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Research on the Efficiency of China's Higher Education System Based on the Three-Stage DEA Model

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Abstract

With the development of China's higher education shifts from the total contradiction to the structural contradiction, it is important to evaluate and improve the efficiency of the higher education system. Based on the three-stage DEA model, we take the higher education system of 31 provinces across the country as the research object, use the data from 2014 to 2018 to evaluate the efficiency of China's higher education system, and obtain the comprehensive efficiency, pure technical efficiency, as well as scale efficiency. Secondly, we analyze the slack variables of the input indicators, remove the influence of environmental factors and random interference, and get the slack variables that are only affected by the management inefficiency. Finally, by combining slack variables, suggestions for improvement from various efficiency perspectives and regional distribution perspectives are proposed. The paper aims to help solve the problems of unreasonable regional allocation of higher education resources and low resource management efficiency, and promote the development of higher education from quantitative to structural transformation.

Keywords

Higher Education System, Three-Stage DEA Model, Efficiency

1. Introduction

With the advancement of China's education system, there is an increasing demand for higher education resources among individuals. The focus has shifted from quantity to quality, necessitating not only access to higher education but also its diversification and intellectual development. Therefore, conducting an analysis on the efficiency of China's higher education system and proposing improvement suggestions in light of relevant shortcomings would contribute to enhancing the rational allocation of educational resources across regions and improving overall service efficiency. Salerno (2003) summarized two commonly used models for evaluating the efficiency of higher education systems: one is a parametric stochastic frontier tool model, and the other is a non parametric data envelopment analysis model. Given that the higher education system is a dynamic entity characterized by complex changes involving multiple inputs and outputs, traditional parametric analysis methods are inadequate for assessing its efficiency. Hence, this study considers employing a nonparametric three-stage DEA analysis method to evaluate the effectiveness of China's higher education system. When the three-stage DEA model is used to analyze the efficiency of China's higher education system, it is only necessary to determine the input and output indicators that can reasonably represent the decision-making unit and the environmental variables that affect it from the perspective of the most favorable decision making unit. Colbert et al. (2000) evaluated the curriculum planning of 24 American universities in 1997, taking the ratio of teachers to students in school, the number of elective courses and the average score of postgraduate entrance examination as input variables, and the satisfaction degree of students and enterprises with schools and the employment rate of graduates as output variables. The end result is that most schools have a high level of efficiency. Johnes and Johnes (1995) combined the stochastic frontier model in the parametric analysis method with the DEA analysis method in the non-parametric method to conduct efficiency analysis on the performance of British higher education universities. Xue and Chen (2015) took 16 universities with doctoral programs in Jiangsu Province, China as research objects, selected the number of active teachers, input funds, and campus area as input indicators, and selected the number of students, funded projects, and published papers as output indicators. Taking economic development level and residents' education level as environmental variables, three-stage DEA method and Malmquist index method were used to study the efficiency of 16 higher education schools in Jiangsu Province from 2009 to 2013. Shen and Gong (2013) analyzed the efficiency of higher education in a single province in China. Yuan Wei's (2013) team conducted a study on the school-running efficiency of 72 universities directly under the Ministry of Education in 2011. Wang et al. (2020), Zhong and Chen (2018), He and Zhang (2019), Yang and Liu (2011), Li and Cui (2011) and others evaluated the efficiency of scientific and technological innovation in Chinese universities.

The studies of the above scholars are of great help for us to analyze the efficiency of the higher education system, but most of the studies are on the efficiency of the higher education system in a certain province, and there are few studies on the efficiency of China's higher education system. When evaluating the efficiency of decision-making units using the three-stage DEA model, the influence of environmental factors and statistical noise on the decision-making units is eliminated, so that the obtained efficiency values are more in line with the actual efficiency values, making it easier for us to provide more accurate improvement suggestions for the decision-making units. The traditional DEA model is used to evaluate the efficiency of higher education system without eliminating the influence of environmental variables and statistical noise. Therefore, this paper chooses the three-stage DEA model to evaluate the efficiency of the national higher education system.

