An Empirical Study on the Development Efficiency and Influencing Factors - of Higher Education in China: Based on the ultra-efficient SBM-Malmquist-Tobit model

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Abstract. It is of great significance to scientifically evaluate the development efficiency of higher education in China to promote the balanced development of higher education in various regions. Based on the panel data of 31 provinces, municipalities and autonomous regions in China from 2012 to 2021, this study analyzes the development efficiency of higher education in China by using the ultra-efficient SBM-Malmquist model, and then constructs the higher education evaluation index system from the three dimensions of educational resources, educational effectiveness and educational opportunities, and uses the panel Tobit model to regress, the results show that the overall development efficiency of higher education in China has not yet reached the optimal level, and is greatly affected by the efficiency of technological progress. There may be problems with higher education development in places such as Inner Mongolia, Jiangxi and Hainan; The number of full-time teachers with doctoral degrees, the number of graduate students involved in scientific research, and the number of enrollments of their specialties in various regions affect the development efficiency of higher education in different places. Finally, this study puts forward corresponding policy recommendations according to the conclusions.

Key words: Higher education, development efficiency, Ultra-efficient SBM-Malmquist-Tobit model, Educational balance.

1. Introduction

Education is an important cornerstone of national rejuvenation and social progress, and an important force for inheriting human civilization and creating a better life. For example, the report of the 18th National Congress of the Communist Party of China clearly pointed out that education should be given priority and emphasized that education is the cornerstone of national rejuvenation and social progress; The report of the 19th National Congress of the Communist Party of China clearly pointed out that education must be given priority to development, and emphasized that strengthening the country through education is the basic project of the great rejuvenation of the Chinese nation[1]. The report of the 20th National Congress of the Communist Party of China clearly stated that education is the "great plan of the country" and "the great plan of the party", and once again emphasized the important strategic position and priority development position of education [2]. However, the uneven regional development of higher education is the reality in the development of higher education in China, which affects the realization of higher education functions and economic and social development to a certain extent. Therefore, this study has important practical significance for promoting the balanced development of higher education and the modernization process of education in China.

For the research on the development efficiency of national higher education, most of the research directions of scholars at this stage focus on the evaluation and influencing factors of national higher education efficiency, such as Xu Jian and Wang Xuhui [4] who used the DEA model to comprehensively evaluate the efficiency of higher education in 31 regions in China, and the results show that the overall level of higher education efficiency in China is not high, and the waste of resources invested in higher education is serious, and the management of scientific research funds should be strengthened and the number of administrative teaching and auxiliary staff should be controlled; Li Xiangyun [5] estimated the comprehensive efficiency of China's colleges and universities by constructing DEA and secondary relative efficiency models, and the results show that there are great differences between regional universities. Therefore, it is necessary to adopt the financial funding model, deepening the reform of the internal management system of universities, and strengthen efficiency evaluation. Zhao Yanzhi [6] used the Malmquist index to evaluate the productivity of higher education in 31 provinces, municipalities and autonomous regions in China from 2003 to 2008, and found that there were significant differences between regions and a significant negative correlation between scale expansion and technological progress. Wei Mei [7] used spatial econometric model to calculate the efficiency of higher education in China from 1995 to 2009, and found that the regional characteristics of higher education efficiency were significant. There was a negative spatial spillover effect on human capital, and regional economic growth had a positive effect. Yonghui and Han Qingfeng [8] evaluated the efficiency and productivity of higher education in 31 provinces in China based on the Hicks-Moorsteen total factor production index, and also found that there were significant differences between regions, and interregional cooperation and exchanges should be promoted. Yi Ming et al. [9] used the Window-Malmquist index method and spatial clustering method to analyze the input-output efficiency of higher education resources in China, and deeply explored the influence of spatial relationship on the input-output efficiency of higher education. Zhou Xiaogang, Lin Rui, Chen Xiao et al. [10] introduced three-stage DEA and super-efficiency DEA models to evaluate the efficiency of higher education in China, and found that the main factor affecting the comprehensive technical efficiency of higher education is scale efficiency. Luo Liqun and Gao Wanyu [11] evaluated the development efficiency of higher education in 31 provinces, municipalities and autonomous regions in China from 2010 to 2021 by constructing an index system and DEA cross-model, and used the Tobit model for regression analysis, and found that the provinces in the eastern and central regions were high efficiency areas and the provinces in the western region were efficiency depressions. Liu Lei, Yan Zhanghua, Yang Guilan et al. [12] analyzed the input-output efficiency of higher education in 31 regions in China from 2006 to 2020 based on BCC and DEA-Malmquist evaluation models, and found that there were always significant differences in different regions, some regions were ineffective due to scale efficiency, while other DEA ineffective areas were mainly affected by pure technical efficiency.

For the research on the influencing factors of national higher education, most scholars in China focus on the construction of the evaluation index system of the development level of provincial higher education, such as Wu Yuming and others to incorporate six first-level indicators of educational resources, education quality, education input, education scale, educational efficiency and educational output into their provincial regional education competitiveness index system. Regarding the evaluation of regional higher education competitiveness or development level, Zhao Hongbin (2008) constructed a regional higher education competitiveness index system; Sun Jihong (2009), Yang Bin (2009), Lv Yan (2010), Zhang Nanxing (2013), Li Ling (2014), Huang Haijun (2018), Pershing Xia (2020) and others have correspondingly constructed a comprehensive evaluation system for the development level of regional higher education. From the perspective of the research system level, most studies use a secondary index system; From the perspective of index content, the five indicators of education scale, education investment or funding investment, teachers, scientific research output or scientific research level are indicators with high frequency of common selection.

In summary, experts and scholars in different fields have carried out a lot of research on the development efficiency and influencing factors of higher education, which provides a basis for this research. However, at this stage, there is a singleness in the selection of models and subjectivity in the selection of indicators, and the research results have not yet been unified. Therefore, starting from the aspects of static and dynamic, this paper first evaluates the development efficiency of higher education in China by establishing a super-efficient SBM-Malmquist model and combining investment redundancy. Secondly, on the basis of referring to the research of previous scholars, the evaluation index system of higher education is constructed from the three dimensions of educational resources, educational effectiveness and educational opportunities. Finally, the panel effect Tobit regression model is used to analyze the mechanism of the main indicators, and corresponding policy suggestions are put forward, in order to provide reference value for the balanced development of national higher education and the modernization process of education in China.

