fiscal expenditure performance evaluation index

Input indexes		Output index
Human input	T1: Teacher student ratio = number of full-time teachers / students T2: Ratio of teaching staff = number of full-time teachers / staff	S: Graduation rate = graduation number / enrollment number
Financial input	T3: Per-student educational appropriation= Amount of financial education expenditure / number of students in school	
Material input	T4: Per-student fixed assets= The amount of capital expenditure / number of students in school	

$$CCR: \begin{cases} \min \theta \\ s. t. \sum_{j=1}^n \lambda_j x_{ij} \leq \theta x_{ik} \\ \sum_{j=1}^n \lambda_j y_{rj} \leq y_{rk} \\ \lambda \geq 0 \\ i = 1, 2, \dots, m; r = 1, 2, \dots, q; j = 1, 2, \dots, n \end{cases} \quad (1)$$

$$BCC: \begin{cases} \min \theta \\ s. t. \sum_{j=1}^n \lambda_j x_{ij} \leq \theta x_{ik} \\ \sum_{j=1}^n \lambda_j y_{rj} \leq y_{rk} \\ \sum_{j=1}^n \lambda_j = 1 \\ \lambda \geq 0 \\ i = 1, 2, \dots, m; r = 1, 2, \dots, q; j = 1, 2, \dots, n \end{cases} \quad (2)$$

In equation (1),  $\lambda$  represents the linear combination factor of DMU; the optimal solution of the model  $\theta^*$  represents the efficiency value, ranging (0,1].  $1-\theta^*$  means at the current level of technology, DMU $k$  is evaluated for maximizing the amount of input that can be reduced without lowering output levels. The smaller the  $\theta^*$ , the greater the extent of the input can be reduced and the lower the efficiency. In actual production, many production units are not in the most productive state. Therefore, Scale Efficiency (SE) can be separated by TE and PTE, and the calculation method is  $SE=TE/PTE$ .

### Scale Elasticity

In the performance evaluation of basic education financial expenditure, when all other input factors remain unchanged, a change of input factors can lead to changes in output performance. The ratio of the ratio of the output change to the change in the input factor is called output elasticity, indicating the sensitivity of the change in product output to the input of production factors. The economic significance of output elasticity is that when a factor of output increases by one percent, how much does the output variable increase. The DEA evaluation is a multi-input process. The rate of technical inefficiency derived from DEA refers to the proportion of DMU inputs should be reduced proportionally under the given conditions of output. Then, for a specific point in the frontier, the fluctuation of output caused by the change of its input factors represents the returns to scale, and it is scale elasticity expressed in quantitative terms. Scale flexibility is the quantification of the state of returns to scale. The equal proportion change of each input index will cause the equal proportion change of each output index, and scale elasticity is the ratio of the proportion of changes in the output index to the proportion of changes in the input index, that is, scale elasticity is equal to the ratio of marginal output to average output.

### Evaluation Index System

In order to evaluate the performance of financial expenditure in different stages of basic education, comprehensive financial efficiency, pure technical efficiency, scale efficiency, scale income and scale elasticity of various types of basic educational expenditure must be measured. On the basis of relevant research, human input, financial input and material input are used as input indicators, and graduation rate is taken as the output index. The evaluation index system is shown in **Table 1**.

**Table 2.** Comprehensive technical efficiency of financial expenditure in basic education

TE	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
a	0.768451	0.772699	0.771602	0.729325	0.691072	0.680569	0.607312	0.574251	0.540805	0.511623
b	0.808968	0.742858	0.655429	0.945149	0.512248	0.499182	0.452066	0.400814	0.354508	0.362145
c	0.939931	0.77833	0.867538	0.837815	0.67484	0.549867	0.527124	0.487432	0.449621	0.429996
d	1	0.961012	0.926823	1	0.782351	0.809161	0.852253	0.776927	0.718676	0.785955
h	0.782169	0.74121	0.694405	0.655891	0.551585	1	1	0.495364	0.462991	0.470197