2. Data Sources and Research Methods

2.1. Construction of Index System and Selection of Variables

The input of the higher education system mainly consists of human input, material input, financial input and intangible asset input. When evaluating the efficiency of the higher education system, considering the availability of data, this paper selects three indicators as input indicators: the number of full-time teachers, the number of schools and science and technology funds. The output of higher education system is mainly composed of personnel training, scientific research output and social output. Considering the availability of data, this paper selects the number of students in school, the number of published papers and the number of scientific and technological projects as output indicators. Previous studies have determined environmental variables from the aspects of per capita GDP, urbanization rate, fiscal decentralization, fixed asset investment, etc. This paper selects three most representative indicators, which are per capita GDP reflecting the economic level of each province, urban population density reflecting the social development level of each province, and education expenditure reflecting the attitude of each provincial government towards the construction of higher education system.

The data collected in this paper come from the regional annual data of the National Bureau of Statistics, the Ministry of Education of the People's Republic of China, the Compilation of Scientific and Technological Statistics of Colleges and Universities, and the China Education Statistical Yearbook, etc., and the relevant data of the higher education system of 31 provinces in China are selected. The 31 provinces were divided into the eastern region (Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan), the central region (Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan) and the western region (Sichuan, Chongqing, Guizhou, Yunnan, Xizang, Shanxi, Gansu, Qinghai, Ningxia, Xinjiang, Guangxi, Inner Mongolia) .

2.2. Construction of Three-Stage DEA Model

Fried et al. (1999) pointed out that the traditional DEA model did not take into account the impact of environmental factors and statistical noise on DUS when evaluating Decision making unit (DMU), so the efficiency value obtained was somewhat different from the actual efficiency value of DMU. Based on this, Fried et al. (2002) proposed a three-stage DEA model. When evaluating the efficiency of DMU, this model will eliminate the influence of environmental factors and statistical noise on DUS, so that the obtained efficiency value is more in line with the actual efficiency value of DMU. This paper takes the higher education system of 31 provinces in China as the observation object, considers the completeness and easy access of the data, selects the data from 2014 to 2018, and calculates the mean value as the initial input-output and environmental factor data for the following analysis.

The first stage: Using the traditional DEA model to analyze the initial efficiency of DMU and calculate the relaxation variables of the input

CCR model is used to evaluate the efficiency of DMU when assuming constant returns to scale. BCC model is used to evaluate the efficiency value of DMU when assuming variable returns to scale. Since the return to scale of input-output in China's higher education system is variable, we choose the BCC model for the first stage of analysis. Secondly, since the resources of higher education are limited, we should use input-oriented approach in our analysis. To sum up, in the first stage, we use the input-oriented BCC model to analyze the efficiency of the higher education system in 31 provinces in China.

The second stage: Use SFA regression to eliminate the impact of environmental factors and statistical noise on DUS and calculate the adjusted input value.

The relaxation variable of input calculated in the first stage is the improvement space of DMU, which is composed of environmental factors, statistical noise and management inefficiency. In the second stage, we will decompose the relaxation variable into these three parts, so as to eliminate the influence of environmental factors and statistical noise on the decision unit, leaving only the management inefficiency term. Slack variables of the three input indicators of full-time teachers, schools and science and technology funds calculated in the first stage were respectively taken as explained variables, and GDP per capita, urban population density and education fund expenditure were taken as explanatory variables. Frontier 4.1 software was used for analysis. According to Fried et al. (2002), we construct the SFA regression function to measure the efficiency of our higher education system:

$$S_{ni} = f\left(Z_i;\beta_n\right) + \nu_{ni} + \mu_{ni}; i = 1,2,\cdots,I; n = 1,2,\cdots,N \quad (1)$$