2. Index selection and empirical research methods

2.1. Indicator selection and data description

1) Construction of indicator system

The selection of input-output indicators is crucial to evaluate the development efficiency of higher education in China, and at present, the input-output index system of higher education development efficiency has not been unified. Therefore, this paper mainly refers to the research of Luo Liqun, Bu Wei [13], Cai Wenbo [14] and others, selects input indicators from the dimensions of human resources, financial resources and material resources, and selects expected output indicators from the three dimensions of talent training, scientific and technological innovation and social services. In addition, considering that education expenditure is affected by per capita disposable income and the employment difficulties faced by college graduates in the post-pandemic era [15]. This study included per capita disposable income and unemployment in input indicators and non-desired output indicators, respectively. The specific indicator system is shown in Table 1

Table 1. National higher education development efficiency input-output index system

The variable type	Measurement dimensions	Measurement metrics	Unit	Data sources	Indicator source
Input indicators	human resources	Number of full-time teachers in higher education	10000 People	China Statistical Yearbook	Reference [15]
		Number of teaching and research personnel	10000 People	Science and technology statistics of colleges and universities	Reference [14]
	Financial resources	Research funding	10000 People	Science and technology statistics of colleges and universities	Reference [15]
		Per capita disposable income	10000 People	National Statistics Bureau	—
	Material resources	Number of general institutions of higher learning	Number of Universities	Science and technology statistics of colleges and universities	Reference [14]
Expected output indicators	Talent development	Number of undergraduate graduates	10,000 people	China Statistical Yearbook	Reference [12]
	Scientific and technological innovation	Number of published papers	chapter	Science and technology statistics of colleges and universities	Reference [12]
		Number of domestic patents granted	item	Science and technology statistics of colleges and universities	Reference [14]
	Social service	Number of projects	item	Science and technology statistics of colleges and universities	Reference [12]
Non-expected output indicators	human resources	Number of unemployed	10,000 people	China Statistical Yearbook	—

2) Data Description

This research was taken to the national higher education development efficiency as the research object from 31 provinces, municipalities and autonomous regions as the decision-making unit, which was to measure and analyze the annual spanning from 2012 to 2021, and the data are from the 2013-2022 China Statistical Yearbook, the 2013-2022 Compilation of Science and Technology Statistics of Colleges and Universities and the database of the National Bureau of Statistics

Table 2. Descriptive statistical analysis

Variable	Sample size	Median	Minimum	Maximum	Mean	Standard deviation
Full-time teacher of higher education	310	4.682	0.237	13.773	5.287	3.132
Number of teaching and research staff	310	2.418	0.100	8.831	2.582	1.557
Research funding	310	174366.300	3105.400	1415950.500	241413.393	239802.369
Per capita disposable income	310	2.254	0.857	7.803	2.523	1.188
Number of general institutions of higher learning	310	42.500	3.000	142.000	50.848	34.415
Number of undergraduate graduates	310	11.729	0.467	30.590	11.976	7.131
Number of published papers	310	16788.500	603.000	68184.000	17976.316	11861.664
Number of domestic patents granted	310	2190.000	1.0000	29821.000	3493.994	4050.179
Number of projects	310	15160.500	197.000	85764.000	219941.910	17163.410
Number of unemployed	310	25.850	1.600	82.500	26.410	15.296

As can be seen from Table 2, it is 52,870 for the average number of full-time teachers in higher education in the country, 25,820 yuan for the average value of teaching and research personnel, the average value of scientific research funds is 2,414,133,930 yuan, and the per capita disposable income is 25,230 yuan. These data shows that China has always paid attention to the development of higher education and given a lot of financial support, which also reflects the improvement of people's material living conditions. Number of ordinary colleges and universities is 50, the number of undergraduate graduates for 119,760, the number of published papers for 17976.316, the number of domestic patent authorizations for 3493.994, and the number of project projects for 219941.91, these data shows that China's higher education continues to develop and achieve certain results; The national average number of unemployed is 264,100, which shows that there may be some challenges in the post-epidemic employment problem in China.

2.2. Empirical Research Method: Ultra-efficient SBM-Malmquist-Tobit Model

1) Ultra-efficient SBM model

The DEA model was proposed by Charnes et al. [16] in 1978, which is based on input-output variables, the relative efficiency of the decision-making unit non-parametric estimation. However, the traditional DEA model has certain limitations, it is difficult to distinguish and compare when multiple decision-making units are effective at the same time. In order to solve this problem, Anderson and Peterson established an improved DEA (Super Efficiency DEA, SE-DEA) model. In this study, the ultra-efficient DEA and SBM models are combined to improve the bias, and the advantage of selecting them is that it can achieve relatively effective comparison and ranking between measured units. The formula is as follows (1):

$$\rho^* = min\frac{\frac{1}{m}\sum_{i=1}^{m}\left(\frac{\bar{x}}{x_{ik}}\right)}{\frac{1}{r_1+r_2}\times\left(\sum_{s=1}^{r_1}\overline{y^d}/y_{sk}^d+\sum_{q=1}^{r_2}\overline{y^u}/y_{qk}^u\right)}$$
$$\begin{cases} \bar{x} \geqslant \sum_{j=1,\neq k}^{n} x_{ij}\lambda_j, i = 1,2,\cdots,m \\ \overline{y^d} \leqslant \sum_{j=1,\neq k}^{n} y_{sj}^d\lambda_j, s = 1,2,\cdots,r_1 \\ -y^u \geqslant \sum_{j=1,\neq k}^{n} y_q^u\lambda_j, q = 1,2,\cdots,r_2 \\ \lambda_j \geqslant 0, j = 1,2,\cdots,n \\ \bar{x} \geqslant x_{ik}, j = 1,2,\cdots,m \\ -y^d \leqslant y_{sk}^d, s = 1,2,\cdots,r_1 \\ -y_q^u, u = 1,2,\cdots,r_2 \end{cases} \tag{1}$$

2) Malmquist Total Factor Production Index

The DEA model is based on static efficiency measured at a fixed time point, while production technology will continue to change over time, so it is necessary to combine the Malmquist total factor productivity index to analyze the dynamic change of higher education development efficiency. On the basis of the SBM model, Fare et al. [18] propose a definition of the Malmquist index and break it down into changes in technological efficiency and technological progress, as follow:

$$ML_0(x_t, y_t, x_{t+1}, y_{t+1}) = \sqrt{\frac{D_0^t(x_{t+1}, y_{t+1})}{D_0^t(x_t, y_t)}} \times \sqrt{\frac{D_0^{t+1}(x_{t+1}, y_{t+1})}{D_0^{t+1}(x_t, y_t)}} = TC \times EC \tag{2}$$

If ML0> 1, it indicates an increase in production efficiency; If ML0=1, it means that the production efficiency is unchanged; If ML0< 1, it means that production efficiency has decreased. TC reflects changes in the production front, and TC>1(<1) indicates that the technical level of the decision-making unit has improved (regressed) compared to the previous period. EC measures the change in the gap between the decision unit and the technology front, and if EC>1(<1) means that the actual production point of the current decision unit is closer (farther away) from the global production front than in the previous period, the technical efficiency has been improved (decreased) [19].

