Research on the Measurement and Influencing Factors of Vocational Skills Training Efficiency in China

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Abstract

Large-scale vocational skill training is an inevitable requirement for China's economy and society to enter the stage of high-quality development. It is of great practical significance to study the training efficiency of the three training subjects in China. Based on the provincial panel data from 2009 to 2018, the Three-stage DEA method is used to measure the training efficiency of private vocational training institutions, technical schools, and employment training centers in 29 provinces and cities in China (excluding Shanghai and Tibet with severe lack of data), and analyze the impact of environmental factors on regional training efficiency. The research shows significant regional differences in training efficiency among training subjects when considering environmental factors and random errors. Moreover, the comprehensive efficiency of the western region is higher than that of the central and eastern regions; the training efficiency of technical schools is the highest, and the employment training center is the lowest. Finally, suggestions are put forward from the aspects of improving the strategic position of vocational skills training, increasing and balancing the support of different training subjects and different provinces and cities, to promote the improvement of training efficiency and realize the better development of vocational skills education in china.

Keywords: vocational skills training; efficiency; three-stage DEA model

1. INTRODUCTION

The report of the 19th National Congress of the Communist Party of China pointed out that China's economy is at the stage of transformation from high-speed growth to high-quality development. It is an inevitable requirement to carry out vocational skills training on a large scale during the current period of significant strategic opportunity [2]. With the rapid development of network information technology, intelligent technology is rapidly creating a new economy and occupations while also putting forward higher requirements on the comprehensive quality and structure of labor force occupations [1]. At the same time, China has abundant labor resources, but the quality of labor is low and thus does not match the employment demand. Therefore, improving the vocational skills training system can better develop human resources and facilitate workers receiving standardized and professional vocational training in the increasingly difficult employment situation.

In recent years, China's vocational training has been developing, accompanied by increasing policy support

(Hu 2016). However, whether it is general vocational skills training or government-subsidized vocational skills training, the proportion of trainees completing the training and vocational skills identification shows a decreasing trend. Thus, how to improve the efficiency of vocational training is an issue worthy of in-depth study. This paper conducted a detailed comparative analysis of the training efficiency of 29 provinces (excluding Shanghai and Tibet, where data are seriously missing) from 2009 to 2018 through a three-stage DEA model (The data from China Labor Statistical Yearbook, China Education Yearbook, and provincial statistical yearbooks). Hopefully, the present work will assist in enriching relevant research and help formulate and optimize the vocational skills training policies in China.

2. LITERATURE REVIEW

The current research on vocational education mainly includes the influencing factors of vocational education development, and the measurement of vocational skills training efficiency. In terms of influencing factors of vocational education development, He and Wang suggest

that the quantity, structure and quality of the population will have an important impact on the quality and scale of vocational education [3]. Tang believe that policy has a guiding role in the internal construction of vocational education [7]. Xu, Pan and Yang conclude that vocational education strongly correlates to economic development through empirical studies [5]. Regarding measuring the VSTE, Li used the DEA model to conclude that financial subsidies are more efficient in the western region. However, there is also variability inefficiency in different regions due to regional and demographic factors [4]. Wang used the DEA-Tobit two-stage model to measure the VSTE for migrant workers in China and found significant differences in training efficiency among different provinces [8]. Shi used the DEA model to analyze the effect of training subsidies of private vocational skills training institutions in each province and concluded that there are significant differences in the effect of subsidies of training institutions in each province [6].

The research above shows that vocational training has been paid more attention in China, but few studies on VSTE. Therefore, this paper analyzes the vocational training efficiency of three major training subjects (private vocational training institutions, technical schools, and employment training centers) in China based on relevant excellent research results through the three-stage DEA model. And then, some policy recommendations were provided to improve the efficiency and system of the vocational skills training in China.

Compared with previous studies, the innovations of this paper include i) the three major training subjects are used as the research objects to analyze the differences in training efficiency of different training subjects and different regions in China; ii) the three-stage DEA model is chosen to measure the overall VSTE in China from 2009-2018, excluding the influence of environmental factors; iii) the Tobit regression model was used to analyze the influencing factors of training efficiency in different regions.

3. STUDY DESIGN

3.1. Research Methodology

The data envelopment analysis (DEA) is an analytical method through multiple input-output indicators, which uses linear programming to evaluate the relative effectiveness of comparable similar decision units. The third-order DEA model considers the influence of environmental factors and random noise on the efficiency evaluation of decision units not considered in the traditional DEA model.