where, S_{ni} is the relaxation value of the n input of the i decision unit; Z_I is the environment variable and β_n is the coefficient of the environment variable, $f^n\left(Z_I;\beta_n\right) = \beta_0 + \beta_1 \cdot Z_1 + \beta_2 \cdot Z_2 + \beta_3 \cdot Z_3 f^n\left(Z_I;\beta_n\right) = \beta_0 + \beta_1 \cdot Z_1 + \beta_2 \cdot Z_2 + \beta_3 \cdot Z_3$ is the influence value of environmental factors on the input of item n of decision unit i; $V_{ni} + \mu_{ni}$ is the mixed error term, V_{ni} represents the random interference value, and represents the influence of random interference factors on the input relaxation variables. U_{ni} represents the management inefficiency value and represents the influence of management factors on the input relaxation variable. The generally recognized formula of Chen et al. (2014) was adopted to calculate the management inefficiency item, as follows:

$$E\left(\mu\middle|\varepsilon\right)=\sigma_*\left[\frac{\phi\left(\lambda\frac{\varepsilon}{\sigma}\right)}{\Phi\left(\frac{\lambda\varepsilon}{\sigma}\right)}+\frac{\lambda\varepsilon}{\sigma}\right] \tag{2}$$

Here,

$$\sigma_*=\frac{\sigma_\mu\sigma_v}{\sigma},\sigma=\sqrt{\sigma_\mu^2+\sigma_v^2},\lambda=\sigma_\mu/\sigma_v$$

Next, the influence of environmental factors and statistical noise on DUS is removed, and the new input variables that only manage the influence of inefficiency items after adjustment are obtained. The adjustment formula is as follows:

$$X_{ni}^{A}=X_{ni}+\left[\max\left(f\left(Z_i;\hat{\beta}_n\right)\right)-f\left(Z_i;\hat{\beta}_n\right)\right]+\left[\max\left(\nu_{ni}\right)-\nu_{ni}\right]$$

$$i=1,2,\cdots,I;n=1,2,\cdots,N$$

where, X_{ni}^{A} is the input of the n item of the i decision unit after adjustment; X_{ni} is the input of item n of decision unit i before adjustment; $\left[\max\left(f\left(Z_I;\beta_n\right)\right)-f\left(Z_I;\beta_n\right)\right]$ is to adjust the corresponding environmental factors of all decision-making units; $\left[\max\left(\left(V_{ni}\right)-V_{ni}\right)\right]$ is to adjust the random disturbance terms of all decision units.

The third stage: the adjusted input value and the original output value are analyzed by the traditional DEA model again

In the second stage, the new input value is obtained, which excludes the influence of environmental factors and statistical noise on DUS. The adjusted input value and the original output value are analyzed again using the traditional DEA model for efficiency analysis. At this time, the obtained result excludes the influence of environmental factors and statistical noise on DUS, and the calculated result only reflects the management inefficiency of DUS. More in line with reality.

3. Empirical Analysis and Results

3.1. DEA Analysis in the First Stage

Considering only six input-output indicators including the number of students, the number of published papers, the number of science and technology projects, the number of full-time teachers, the number of schools, and the amount of science and technology funds, DEAP2.1 software was used to analyze the efficiency of the higher education system in 31 provinces of China, as shown in Table 1. Among the results obtained, 14 provinces, including Beijing, Inner Mongolia, Jilin, Shanghai, Zhejiang, Henan, Guangdong, Guangxi, Hainan, Sichuan, Guizhou, Gansu, Ningxia and Xinjiang, reached the technology effective state. Other provinces have room for improvement. The average comprehensive efficiency of the higher education system in China's provinces is 0.964, the average pure technical efficiency is 0.983 and the average scale efficiency is 0.981.

Table 1. Comprehensive efficiency and efficiency breakdown of higher education system in 31 provinces and cities of China.