3) Panel Tobit model

Tobit model, also known as limited dependent variable model, is when Tobin studies the demand for durable consumer goods, he finds that the expenditure of household units is non-negative, and if the least squares estimation is used, it will lead to biased parameters, so the dependent variable limited analysis framework model is proposed[20], when the truncation point is a, the form is as follows:

$$\begin{gathered} y^* = \beta^T x + \varepsilon,\ \varepsilon \sim N(0, \delta^2) \\ y = max(0, y^*) = \begin{cases} y^* & \text{if } y^* \geq a \\ 0 & \text{if } y^* < a \end{cases} \end{gathered} \tag{3}$$

Tobit borrows the latent variable y^* in its estimation, which follows a normal homovariance distribution. y is the restricted dependent variable, β is the parameter vector, ε is the random perturbation term, following the normal distribution.

3. Empirical analysis

3.1. Ultra-efficient SBM overall efficiency value - static analysis

The DEA model does not consider the problem of data dimension, and this paper uses Dearun v 3.1.0.2 software to solve the higher education development efficiency and investment redundancy in 31 provinces in China, and the specific results obtained are shown in Table 3, 4 and Figures 1, 2 and 3.

Table 3. Higher education development efficiency in 31 provinces in China, 2012-2021

Region	Province	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
North China	Beijing	1.390	1.486	1.454	1.440	1.455	1.455	1.447	1.428	1.137	1.173
	Tianjin	1.009	1.023	1.043	1.073	1.087	1.068	1.068	1.036	1.047	1.087
	Hebei	0.754	0.696	0.640	0.650	0.608	1.001	0.603	0.681	0.682	0.678
	Shanxi	0.642	0.608	0.638	0.737	0.592	0.719	1.005	1.010	1.025	1.045
	Inner Mongolia	1.022	1.020	1.030	1.009	1.014	1.001	0.546	0.612	0.662	0.716
	Average value	0.963	0.967	0.961	0.982	0.951	1.049	0.934	0.953	0.911	0.940
Northeast China	Liaoning	1.026	1.024	1.016	1.018	1.044	1.072	1.063	1.068	1.061	1.051
	Jilin	1.015	1.020	1.019	1.026	1.030	1.034	1.012	1.044	1.041	1.026
	Heilongjiang	1.063	1.076	1.083	1.075	1.027	1.055	1.051	1.071	1.051	1.070
	Average value	1.035	1.040	1.039	1.040	1.034	1.054	1.042	1.061	1.051	1.049
East China	Shanghai	1.173	1.142	1.166	1.054	1.054	1.056	1.061	1.101	1.120	1.108
	Jiangsu	1.337	1.355	1.373	1.292	1.237	1.142	1.136	1.141	1.180	1.348
	Zhejiang	1.126	1.135	1.119	1.105	1.069	1.067	1.047	1.019	1.027	0.763
	Anhui	1.000	0.795	1.001	1.012	1.015	0.792	0.750	1.003	0.823	1.004
	Fujian	1.006	1.010	1.014	0.605	0.621	1.004	1.005	1.010	0.654	0.662
	Jiangxi	1.003	1.011	0.822	0.737	0.642	0.618	0.592	0.610	0.629	0.662
	Shandong	1.040	1.040	1.019	1.039	1.001	0.695	0.720	0.757	1.004	1.010
	Average value	1.098	1.070	1.073	0.978	0.948	0.911	0.902	0.949	0.920	0.937
Central China	Henan	1.106	1.095	1.146	1.145	1.226	1.117	1.109	1.113	1.148	1.184
	Hubei	1.103	1.088	1.084	1.043	1.065	1.062	1.053	1.051	1.039	1.041
	Hunan	0.724	0.781	0.751	0.691	0.696	0.749	0.665	0.751	0.769	1.005
	Average value	0.978	0.988	0.994	0.960	0.996	0.976	0.942	0.972	0.985	1.077
South China	Guangdong	1.058	1.060	1.082	1.061	1.040	0.777	0.829	1.019	1.025	1.033
	Guangxi	1.041	1.049	1.052	1.004	0.846	0.725	0.687	0.738	0.778	1.019
	Hainan	0.755	0.776	1.014	1.012	1.007	0.673	0.631	0.657	0.640	0.744
	Average value	0.951	0.962	1.049	1.026	0.964	0.725	0.716	0.805	0.814	0.932
Southwest China	Chongqin	0.778	0.843	1.021	0.771	0.747	0.783	1.010	1.003	1.028	1.000
	Sichuan	1.027	1.028	1.016	1.001	0.799	1.010	1.027	1.058	1.042	1.025
	Guizhou	1.020	1.000	1.009	1.012	1.005	0.791	0.779	1.025	1.020	1.004
	Yunnan	0.816	1.025	1.024	1.025	1.005	0.716	0.718	1.002	1.008	1.026
	Tibet	1.652	1.636	1.548	1.584	1.598	1.019	1.010	1.005	1.004	1.281
	Average value	1.059	1.106	1.124	1.079	1.031	0.864	0.909	1.019	1.020	1.067
Northwest China	Shanxi	1.213	1.206	1.169	1.173	1.165	1.155	1.157	1.118	1.132	1.129
	Gansu	1.050	1.101	1.102	1.063	1.086	1.038	1.052	1.078	1.061	1.204
	Qinhai	1.002	0.786	1.004	1.007	1.017	0.749	1.003	1.007	1.022	1.023
	Ningxia	1.064	1.053	1.099	1.021	1.023	1.021	0.726	1.013	0.839	0.812
	Xinjiang	1.000	0.797	1.020	1.044	1.031	1.036	1.033	1.022	1.012	1.038
	Average value	1.066	0.989	1.079	1.062	1.064	1.000	0.994	1.048	1.013	1.041

Note: The main basis for dividing the national regions in this study comes from the National Bureau of Statistics, that is, the country is divided into seven regions: North China, Northeast China, East China, Central China, South China, Southwest China and Northwest China.