Stage I: The initial efficiency is evaluated based on the raw input and output data. The input-oriented BCC model is chosen in most studies that use a three-stage

DEA model. For any decision unit (DUM), it can be expressed as

$$
\text{s.t.} \begin{cases} min\theta\text{-}\varepsilon(\, \hat{e}^T S^- + e^T S^+) \\ \sum_{j=1}^{n} X_j \lambda_j + S^- = \theta X_0 \\ \sum_{j=1}^{n} Y_j \lambda_j - S^+ = Y_0 \\ \lambda_j \geq 0, S^-, S^+ \geq 0 \end{cases}
$$

Where j=1,2,......,n is the decision unit and X and Y represent the inputs and outputs.

If $\theta = 1$, $S^- = S^+ = 0$, it means that the DUM is fully DEA valid.

If $\theta = 1$, $S^- \neq 0$ or $S^+ \neq 0$, it means that the DUM is weakly DEA valid.

If $\theta < 1$, it means that the DUM is invalid.

The combined technical efficiency value (TE) is derived from the BCC model, and TE is the product of pure technical efficiency (PTE) and scale efficiency (SE) (TE = PTE * SE).

Stage 2: This phase focuses on the slack variables because such slack variables can reflect the initial efficiency and consist mainly of environmental factors, managerial inefficiency, and statistical noise. The main goal of the second stage is to decompose the slack variables of the first stage into the above three components.

Stage 3: The adjusted input-output variables are applied to measure the efficiency of each decision unit again, which is true and accurate at this time because the effects of environmental factors and random factors have been removed.

3.2. Data Sources

This study analyzes the training efficiency of three training subjects in 29 provinces and cities from 2009 to 2018. The data of input-output indicators involved in this paper are obtained from the comprehensive situation of private vocational training institutions, technical schools, and employment training centers in the China Labor Statistics Yearbook. The data of environmental variables are obtained from the China Education Statistics Yearbook and the statistical yearbooks of provinces and cities.

3.3. Construction of Indicators

This paper mainly considers the input indicators from three aspects: material, human, and financial resources. Three indicators are used namely the number of institutions (X1), the number of the school staff (including concurrent teachers) (X2) and per capita

training expenses (X3). The larger the indicator, the better the development of vocational training in the province. The output indicators in this paper mainly consider the employment situation and certificate acquisition situation after training, mainly including the employment rate of trainers (Y1) and the acquisition rate of certificates (including junior, intermediate, senior, technician and senior technician) (Y2).

The training environment factors mainly include economic factors, educational factors and political factors, which corresponding environmental variables are GDP per capita, years of education per capita, and the percentage of gross tertiary industry of each province, respectively. Firstly, GDP per capita reflects the level of economic development of a region, and economic development brings more employment opportunities, which will interact with the willingness and efficiency of training in the region [10]. Secondly, years of education per capita affect training efficiency, and the more educated individuals are more willing to improve themselves. Similarly, the level of education of an individual facilitates his or her access to vocational training [11]. Finally, the share of gross domestic product in the tertiary sector also affects training efficiency in

each province, as the tertiary sector predominates in the types of training offered in each province.

4. EMPIRICAL ANALYSIS

This paper provides a detailed analysis of efficiency values at different stages based on input-output index data and environmental variables for 29 provinces from 2009 to 2018 in China using DEAP 2.1 software. The efficiency differences of training among different institutions and inter-provincial have been analyzed. Moreover, this paper divides these provinces into three parts, namely, eastern, western, and central, based on administrative regions, further to analyze the differences in training effects across regions.

4.1. The Calculation Results of Traditional DEA

Without considering the influence of environmental variables and random factors, the DEAP2.1 software is used to calculate the input-output indicators of training efficiency of training institutions in 29 provinces and cities in China, and the results are shown in Table 1 and 2.

Table 1 Training efficiency of provinces

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Nation-wide	0.637	0.658	0.733	0.611	0.653	0.567	0.575	0.628	0.674	0.590
Eastern	0.595	0.619	0.658	0.574	0.601	0.557	0.550	0.576	0.602	0.600
Western	0.724	0.749	0.814	0.697	0.668	0.579	0.622	0.713	0.734	0.676
Midland	0.593	0.605	0.727	0.563	0.689	0.563	0.554	0.594	0.686	0.493

Table 2 Training efficiency of training institutions

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Nation-wide	0.637	0.658	0.733	0.611	0.653	0.567	0.575	0.628	0.674	0.590
Eastern	0.476	0.706	0.752	0.611	0.725	0.606	0.598	0.721	0.585	0.718
Western	0.753	0.663	0.732	0.670	0.674	0.550	0.766	0.749	0.768	0.603
Midland	0.683	0.605	0.716	0.553	0.560	0.544	0.362	0.414	0.670	0.448