Region	Comprehensive efficiency (CE)	Pure Technical Efficiency (PTE)	Scale efficiency(SE)	return to scale
Beijing	1	1	1	-
Tianjin	0.958	0.964	0.994	irs
Hebei	0.91	0.941	0.968	drs
Shanxi	0.94	0.953	0.987	drs
Inner Mongolia	1	1	1	-
Liaoning	0.914	0.915	0.999	drs
Jilin	1	1	1	-
Heilongjiang	0.938	0.938	1	-
Shanghai	1	1	1	-
Jiangsu	0.98	1	0.98	drs
Zhejiang	1	1	1	-
Anhui	0.99	0.994	0.996	drs
Fujian	0.977	0.992	0.984	drs
Jiangxi	0.919	0.936	0.982	drs
Shandong	0.998	1	0.998	drs
Henan	1	1	1	-
Hubei	0.988	1	0.988	drs
Hunan	0.989	1	0.989	drs
Guangdong	1	1	1	-
Guangxi	1	1	1	-
Hainan	1	1	1	-
Chongqing	0.968	0.974	0.994	irs
Sichuan	1	1	1	-
Guizhou	1	1	1	-
Yunnan	0.929	0.934	0.995	drs
Xizang	0.711	1	0.711	irs
Shaanxi	0.973	0.977	0.997	irs
Gansu	1	1	1	-
Qinghai	0.812	0.963	0.843	irs
Ningxia	1	1	1	-
Xinjiang	1	1	1	-
Average	0.964	0.983	0.981	

3.2. The Second Stage of SFA Regression Analysis

In the first stage, DEAP2.1 software was used to analyze the environmental efficiency of DUS without considering the impact of environmental factors and random noise, so the results we obtained were somewhat different from the real efficiency. Therefore, we added three environmental indicators, including per capita GDP, urban population density and education expenditure, and analyzed them using Frontier4.1 software. The SFA results are shown in **Table 2**.

Per capita GDP. As can be seen from **Table 2**, the regression coefficients of per capita GDP for the three input relaxation variables of the number of full-time teachers, the number of schools, and science and technology funds are all positive. It shows that provinces with higher per capita GDP have more full-time teachers, schools and science and technology funding resources, and to some extent, they are excessive. Too much resource investment is not fully utilized in time, thus lowering the efficiency of the whole province.

Population density. As can be seen from **Table 2**, the regression coefficients of population density for the three input relaxation variables of the number of full-time teachers, the number of schools, and science and technology funds are all positive. It shows that the higher the population density in the province, the greater the demand for higher education resources, in order to meet the needs of people, the corresponding increase in the number of full-time teachers, schools, science and technology funding resources investment. However, due to the increasing number of cross-provincial students, the cross-provincial flow of higher education resources is increasing. If higher education resources are not properly allocated in a timely manner, there will be a mismatch between the input and demand of higher education resources in each province, thus reducing the efficiency of higher education in the province.

Government funding for education. As can be seen from **Table 2**, the regression coefficients of government education funds for the three input relaxation variables of the number of full-time teachers, the number of schools, and the science and technology funds are all negative. It shows that the investment of government education funds is helpful to improve the efficiency of higher education in this province. The increase of government education funds has further

Table 2. Estimated results based on the second phase of SFA.

	Number of full-time teachers	number of schools	science and technology funds
Constant term	−975.22	−3250.49	−13731.59
Per Capita GDP	0.02	0.07	0.43
urban population density	0.24	0.75	3.21
educational fund	−0.17	−0.42	−3.47
sigma-squared	4614249.60	160813980.00	518027650.00
gamma	1.00	1.00	1.00
LR unilateral test	22.65	25.44	20.62

solved the problem of insufficient higher education resources, so that people can accept the welfare brought by national higher education to a greater extent, improve happiness, reduce the unreasonable distribution of higher education resources, promote the rational use of higher education resources, and thus improve the efficiency of the entire higher education system.