Table 4. Redundancy of investment in the development efficiency of higher education in the country

DMU	Input	Input	Input	Input	Input	Efficiency
Beijing	0.000	0.000	0.000	0.000	-0.017	1.391
Tianjin	-0.005	0.000	0.000	0.000	-0.033	1.055
Hebei	0.017	0.161	0.004	0.005	0.148	0.699
Shanxi	0.003	0.045	0.014	0.037	0.037	0.805
Inner Mongolia	0.001	0.027	-0.008	0.077	0.040	0.865
Liaoning	-0.024	0.000	0.000	0.000	-0.015	1.045
Jilin	-0.017	0.000	0.000	0.000	0.000	1.027
Heilongjiang	-0.011	0.000	-0.037	0.000	-0.004	1.063
Shanghai	-0.013	-0.069	0.000	0.000	-0.017	1.104
Jiangsu	0.000	0.000	-0.001	0.000	0.000	1.260
Zhejiang	-0.023	0.006	0.006	0.031	0.004	1.049
Anhui	0.000	0.049	0.009	0.002	0.090	0.920
Fujian	0.004	0.035	0.040	0.091	0.104	0.859
Jiangxi	0.041	0.061	0.032	0.045	0.130	0.734
Shandong	0.020	0.028	0.031	0.011	0.023	0.949
Henan	0.000	0.000	-0.003	-0.056	-0.022	1.143
Hubei	0.000	-0.006	-0.024	0.000	0.000	1.063
Hunan	0.021	0.089	0.011	0.041	0.174	0.759
Guangdong	0.001	0.015	0.036	0.006	-0.027	1.023
Guangxi	0.005	0.069	0.012	0.011	0.040	0.897
Hainan	0.001	0.024	0.012	0.092	0.021	0.824
Chongqing	0.002	0.008	0.013	0.039	0.033	0.920
Sichuan	0.016	0.006	-0.010	-0.001	0.013	1.003
Guizhou	0.004	0.001	-0.005	0.001	0.006	0.988
Yunnan	0.002	0.017	0.003	0.003	0.038	0.942
Tibet	-0.010	-0.039	-0.013	-0.052	-0.034	1.390
Shanxi	0.000	0.000	-0.009	-0.024	-0.012	1.162
Gansu	0.000	-0.011	-0.015	-0.010	0.000	1.090
Qinhai	-0.002	0.008	0.002	0.010	0.005	0.966
Ningxia	-0.001	0.011	-0.002	0.020	0.004	0.967
Xinjiang	0.000	0.008	-0.001	0.001	0.007	1.004

Note: Input 1, 2, 3, 4 and 5_slacks correspond to the five input indicators in Table 1, namely, the number of full-time teachers in higher education, the number of teaching and research researchers, scientific research funds, per capita disposable income and the number of ordinary colleges and universities.

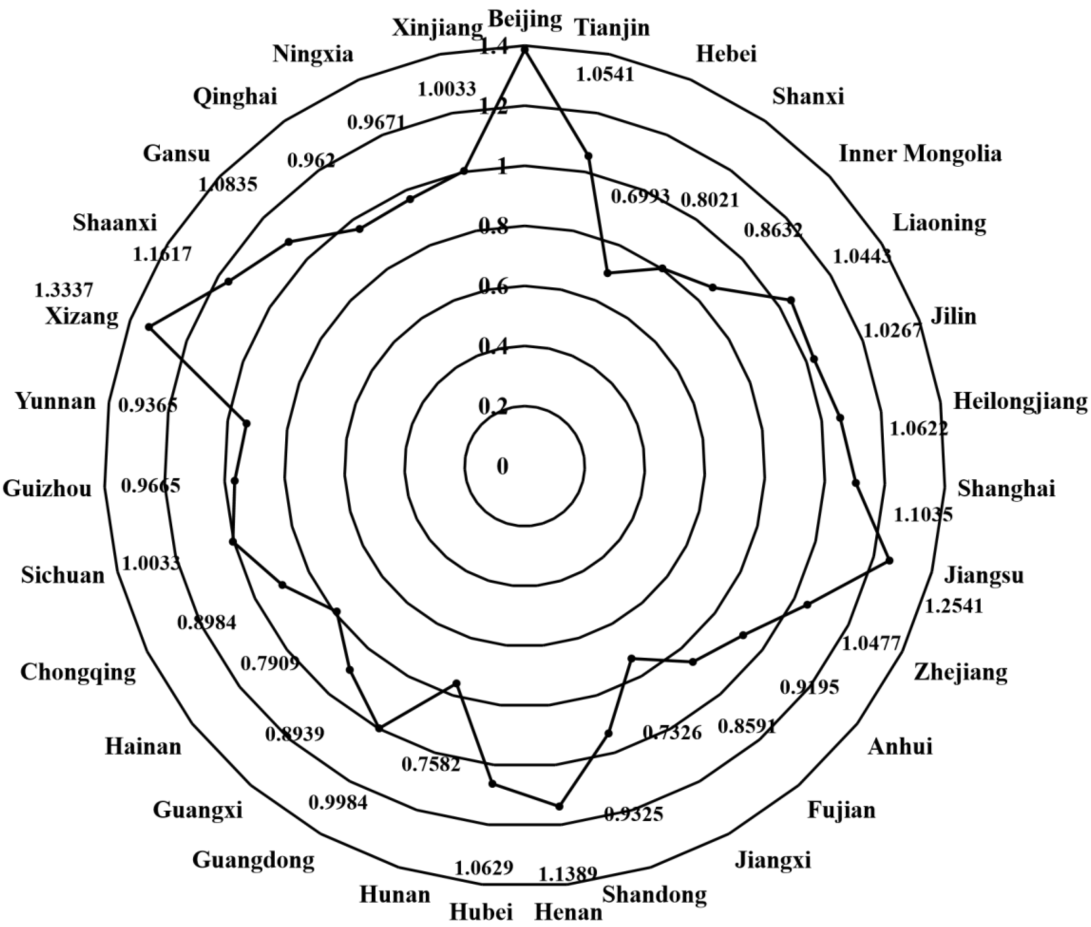

Figure 1. Average higher education development efficiency in 31 provinces in China from 2012 to 2021