Due to space constraints, the specific data of provinces are not listed. When the effects of environmental variables and random factors are not considered, the average overall efficiency value of private vocational skills training institutions, technical schools, and employment training center in China from 2009-2018 is 0.644, 0.694 and 0.562, respectively. The overall efficiency of technical schools is the highest, while the employment training center is the lowest. The efficiency values of all three types of training subjects in 29 provinces and cities are not 1, which means none of them are on the technological frontier side and indicates the management efficiency and scale efficiency should be improved in China. This result also indicates that the

training effect of China's current vocational training system is not optimistic and requires corresponding measures. Additionally, the western region has the highest overall training efficiency. In contrast, the eastern and central regions have lower overall efficiency, which was lower than the national average.

4.2. Analysis of SFA Regression Results

The slack variables of the original input indicators in the first stage were used as the explanatory variables. The GDP per capita, years of education per capita, and the share of gross tertiary industry in each province and city were used as explanatory variables in the SFA regression. The results are shown in the Table 3.

Table 3 SFA results in the second stage

Explanatory Variable	Explained Variable		
	Number of Institutions	Number of In-Service Faculty	Personal Training Funds
Constant Term	6.01E+02***	1.12E+04***	5.36E+02***
GDP Per Capita	1.49E+00	3.02E+00*	8.33E+00***
Average Schooling Years	-3.76E+01***	-1.02E+03**	-4.00E+01***
Proportion of GDP of Tertiary Industry	-8.87E+00***	-1.40E+02***	-1.25E+01***
Sigma-Squared	2.27E+05	1.20E+08	6.12E+05
gamma	0.99E+00	0.98E+00	0.99E+00
LR	1.54E+01	1.47E+01	2.40E+01

Note: * means significant at the 10% confidence level, * * means significant at the 5% confidence level, * * * means significant at the 1% confidence level of the coefficient

As shown in Table 5, the LR values all pass the 1% significance test. The regression coefficients of the three types of environmental variables on the input slack variables can pass the test at 10%, 5%, or 1% significance level, indicating that external environmental factors greatly influence the input slack variables of training institutions in all provinces of the country. The regression results show that: i) the coefficient of the effect of GDP per capita on all three types of inputs is positive, meaning that the higher the GDP per capita, the larger the slack variable and the more money is wasted. The reason may be that the increase of GDP will lead to a decrease in resource allocation efficiency, and too much input will instead cause the waste of resources, which will reduce the training efficiency [9]. ii) The coefficient of the effect of years of education per capita on the three types of inputs is primarily negative, implying that the higher the education level, the smaller the slack variable. The increase of education level can make people have a stronger sense of learning. iii) The ratio of tertiary GDP to total output value has a negative coefficient of influence on all three types of inputs, implying that the higher the proportion of tertiary GDP to the total, the smaller the slack variable and the more effectively the funds can be used. The provinces and cities provide training jobs mainly in the service industry, so the higher the ratio of tertiary GDP to total output, the more

effectively the invested resources can be utilized.

4.3. Input-adjusted DEA Empirical Analysis

After excluding the effects of the external environment and random factors, the adjusted inputs were used to measure the training efficiency of the three types of training institutions in 29 provinces and cities in China again using DEAP2.1 software, and the results are shown in Table 4.

Table 4 Average training efficiency of training institutions after adjustment from 2009 to 2018

Region	Area	Private Vocational Skills Training Institutions		Technical School		Employment Training Center	
		TE	Improved Rate	TE	Improved Rate	TE	Improved Rate
Eastern	Beijing	0.554	3.57%	0.848	48.16%	0.905	-1.90%
	Tianjin	0.806	-8.68%	1.000	1.62%	0.966	0.86%
	Hebei	0.708	12.09%	0.611	12.35%	0.861	13.09%
	Liaoning	0.525	1.33%	0.450	18.44%	0.595	34.62%
	Jiangsu	0.346	-22.35%	0.508	8.04%	0.449	14.23%
	Zhejiang	0.601	-1.57%	0.426	6.32%	0.611	45.01%
	Fujian	0.684	31.82%	0.776	-2.01%	0.880	14.41%
	Shandong	0.475	24.07%	0.501	15.18%	0.329	14.94%
	Guangdong	0.292	3.95%	0.548	18.06%	0.275	25.78%
	Hainan	0.882	-3.56%	0.968	-0.54%	0.985	10.59%
Western	Sichuan	0.464	50.39%	0.691	6.65%	0.477	26.90%
	Chongqing	0.623	-9.96%	0.913	-2.71%	0.804	10.51%
	Guizhou	0.853	47.90%	0.597	-7.60%	0.627	20.63%