3.3. The Third Stage DEA Analysis

After the second stage of SFA regression analysis, we eliminate the influence of environmental factors and statistical noise on DMU efficiency. Get adjusted new data. The adjusted new data are used again to analyze the efficiency of higher education in 31 provinces of China by using DEAP2.1 software. As shown in **Table 3**, a total of 10 provinces in Beijing, Inner Mongolia, Shanghai, Zhejiang, Guangdong, Guangxi, Sichuan, Guizhou, Gansu, and Xinjiang have reached the technically effective state. It shows that the efficiency of higher education resources allocation in these 10 provinces is good, and the other provinces still have room for improvement. The average comprehensive efficiency, the average technical efficiency and the average scale efficiency of the higher education system are 0.959, 0.987 and 0.972 respectively.

3.3.1. Comprehensive Efficiency Analysis of Higher Education System in 31 Provinces

As shown in **Figure 1**, after removing environmental factors and random error, the average comprehensive efficiency of China's higher education system is 0.959, which is lower than the efficiency value of 0.964 when environmental factors and random error factors are not removed. The overall efficiency of eight provinces has declined, and Qinghai and Xizang, which are located in the western region, have experienced a large decline. It can be seen that if environmental factors and random error factors are not removed, the efficiency of some DMU is greatly affected. After adjustment, 11 provinces, including Beijing, Inner Mongolia, Shanghai, Zhejiang, Henan, Guangdong, Guangxi, Sichuan, Guizhou, Gansu and Xinjiang, reached the technically effective state. Compared with the provinces without removing environmental factors and random error factors, there are less Jilin, Hainan and Ningxia provinces. The comprehensive efficiency of Xizang, located in the western region, decreased from 0.711 to 0.549, and that of Qinghai decreased from 0.812 to 0.726, indicating that the original environmental factors in these two provinces greatly contributed to the improvement of their efficiency. After removing the environmental factors and random error factors, the efficiency value is much lower than the national average efficiency level. It shows that the original higher education resources in these two provinces are seriously insufficient. In the remaining provinces, the comprehensive efficiency of Liaoning, Jilin, Shandong, Hainan, Chongqing and Ningxia has decreased slightly. These provinces should improve the management ability of higher education system and the allocation ability of higher education resources to improve their comprehensive efficiency.

Table 3. Relative efficiency of China's higher education system before and after adjustment.

Region	First Stage				Third Stage			
	(CE)	(PTE)	(SE)	return to scale	(CE)	(PTE)	(SE)	return to scale
Beijing	1	1	1	-	1	1	1	-
Tianjin	0.958	0.964	0.994	irs	0.962	0.976	0.985	irs
Hebei	0.91	0.941	0.968	drs	0.919	0.938	0.98	drs
Shanxi	0.94	0.953	0.987	drs	0.961	0.964	0.997	irs
Inner Mongolia	1	1	1	-	1	1	1	-
Liaoning	0.914	0.915	0.999	drs	0.911	0.913	0.998	irs
Jilin	1	1	1	-	0.996	1	0.996	irs
Heilongjiang	0.938	0.938	1	-	0.949	0.953	0.997	irs
Shanghai	1	1	1	-	1	1	1	-
Jiangsu	0.98	1	0.98	drs	0.983	1	0.983	drs
Zhejiang	1	1	1	-	1	1	1	-
Anhui	0.99	0.994	0.996	drs	0.994	0.996	0.997	drs
Fujian	0.977	0.992	0.984	drs	0.986	1	0.986	drs
Jiangxi	0.919	0.936	0.982	drs	0.95	0.95	0.999	irs
Shandong	0.998	1	0.998	drs	0.992	1	0.992	drs
Henan	1	1	1	-	1	1	1	-
Hubei	0.988	1	0.988	drs	0.992	1	0.992	drs
Hunan	0.989	1	0.989	drs	0.997	1	0.997	drs
Guangdong	1	1	1	-	1	1	1	-
Guangxi	1	1	1	-	1	1	1	-
Hainan	1	1	1	-	0.971	1	0.971	irs
Chongqing	0.968	0.974	0.994	irs	0.965	0.975	0.99	irs
Sichuan	1	1	1	-	1	1	1	-
Guizhou	1	1	1	-	1	1	1	-
Yunnan	0.929	0.934	0.995	drs	0.938	0.943	0.995	drs
Xizang	0.711	1	0.711	irs	0.549	1	0.549	irs
Shaanxi	0.973	0.977	0.997	irs	0.981	0.986	0.995	irs
Gansu	1	1	1	-	1	1	1	-
Qinghai	0.812	0.963	0.843	irs	0.726	1	0.726	irs
Ningxia	1	1	1	-	0.999	1	0.999	irs
Xinjiang	1	1	1	-	1	1	1	-
Average	0.964	0.983	0.981		0.959	0.987	0.972	