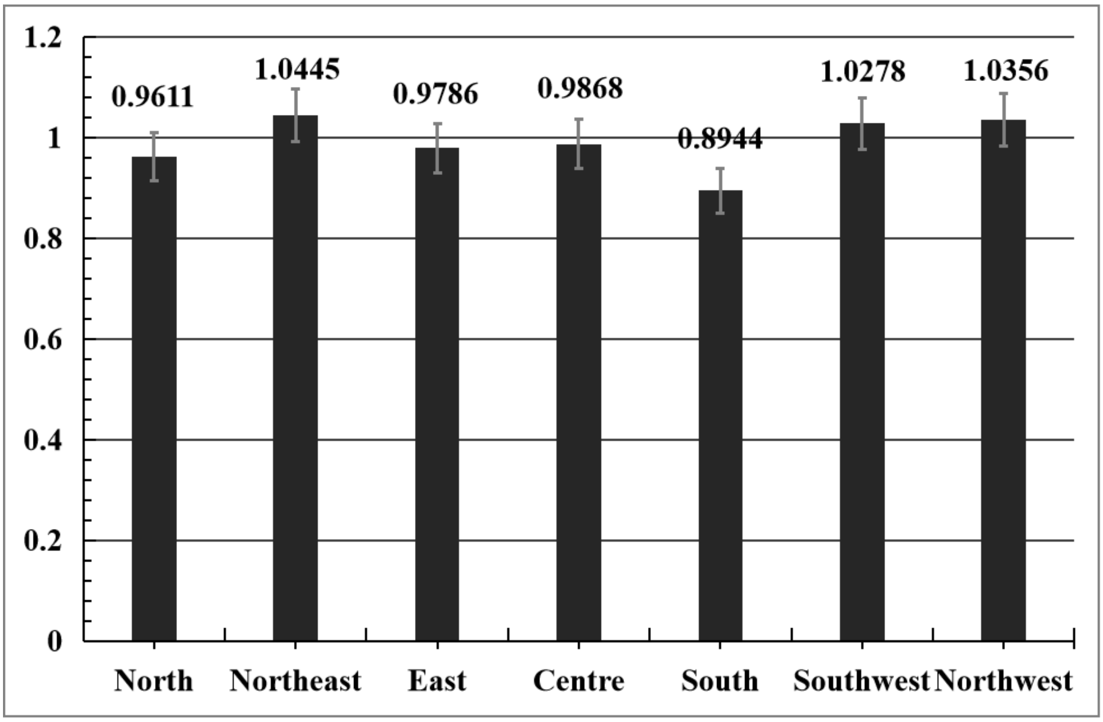

Figure 2. Overall average higher education development efficiency by region

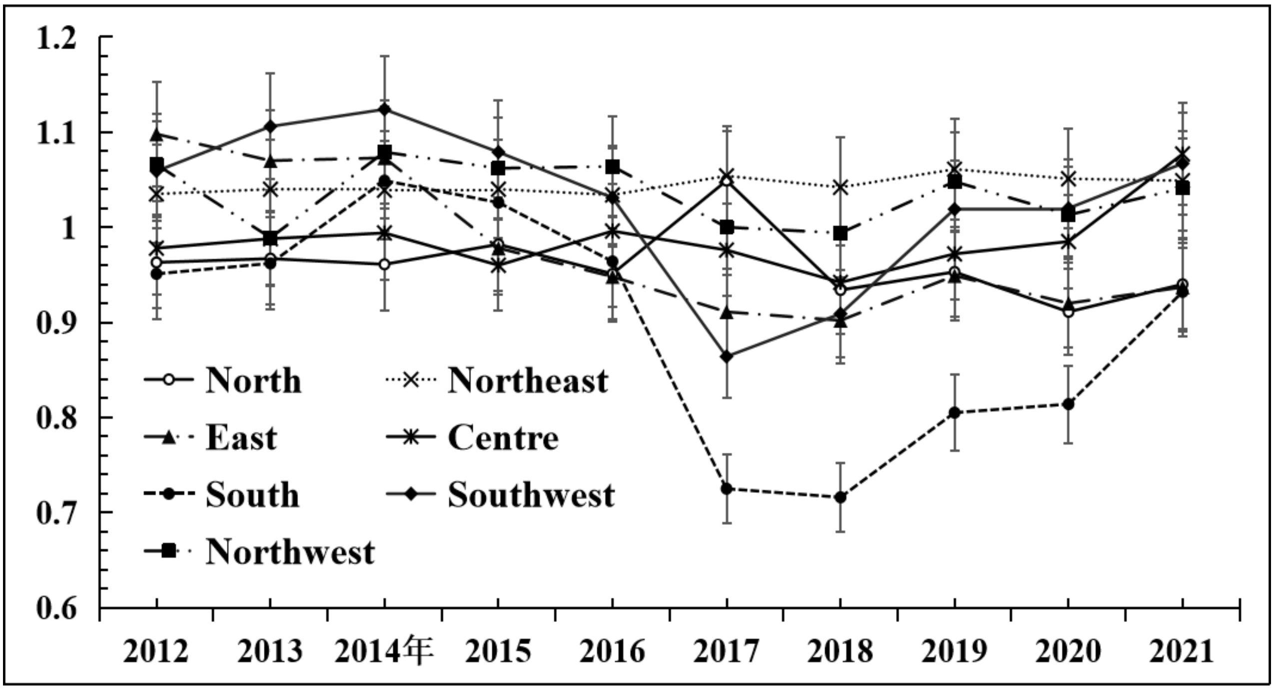

Figure 3. Trends in the development efficiency of higher education in different regions

From the perspective of the whole country, it can be seen from Figure 3 that during the study period, the development efficiency of higher education in various regions of China roughly showed a U-shaped change trend, that is, it first decreased and then rose, and the national average higher education development efficiency was 0.9898, which indicates that the overall development efficiency of higher education in China may not have reached the optimal, and the specific reasons need to be further analyzed.

From the perspective of the seven major regions, it can be seen from Figure 2 that the Northeast Region, the Southwest Region and the Northwest Region have reached the DEA effective level, respectively, 1.0278 and 1.0356, while other regions are DEA invalid areas, South China the lowest development efficiency of higher education, only 0.8944. However, it cannot be judged that all provinces, municipalities and autonomous regions in South China have problems in higher education development, which may be caused by the relatively low development efficiency of individual provinces, so further exploration is still needed.

From the perspective of 31 provinces, municipalities and autonomous regions in China, it can be seen from Figure 1 that the higher education development efficiency in North China, Beijing and Tianjin are effective DEA. However, the development efficiency of Hebei, Shanxi and Inner Mongolia is less than 1, which can be judged that the development of higher education in North China may exist in Hebei, Shanxi and Inner Mongolia. Similarly, in East China, Shanghai, Jiangsu and Zhejiang have reached the DEA effect, while Anhui, Fujian, Jiangxi and Shandong may have problems in the development of higher education. In central China, only Hunan is invalid; In South China, Guangdong, Guangxi and Hainan are all DEAs invalid; In the southwest region, Guizhou and Yunnan are invalid DEAs, indicating that there may be problems in the development of higher education in the two places.