	Yunnan	0.866	48.53%	0.895	0.46%	0.655	30.07%
	Shaanxi	0.765	22.80%	0.812	18.64%	0.429	32.85%
	Gansu	0.921	5.70%	0.866	-0.29%	0.614	21.33%
	Qinghai	0.963	0.28%	0.819	-12.62%	0.932	2.08%
	Ningxia	0.879	4.54%	0.903	2.38%	1.000	0.00%
	Xinjiang	0.942	1.78%	0.571	11.21%	0.727	25.58%
	Guangxi	0.859	27.12%	0.908	7.13%	0.680	31.03%
	Inner Mongolia	0.805	23.56%	0.590	0.56%	0.803	69.97%
Central	Shanxi	0.772	31.66%	0.867	14.30%	0.437	33.52%
	Jilin	0.696	-8.57%	0.793	13.40%	0.749	21.52%
	Heilongjiang	0.871	4.49%	0.715	9.83%	0.515	34.88%
	Anhui	0.727	31.67%	0.613	2.54%	0.670	30.38%
	Jiangxi	0.863	34.53%	0.773	5.73%	0.660	17.12%
	Henan	0.534	1.33%	0.727	4.02%	0.558	16.28%
	Hubei	0.698	20.51%	0.828	7.66%	0.574	16.85%
	Hunan	0.771	25.71%	0.845	10.69%	0.506	19.58%
Mean		0.713	11.99%	0.737	7.50%	0.665	21.82%

Compared with the first and third stages, the influence of the external environment and random error, the efficiency values of most provinces and cities have changed significantly after excluding when each decision unit is in the same external environment. From the national average, the efficiency values of private vocational training institutions, technical schools and employment training centers in China increased slightly, from 0.664, 0.694 and 0.562 to 0.713, 0.737 and 0.665, respectively. In addition, the efficiency values increased in most provinces. Therefore, external factors such as the social environment can cause the traditional DEA method to underestimate the overall efficiency level. The overall efficiency of a few provinces and cities has decreased to varying degrees, indicating that their training efficiency is also disturbed by environmental factors, and excluding the influence of these factors exposes their training problems.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

This paper evaluates the training efficiency of various training institutions in 29 provinces in China through a three-stage DEA model and draws the following conclusions.

1. The overall training efficiency of China's vocational training institutions is not high enough, and the overall efficiency still has more room for improvement. Among them, technical schools are the most efficient, employment training centers are the least efficient.

2. The results of the second-stage SFA regression show that there is a negative impact of GDP per capita on institutional training efficiency. That is, the higher the GDP per capita, the redundancy of training input increases instead, which is not conducive to improving training efficiency; the years of education per capita and the ratio of the gross tertiary industry to total output value have a positive impact on institutional training efficiency, which are favorable factors and conducive to training efficiency.

3. After excluding the effects of external environmental factors and random errors, the efficiency of vocational training institutions in each province has changed to different degrees, indicating that these external environmental variables have an important impact on training efficiency. In addition, after excluding environmental factors, the training efficiency of most provinces increased, which shows that the traditional DEA model can underestimate the training efficiency of vocational training institutions in China.

5.2. Recommendations

1. Promote the strategic position of vocational skills training

A significant gap in efficiency among provinces and cities in various regions caused by most provinces failed to understand the significance and importance of vocational training objectively. In order to improve the quality of workers and promote the development of employment, entrepreneurship and economic society, the

importance and necessity of vocational skills training should be taken seriously. Moreover, vocational skills training should be essential for building a new development pattern.

2. The government increases and balances different training subjects and different provincial and municipal support efforts

The training efficiency in different regions shows different trends again, with higher financial subsidies in remote regions such as Ningxia and Qinghai. The study found that their training efficiency is also high, while on the contrary, the training efficiency in economically developed regions such as Guangdong and Jiangsu is lower than the national average. They are all in the state of incremental scale efficiency, indicating that the investment in these regions is not enough, so the government needs to support and guide.

3. Integrated construction of diversified training system

Combined with relevant statistics, it is found that the training base of private vocational training institutions is significant, but the training efficiency is low. Technical schools have a small training base, but the highest percentage of the trained population obtains advanced certificates. The training base of employment training centers decreases year by year, but the rate of obtaining primary certificates for the trained population is high, which indicates that different training subjects have different training objectives and willingness. Therefore, in order to build and improve China's vocational education system, the government should take market demand as the guide, effectively integrate and guide all kinds of training subjects to form a situation that complements and promotes each other.

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