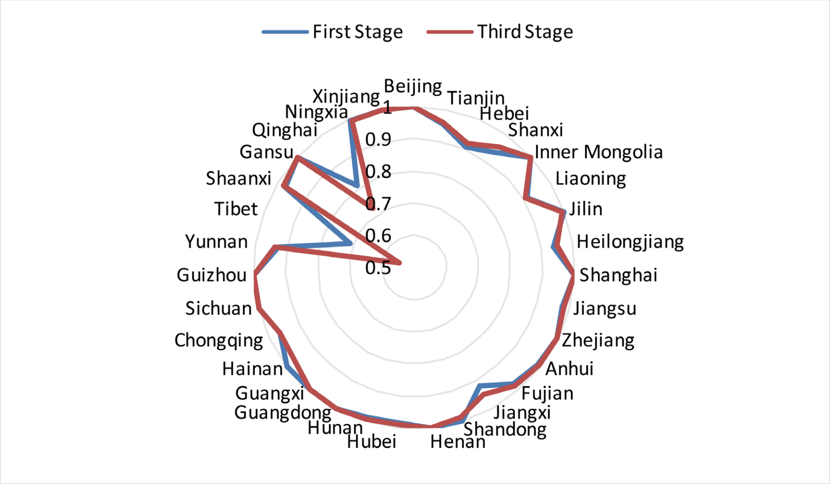

Figure 1. Overall efficiency diagram.

3.3.2. Pure Technical Efficiency Analysis of Higher Education System in 31 Provinces and Cities

As shown in Figure 2, the average pure technical efficiency of China's higher education system is 0.987, which is higher than the efficiency value of 0.983 when environmental factors and random error factors are not removed. Without removing environmental factors and random error factors, Beijing, Inner Mongolia, Jilin, Shanghai, Jiangsu, Zhejiang, Shandong, Henan, Hubei, Hainan, Guangdong, Guangxi, Hainan, Sichuan, Guizhou, Xizang, Gansu, Ningxia and Xinjiang are technically effective. After removing environmental factors and random error factors, two more provinces, Fujian and Qinghai, are technically effective. Among them, the efficiency of Qinghai province has improved the most, which indicates that the management technology level of the higher education system in Qinghai Province is high. The pure technical efficiency values of Hubei, Liaoning, Heilongjiang, Jiangxi and Yunnan are much lower than the national average, indicating that the management and technical level of the higher education system in these provinces needs to be improved.

3.3.3. Analysis of Scale Efficiency of Higher Education System in 31 Provinces and Cities

As shown in Figure 3, the average scale efficiency of China's higher education system is 0.972, which is lower than the efficiency value of 0.981 when environmental factors and random error factors are not removed. The scale efficiency values of Qinghai, Xizang and Hainan are lower than the national average, and the scale efficiency values of the remaining provinces are higher than the national average, indicating that except Qinghai, Xizang and Hainan, the other provinces have a good level of higher education resource allocation. Qinghai, Xizang and Hainan should strengthen the allocation of higher education resources, so as to improve the efficiency of the entire higher education system.