**Table 3.** Pure technical efficiency of financial expenditure in basic education

PTE	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
a	0.794659	0.788387	0.812583	0.761662	0.720158	0.714027	0.645145	0.638388	0.688485	0.547852
b	1	0.928053	0.712898	1	0.691498	0.944051	0.942062	0.826129	0.511279	0.63133
c	1	0.904658	0.924453	0.934175	0.703895	0.571883	0.542938	0.499065	0.456548	0.431756
d	1	0.988659	0.983687	1	0.95636	0.955733	0.883713	0.810446	0.748034	0.791125
h	0.868427	0.817671	0.734873	0.676135	0.581772	1	1	0.504313	0.469195	0.475731

**Table 4.** Scale efficiency of financial expenditure in basic education

SE	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
a	0.96702	0.980101	0.949568	0.957544	0.959611	0.953142	0.941358	0.899534	0.785499	0.93387
b	0.808968	0.800448	0.919386	0.945149	0.740781	0.528766	0.479868	0.485172	0.693375	0.573623
c	0.939931	0.860359	0.938434	0.89685	0.958722	0.961502	0.970873	0.976691	0.984828	0.995924
d	1	0.972036	0.942193	1	0.818051	0.846639	0.964399	0.958641	0.960753	0.993465
h	0.900673	0.906489	0.944931	0.970059	0.948112	1	1	0.982256	0.986776	0.988368

### Data

All the data in this paper are from the Chinese Statistical Yearbook of Education and the Statistical Yearbook of Educational Funds from 2006 to 2015. According to the high school (a), junior high school (b), primary school (c), pre-school education (d) to segment the statistical data, the sum of the above four data is used as the statistics of basic education (h). Among them, the amount of financial education expenditure refers to the total amount of the national financial education funds, and the amount of capital expenditure refers to the expenditure of infrastructure construction in the expenditure of educational institutions at all levels.

### EMPIRICAL RESULTS

In order to observe the changing trend of the performance of basic education expenditure more clearly, MaxDEA software is used to obtain comprehensive technical efficiency, pure technical efficiency, scale efficiency and scale returns. The data are summarized in **Table 2**, **Table 3** and **Table 4**, as shown in **Figure 1**, **Figure 2** and **Figure 3**, respectively. The resulting scale returns and scale elasticities are shown in **Tables 5** and **6**. As found in **Figure 1**, the overall technical efficiency of basic education expenditure showed a downward trend from 2005 to 2014. Among them, the comprehensive technical efficiency of education expenditure in preschool education stage decreases the least, and the comprehensive technical efficiency of educational expenditure in junior middle school is the most variable.

From the comparison of **Figure 1**, **Figure 2** and **Figure 3**, it is observed that, besides the junior high school stage, the trend of the comprehensive efficiency of the basic education expenditure in the other stages is basically the same as the trend of the pure technical efficiency. The pure technical efficiency of financial expenditure in junior middle school fluctuates most. Except for 2013, the pure technical efficiency of other years is in the stage of growth, while the scale efficiency is the opposite, which leads to the biggest decline in comprehensive technical efficiency in junior high school. In addition, the trend of scale efficiency shows that in addition to junior high school, the scale efficiency of basic education in other stages are basically in the range of 0.8 to 1, which indicates that relying solely on expanding the scale of input in basic education expenditure is not an effective way to improve the performance

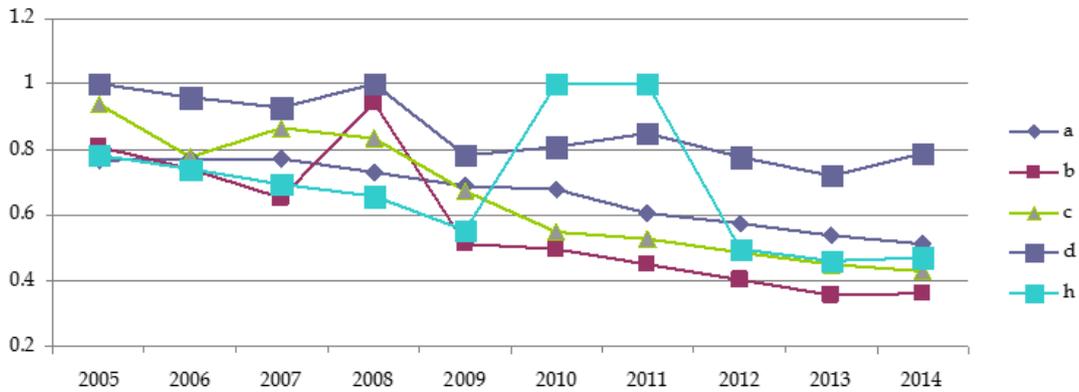


Figure 1. The trend of comprehensive technical efficiency of financial expenditure in basic education