From the study period, it can be seen from Table 3 that the validity of DEA is only reached to Hebei Province in 2017, Shanxi Province has been effective and showing a steady upward trend since 2018, and Inner Mongolia has become DEA invalid since 2018. Therefore, the development of higher education in Hebei Province and Inner Mongolia Autonomous Region may be more prominent. Anhui Province has shown a W-shaped growth trend since 2017, most of the years for DEA valid, Fujian Province since 2020 began to become DEA invalid, indicating that Fujian Province's higher education development problems are gradually prominent, Jiangxi Province since 2014 DEA is invalid, Shandong Province in 2017-2019 DEA invalid, and then become effective again, therefore, Fujian

Province and Jiangxi Province's higher education development problems may be more prominent. Hunan only reached the DEA effect in 2021, indicating that although Hunan Province had problems in the development of higher education in the past, Hunan Province gradually paid attention to this problem and continuously improved; Guangdong Province only invalidated DEA in 2017-2018, while Guangxi Province became DEA invalid since 2016, and Hainan Province became invalid in 2017, which can be judged that there may be problems in higher education development in Guangxi and Hainan. Similarly, Guizhou and Yunnan have only been ineffective in a few years, which can rule out the development of their higher education.

From the perspective of investment redundancy, it can be seen from Table 4 that the redundancy of the five input indicators in Hebei Province is greater than 0, indicating that there is a waste of educational resources in Hebei Province. Among them, input 2 and input 5 consume 16.1% and 14.8% more than the optimal decision-making unit, respectively, that is, there may be waste of resources in terms of the number of teaching and research personnel and the number of ordinary universities. Similarly, Inner Mongolia may have more room for improvement in per capita disposable income and education expenditure. Fujian and Jiangxi provinces may need to make improvements in the number of ordinary universities, such as the shift from the number of universities to the quality of education. Guangxi Province may need to make improvements in bringing in teaching and researchers, while Hainan Province may improve the efficiency of the use of research funds.

3.2. Total factor productivity index and decomposition-dynamic analysis

After static analysis, this paper uses Dearun v 3.1.0.2 software to calculate the Malmquist change index and its decomposition index of China's higher education development efficiency from 2012 to 2021, as follow table 5, table 6, and figure 4, figure 5:

Table 5. Annual change index and decomposition index of China's higher education development efficiency from 2012 to 2021

Years	Technical efficiency change index	Technical Progress Index	Pure technical efficiency change index	Scale efficiency change index	Total factor productivity change index
2012-2013	1.0027	1.0031	0.9994	1.0034	1.0058
2013-2014	1.0003	1.0005	1.0012	0.9991	1.0007
2014-2015	0.9954	1.0055	0.9967	0.9987	1.0010
2015-2016	0.9934	1.0042	0.9950	0.9984	0.9973
2016-2017	1.0034	0.9766	1.0033	1.0000	0.9798
2017-2018	0.9946	0.9981	0.9921	1.0024	0.9927
2018-2019	1.0055	0.9739	1.0034	1.0021	0.9791
2019-2020	1.0025	1.0261	1.0011	1.0014	1.0287
2020-2021	0.9948	1.0028	0.9989	0.9957	0.9969
Average value	0.9992	0.9990	0.9990	1.0001	0.9980

Table 6. Changes in the development efficiency of higher education in Chinese provinces and their decomposition index, 2012-2021

Area	Province	Technical efficiency change index	Technical progress change index	Pure technical efficiency change index	Scale efficiency change index	Total factor productivity change index
North China	Beijing	1.0000	0.9801	1.0000	1.0000	0.9801
	Tianjin	1.0049	1.0119	1.0000	1.0049	1.0168
	Hebei	0.9990	0.9791	0.9975	1.0014	0.9773
	Shanxi	1.0156	1.0124	1.0102	1.0056	1.0278
	Inner Mongolia	0.9990	0.9970	0.9987	1.0005	0.9961
	Average value	1.0037	0.9961	1.0013	1.0025	0.9996
Northeast	Liaoning	1.0000	0.9998	1.0000	1.0000	0.9998
	Jilin	1.0000	0.9999	1.0000	1.0000	0.9999
	Heilongjiang	1.0000	0.9971	1.0000	1.0000	0.9971
	Average value	1.0000	0.9989	1.0000	1.0000	0.9989
East China	Shanghai	1.0000	0.9950	1.0000	1.0000	0.9950
	Jiangsu	1.0000	1.0392	1.0000	1.0000	1.0392
	Zhejiang	0.9945	1.0103	0.9956	0.9988	1.0042
	Anhui	1.0002	1.0019	1.0000	1.0002	1.0021
	Fujian	0.9941	1.0149	0.9929	1.0011	1.0080
	Jiangxi	0.9860	0.9912	0.9856	1.0005	0.9778
	Shandong	1.0010	1.0095	1.0001	1.0009	1.0102
	Average value	0.9966	1.0089	0.9963	1.0002	1.0052
Central China	Henan	1.0000	0.9726	1.0000	1.0000	0.9726
	Hubei	1.0000	0.9806	1.0000	1.0000	0.9806
	Henan	1.0052	0.9931	1.0049	1.0003	0.9978
	Average Value	1.0017	0.9821	1.0016	1.0001	0.9837
South China	Guangdong	1.0000	0.9967	1.0000	1.0000	0.9969
	Guangxi	1.0007	0.9883	1.0004	1.0002	0.9895
	Hainan	0.9861	1.0101	0.9897	0.9963	0.9957
	Average Value	0.9956	0.9984	0.9967	0.9988	0.9940
Southwest	Chongqing	1.0001	1.0179	1.0005	0.9996	1.0180
	Sichuan	1.0000	0.9716	1.0000	1.0000	0.9715
	Guizhou	1.0007	1.0073	1.0000	1.0007	1.0077
	Yunnan	1.0019	1.0003	1.0017	1.0001	1.0024
	Tibet	0.9946	0.9856	1.0000	0.9946	0.9798
	Average Value	0.9995	0.9965	1.0004	0.9990	0.9959
Northwest	Shanxi	1.0000	0.9942	1.0000	1.0000	0.9942
	Gansu	1.0000	1.0078	1.0000	1.0000	1.0078
	Qinghai	1.0000	1.0060	1.0000	1.0000	1.0060
	Ningxia	0.9871	0.9996	0.9918	0.9949	0.9864
	Xijiang	1.0033	0.9966	1.0000	1.0033	0.9999
	Average Value	0.9981	1.0008	0.9984	0.9996	0.9989