3.3.4. Regional Distribution of Higher Education System Efficiency

As shown in Table 4, after removing environmental factors and random error

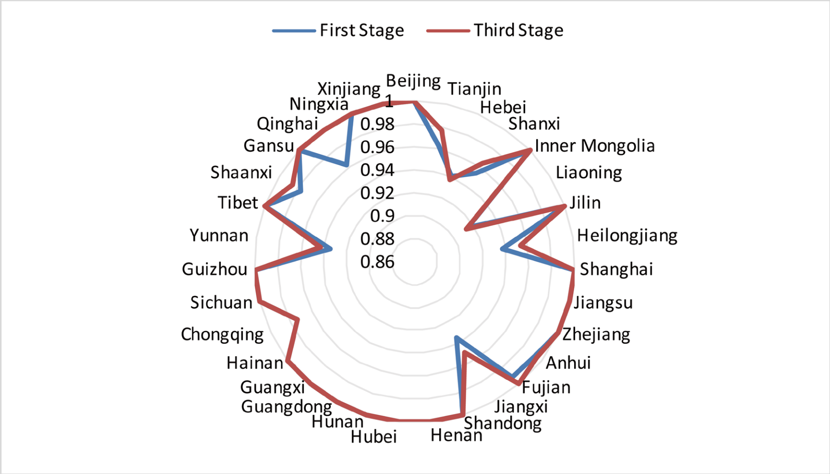

Figure 2. Pure technical efficiency diagram.

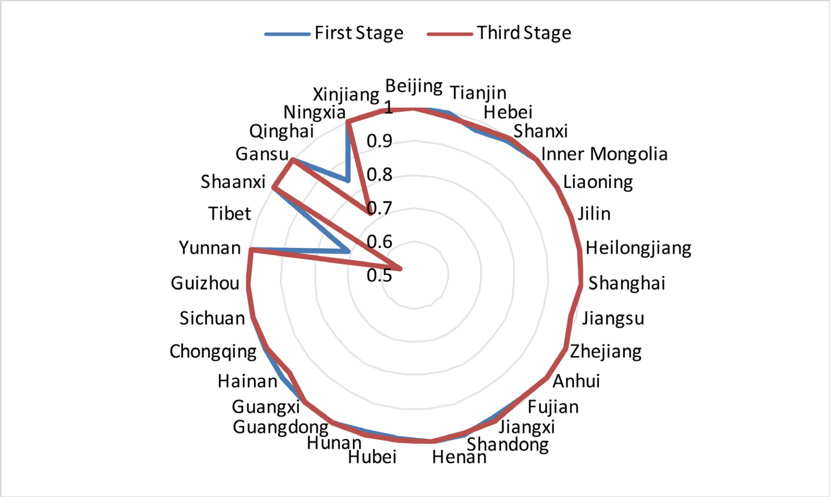

Figure 3. Scale efficiency diagram.

Table 4. Regional efficiency tables of higher education system in China.

	First Stage			Third Stage		
	(CE)	(PTE)	(SE)	(CE)	(PTE)	(SE)
Eastern area	0.9761	0.9829	0.9930	0.9749	0.9843	0.9905
Central area	0.9705	0.9776	0.9928	0.9799	0.9829	0.9969
Western area	0.9494	0.9873	0.9617	0.9298	0.9920	0.9378

factors, the efficiency of regional distribution of the efficiency of China's higher education system has significantly changed. The overall efficiency and scale efficiency of eastern and western regions have decreased to a certain extent, while the overall efficiency and scale efficiency of central region have increased to a certain extent. The pure technical efficiency increased after adjustment in the three regions. Before adjustment, the comprehensive efficiency value of the eastern region is slightly higher than that of the central region and much higher than that of the western region. The adjusted comprehensive efficiency value of the central region is reversed, and the central region is slightly higher than the eastern region and much higher than the western region. This indicates that the comprehensive efficiency value of the eastern region is somewhat high when environmental factors and random error factors are not removed. The pure technical efficiency value of western region is higher than that of central and eastern regions, but the scale efficiency value is much lower than that of central and eastern regions, which indicates that the low comprehensive efficiency of western region is mainly caused by the low level of higher education resources allocation in western region.