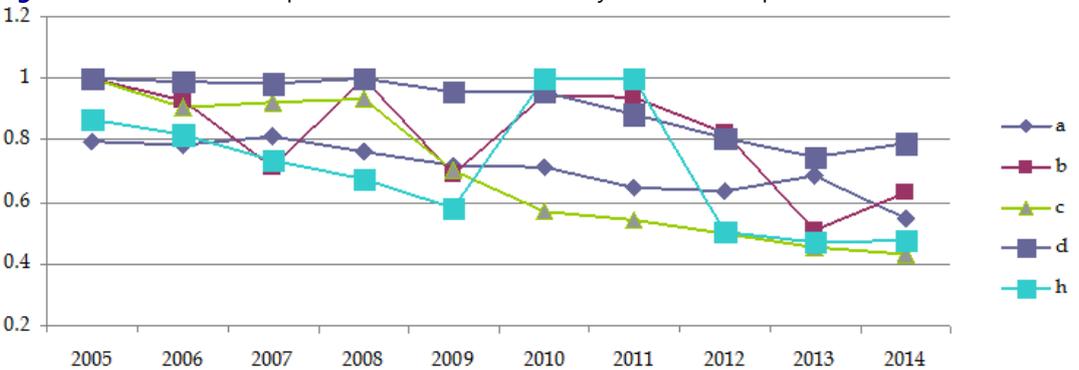


Figure 2. The trend of pure technical efficiency of financial expenditure in basic education

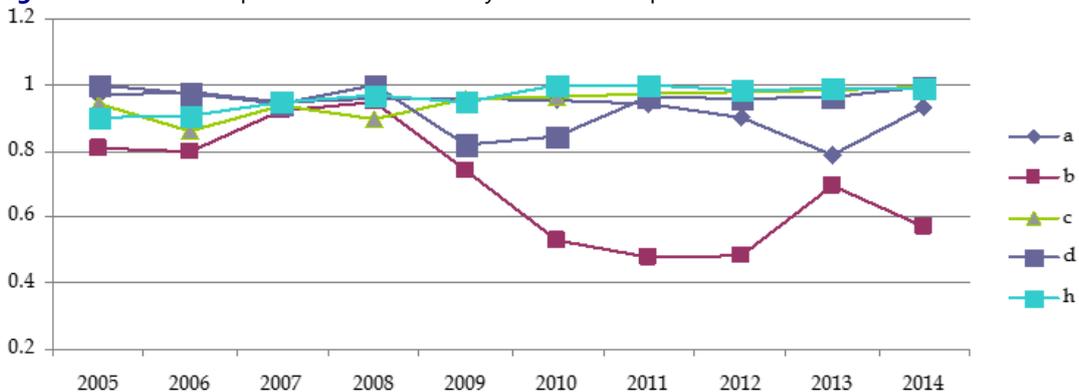


Figure 3. The trend of scale efficiency of financial expenditure in basic education

of basic education expenditure, and the input structure and resource matching degree of the basic education expenditure should be optimized.

Table 5 shows that in addition to the decline of the returns to scale of fiscal expenditure in preschool education stage, the returns to scale of fiscal expenditure in other stages are increasing, which indicates that high school, junior high school and primary school can improve their comprehensive technical efficiency by increasing the scale, thus improving their performance level.