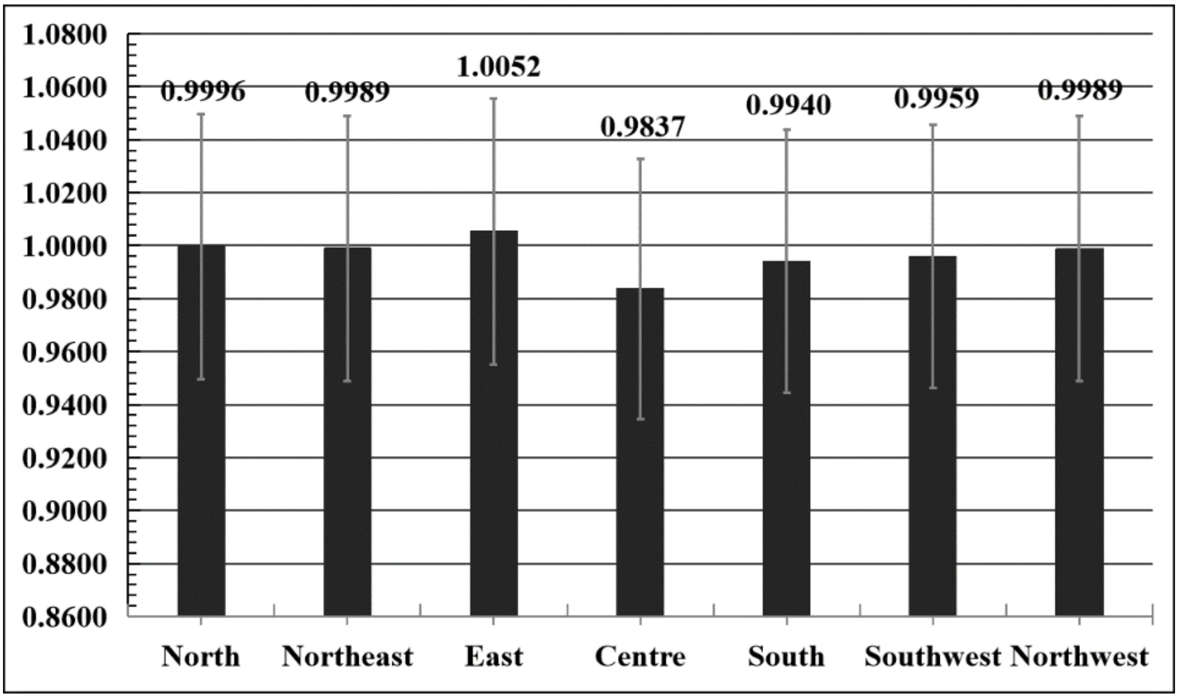

Figure 4. Average total factor productivity by region

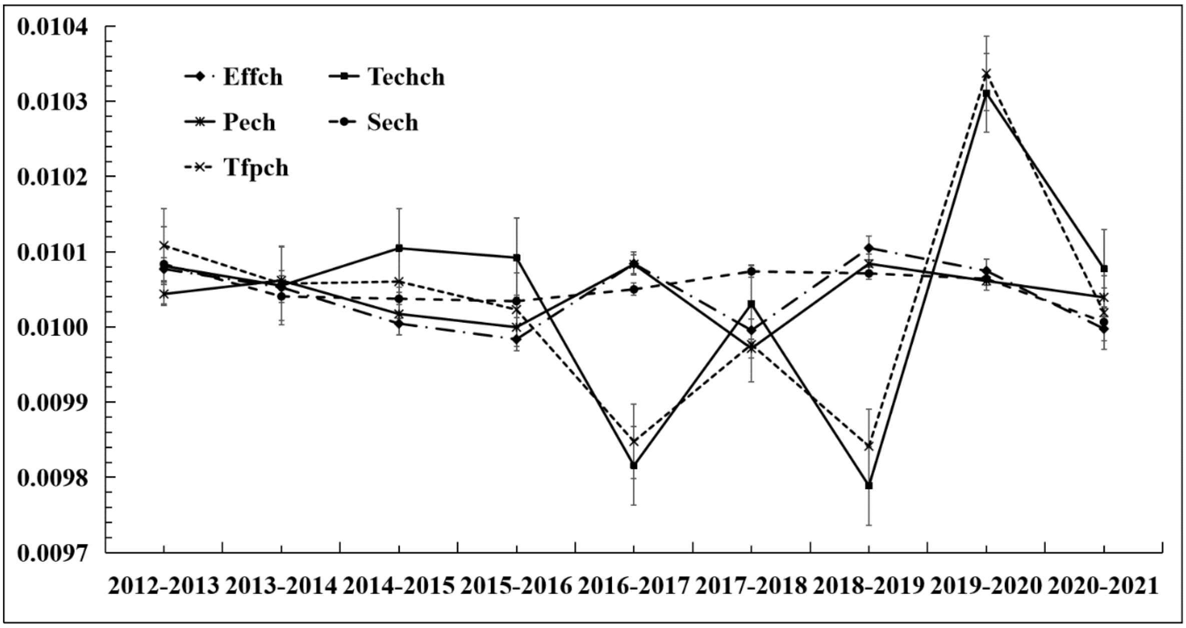

Figure 5. Changes in higher education development efficiency and decomposition index

From the research period, it can be seen from Table 5 that the average total factor productivity of China's higher education development efficiency from 2012 to 2021 is 0.9980, which once again shows that China's higher education development efficiency may not have reached the optimal. From 2012 to 2015, China's higher education total factor productivity was greater than 1, in 2015-2019, total factor productivity was less than 1, in 2019-2020 it was greater than 1 again, and in 2020-2021 it was less than 1 again, showing a W-shaped fluctuation trend as a whole.

From the perspective of regional distribution, it can be seen from Figures 4, 5 and Table 6 that in North China, Beijing is mainly affected by technological progress, while Hebei and Inner Mongolia have room for improvement in all aspects except for optimal scale efficiency. In East China, Shanghai is also limited to technological progress, while Fujian is affected by technological efficiency and pure technological efficiency, and Jiangxi has not yet reached the best in other aspects except scale efficiency. Central China is constrained by technological progress; In South China, Guangdong and Guangxi are mainly affected by technological progress, while Hainan may need to improve more comprehensively. In the southwest region, Sichuan is affected by technological progress, and Tibet may need multi-faceted improvements; In the northwest region, Shaanxi and Xinjiang are also affected by technological progress, while Ningxia may need to explore and improve in all aspects.

4. Analysis of influencing factors

4.1. Variable selection and research methods

1) Research methods

According to the above analysis results, the overall development level of higher education in China may not have reached the optimal, and the development level of higher education in various places may not be balanced. It is truncated data to consider the efficiency value estimated by the super-efficiency SBM model. If the least squares method is used, the parameter estimation will produce a certain deviation [21]. Therefore, this paper uses the panel effect Tobit model to measure and analyze the influencing factors of higher education development efficiency.