3.3.5. Distribution of Higher Education System Efficiency in 31 Provinces and Cities

As shown in Table 5, 11 of China's 31 provinces' higher education systems are in a state of constant scale efficiency. Although more provinces are in the stage of increasing scale efficiency, relatively few provinces have achieved technical efficiency. The higher education system still has room for improvement. Reasonable establishment of higher education system, reasonable distribution of higher education resources among regions, and improvement of management efficiency and technical level of higher education system are the directions for improvement.

4. Conclusion and Policy Recommendations

In order to avoid the impact of traditional DEA analysis tools that cannot eliminate environmental factors and statistical noise on efficiency evaluation, this paper uses three-stage DEA method to analyze the efficiency of higher education system in various provinces in China during 2014-2018. Considering that per capita GDP, urban population density, and education funding are the main factors affecting the quality of the higher education system, we put forward suggestions from the perspectives of efficiency and regional distribution. It is helpful to improve the management level of higher education system and the allocation level of higher education resources. In summary, the following conclusions and policy recommendations are drawn:

Without eliminating environmental errors and random factors, 14 provinces have reached the technically effective state. After eliminating environmental errors and random factors, only 10 provinces reached the technically effective

Table 5. Distribution of efficiency status of higher education systems in 31 provinces and cities in China.

	First Stage	Third Stage
Efficiency unchanged state	15	11
Efficiency increasing state	5	12
Efficiency decreasing state	11	8

state. It shows that environmental indicators will have a great influence on evaluating the efficiency of our country's higher education system. The three-stage DEA model is superior to the traditional DEA model to evaluate the efficiency of China's higher education system. The results measured by the three-stage DEA model are more in line with the real efficiency of China's higher education system.

In the SFA regression analysis, the impact of environmental factors and statistical noise is excluded, and per capita GDP, urban population density, and education funds all have an impact on the relaxation variables of the three input indicators: the number of full-time teachers, the number of schools, and the science and technology funds, which indicates that it is very necessary for us to carry out this step to make the results more realistic. Provinces with higher per capita GDP are richer in higher education resources, even more so to a certain extent. Therefore, in order to improve efficiency, the government and schools need to rationally allocate higher education resources to meet the balance between supply and demand as far as possible and promote development. The higher the population density of a city, the greater the demand for higher education resources, the government and schools should adapt to local conditions, find a higher education resources allocation scheme in line with the actual situation of the local, reasonable allocation of higher education resources. The relaxation variable coefficients of government education expenditure on the three inputs are all negative, indicating that increasing government education expenditure is helpful to improve the efficiency of higher education system. Of course, the more investment in education funds is not the better, but also the reasonable distribution of education funds among various provinces should be considered, in order to achieve the optimal overall efficiency of the country.

After excluding the impact of environmental variables and statistical noise, the comprehensive efficiency and scale efficiency of the western region are much lower than that of the eastern and central regions, but the pure technical efficiency of the western region is higher than that of the eastern and central regions. This shows that the western region should focus on improving the allocation level of higher education resources.

From a macro perspective, educational resources should be reasonably mobilized in each province; key support from relevant government education funds; the integration of relevant technology and education promotes the development of the higher education system. In order to solve the imbalance of regional distribution of China's higher education resources and improve the efficiency of China's higher education system, we should adapt to local conditions, fully understand the needs of all aspects of the higher education system according to the actual situation of each province, and dynamically adjust the higher education resources required by each province in combination with the needs of future development strategies. Strengthen the supervision of the higher education system, promote the rational allocation and efficient use of higher education resources, and avoid redundancy and insufficiency of higher education resources. Improve the training of staff in the higher education system, and continue to encourage high-level talent into the higher education system, so as to promote efficiency. Make full use of Internet technology, artificial intelligence technology, block chain technology and other technologies to constantly explore and strengthen the construction and innovative development of "Internet education" and "intelligent education" models, and guide the comprehensive and healthy development of China's higher education system.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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