**Table 5.** Scale income statistics of financial expenditure for basic education

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
A	-	+	+	+	+	+	+	+	+	+
B	+	+	+	+	+	+	+	+	+	+
C	+	+	+	+	+	+	+	+	+	+
D	=	-	-	=	-	-	-	-	-	-
H	+	+	+	+	+	=	=	+	+	+

**Table 6.** Scale elasticity statistics of expenditure on basic education

	a-E(ub)	a-E(lb)	b-E(ub)	b-E(lb)	c-E(ub)	c-E(lb)	d-E(ub)	d-E(lb)	h-E(ub)	h-E(lb)
2005	2.6617E+12	0.588316	0.00134	0	0.884469	0.00008	2.8351E+12	0.110899	0.84308	0.663162
2006	0.815585	0.604142	0.883728	0.186391	0.861435	0.702561	1.5423E+13	0.5744	0.842165	0.661197
2007	0.827383	0.629467	0.856509	0.691988	0.882857	0.180298	4.7332E+12	2.032952	0.840697	0.658047
2008	0.826156	0.626834	0.888904	0.02831	0.883113	0.18209	1.403E+13	0.003384	0.838257	0.781299
2009	0.826553	0.627685	0.878023	0.146471	0.874716	0.803729	1.9429E+12	0.578557	0.832651	0.640776
2010	0.830999	0.637229	0.882755	0.179583	0.865433	0.789186	1.66E+12	0.581583	4.4812E+13	0.147484
2011	0.83854	0.653416	0.882619	0.178632	0.865428	0.789178	2.9984E+12	0.587885	2.579264	0.023966
2012	0.84936	0.233586	0.879903	0.159631	0.861852	0.783576	2.0957E+12	0.594352	0.860766	0.781874
2013	0.872832	0.110152	0.872062	0.104764	0.855304	0.773318	2.5487E+12	0.599311	0.857757	0.777161
2014	0.847889	0.226102	0.874995	0.125282	0.84501	0.757191	2.612252	1.962548	0.855907	0.774262

In **Table 6**, the smaller the scale elasticity value (upper bound) is, the closer it is to the upper limit of the sample DMU production scale, and no other DMU scale is on top of it. The greater the scale elasticity value (lower bound) is, the lower the sample production scale will be; if there is a maximum value, the projection point of the DMU is at the lower limit of the sample production scale, and no other DMU scale is under it. According to the statistical value of **Table 6**, it is found that over the years, preschool education scale elasticity (above) is the biggest, which indicates under the circumstance that expenditure in other educational stages remains unchanged, increasing the amount of pre-school input alone will not lead to an increase in the output of basic education. According to the scale elasticity (lower bound) value in each stage of education, it is found that the junior high school stage has the lowest value over the years, which shows increasing the expenditure of junior middle school can maximize the expenditure performance of the whole elementary education. Therefore, on the basis of the analysis of elasticity of scale, it is believed the input scale of educational expenditure in junior middle school should be strengthened.

### DISCUSSION AND CONCLUSION

Since 2012, the national financial education expenditure accounted for 4% of GDP, expenditure on basic education has been greatly improved. However, from the point of view of the performance evaluation results, the overall performance level has not improved, which is caused by the combined effects of various factors. First of all, China's population birth rate has declined, which constitutes the basic supply structure of China's basic education and education. In this context, the number of enrolled students and the number of students at school in each stage of basic education also declined. Secondly, the problem of resource balance is one of the reasons for the decline of the basic education expenditure performance. Compared with the higher education, the financial expenditure of basic education depends more on the level of local economic development, and the mobility of students is small. Thirdly, although in recent years, the country's input in education has gradually tilted to the field of basic education, the national input in training a junior high school student and a college student is 9,258 yuan and 15,592 yuan respectively, which shows that input in basic education is still weak. Finally, the problem of left-behind children and the phenomenon of younger students studying abroad is also an aspect affecting the development level of basic education.

In this paper, through the calculation of the comprehensive technical efficiency, pure technical efficiency, scale efficiency, scale income and scale flexibility index of the financial expenditure of basic education, it is considered in the input structure of basic education, raising the amount of input in junior middle school can

improve the expenditure performance of the whole basic education better than the other three stages. At the same time, in the way of basic education input, improving the quality of resource allocation of input factors can improve the performance of basic education expenditure better than simply increasing the scale of input factors. Therefore, the performance of fiscal expenditure can be improved by optimizing the input structure of the financial expenditure and the matching quality of resources in the basic education stage.

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