2) Variable selection

In this study, the selection of influencing factors is selected and constructed from three dimensions: educational resources, educational effectiveness and educational opportunities based on comprehensive reference to the research results of Huang Haijun, Li Dexian et al. [22-24]. Since the data on the acceptance rate of college entrance examination enrollment has not yet been unified, this study replaces this indicator with the number of general and vocational college enrollment by region, as shown in Table 7

Table 7. Evaluation index system of higher education development efficiency

Level 1 indicators	Secondary indicators	Indicator content	Unit	Indicator source
Educational resources	Faculty	Number of full-time faculty with doctoral degrees	per capita	Reference [23]
	Funding	Research Funding (Granted)	1,0000 Yuan	Reference [23]
Teaching effectiveness	Social services	Technology transfer contract amount	1,0000 Yuan	Reference [23]
	Student experience	Sports field area	m^2	Reference [25]
		Number of postgraduate research participation	per capita	Reference [25]
Educational opportunities	Overall size	Average number of students enrolled per 100,000 population	per capita	Reference [24]
	Education is balanced	The number of general and vocational college students enrolled by region	per capita	Reference [24]
	Educational background	GDP per capita	Yuan/Per capita	Reference [24]

Note: The above data are from China Education Statistics, National Bureau of Statistics, Scientific Research Statistical Yearbook of Colleges and Universities and China Statistical Yearbook

4.2. Analysis of empirical results

In this study, the likelihood ratio chi-square test of the model is firstly performed, and the results showed that the P value of the model is 0.025**, which shows significance at the significance level of 5% and rejects the null hypothesis. Therefore, the model established in this study is proved to be reasonable, and then the stata16.0 software is used to perform panel Tobit regression, and the detailed results are shown in Table 8, and the specific analysis is as follows:

The number of full-time teachers with doctoral degrees had a significant positive impact on the development efficiency of higher education at a significance level of 5%. The possible reason is that Ph.D. faculty members usually have rich knowledge and experience in research methods and theoretical frameworks, which may help to improve the research level and results of higher education institutions, thereby improving the overall efficiency of higher education development.

The number of postgraduate research participation has a significant positive impact on the development efficiency of higher education at the significance level of 1%. The possible reason may be that scientific research activities usually need to explore unknown problems, which requires graduate students to apply learning theory to practice, which is conducive to cultivating graduate students' innovative thinking and problem-solving ability, and of positive significance for improving the development efficiency of higher education.

The impact of the enrollment of general and vocational college students in different regions on the development efficiency of higher education is positive and significant at the significance level of 10%. To a certain extent, this indicator reflects the problem of education balance in various regions, and education balance means that all kinds of educational resources have been fully allocated and utilized in each region, so as to ensure that the vast number of people have access to high-quality education, forming a broader talent pool, and to improve the overall development efficiency of higher education.

Table 8. Tobit regression results

Level 1 indicators	Level 2 indicators	Indicator content	Coefficient	Standard error	t Value	P Value
Educational resources	Faculty	Number of full-time faculty with doctoral degrees	0.406	0.184	2.205	0.027*
	Funding	Research Funding (Granted)	-0.054	0.221	-0.245	0.806
Educational effectiveness	Social services	Technology transfer contract amount	0.129	0.179	0.719	0.472
	Student experience	Sports field area	0.166	0.21	0.791	0.429
		Number of postgraduate research participation	0.46	0.174	2.70	0.008*
Educational opportunities	Overall size	Average number of students enrolled in tertiary education per 100,000 population	-0.027	0.131	-0.207	0.836
	Equality in education	The number of general and vocational college students enrolled by region	-0.42	0.252	-1.669	0.095*
	Educational background	GDP per capita	-0.076	0.224	-0.338	0.735

Note: ***, ****, * represent the significance levels of 1%, 5% and 10%, respectively

5. Conclusions and recommendations

5.1. Research conclusion

Education is the cornerstone of national revitalization and social progress, in order to promote the balanced development of higher education in various regions and promote the process of China's educational modernization. This paper uses the ultra-efficient SBM-Malmquist-Tobit model to measure the development efficiency of higher education in 31 provinces, municipalities and autonomous regions in China, and makes an empirical analysis of the main factors affecting the development of higher education

Static efficiency aspects: There are six regions that may have problems in the development of higher education and need improvement: Hebei Province, Inner Mongolia Autonomous Region, Fujian Province, Jiangxi Province, Guangxi Zhuang Autonomous Region, and Hainan Province.

Dynamic efficiency aspects: Most regions in China have the problem of technological progress, including Beijing, Shanghai, Guangdong and other developed cities, while Hebei, Inner Mongolia, Jiangxi, Hainan, Ningxia and other places may need to explore and improve the development of local higher education in multiple aspects.

Influential aspects: The influence of the number of full-time teachers with doctoral degrees, the number of postgraduate research participation, and the number of general and vocational college students enrolled in different regions on the development efficiency of higher education showed significant positive effects at the significance levels of 5%, 1% and 10%, respectively, while the remaining indicators had not passed the significance test, indicating that their impact on the development efficiency of higher education was relatively small.

5.2. Policy advice

This paper will put forward three suggestions based on the above conclusions, in order to improve the development efficiency of China's higher education, promote the balanced development of China's higher education, and realize the modernization of education:

It is to improve the management system of teachers in colleges and universities in various places, and strive to improve the quality and professional quality of teachers. For regions where the development efficiency of higher education has not yet reached the effectiveness of DEA, the employment mechanism and development mechanism of college teachers should be improved according to the actual situation of each region, and the introduction of full-time teachers with high degrees should be encouraged, and a professional teacher talent team should be built. It is to encourage teachers to participate in teaching research projects, and provide regular opportunities for teacher training and researching. A fair teacher evaluation mechanism should be established and respect students' feedback to teachers. It is to optimize the incentive mechanism for teachers, combining the results of teacher evaluation, and to reward outstanding teachers through salary bonuses, promotion opportunities, scientific research funds, etc. A teacher mobility mechanism implemented to encourage teachers to conduct academic exchanges and study visits to other universities and research institutions, so as to broaden their academic horizons and improve their teaching and research capabilities.

It is to deepen the talent training mechanism and build a competency-based postgraduate education model. For areas where there may be problems with technological progress, efforts should be made to cultivate the ability of graduate students to participate in scientific research, establishing close ties with society and industry and strengthening opportunities for postgraduate practical research. It is to encourage the implementation of the mentor team system to provide them with richer academic resources and guiding ideas. A reasonable and effective incentive mechanism should be established to provide incentives for outstanding graduate students through various scholarships, honors, priority funding, etc.

It is to optimize the efficiency of educational resource allocation and promote the balanced development of education. To a certain extent, the enrollment of ordinary and vocational college students in different regions reflects the problem of balanced education, in order to promote the balanced development of education. The government should formulate and implement a more scientific strategy for the allocation of educational resources to ensure that educational resources can be effectively allocated to areas in need. Given regional differences, education policies should be flexible to accommodate the special needs of different regions. It is to establish an education monitoring and evaluation mechanism, which can help policy makers monitor and evaluate the effect of education resource allocation, so as to adjust education policies in a timely manner and further optimize resource allocation

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