Research on the impact of human capital on economic growth in China 's provinces based on panel data model

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Abstract. Because human capital can promote economic development, promote social progress and achieve sustainable development, it plays an important role in Chinese modernization. Therefore, it is of great significance to study the impact of human capital on economic growth. This paper first constructs the index system, and uses the Topsis entropy weight method to comprehensively score the indicators ; then, a 25-year panel data model of 31 provinces (cities) in China from 1997 to 2021 is established. Through F test, Breusch-Pagan test and Hausman test, a variety of panel data models are selected. It is found that the individual time point double fixed effect model has a good regression fitting effect on the relevant data. Therefore, this model is selected to analyze the impact of education human capital and health human capital on economic growth, and it is found that both education human capital and health human capital have a significant role in promoting economic growth, but the role of education human capital is more obvious. When education human capital changes 1 unit, China 's economic growth will change 0.105 units. When health human capital changes 1 unit, China 's economic growth will change 0.09 units.

Keywords: Human Capital, Economic Growth, Panel Data, Individual Time Point Double Fixed Effect Model.

1. Introduction

With the rapid economic growth, China 's human capital structure shows the characteristics of low-quality human capital to high-quality human capital, which is typical in the process of China 's economic development[1]. In recent years, the educational level of graduates is significantly higher than the ability demand of jobs[2],so it is very important to study the impact of educational human capital on economic growth. At the same time, people 's work enthusiasm and labor efficiency are directly affected by the level of healthy human capital, which promotes the development of provincial economy to a certain extent. Through the analysis of this paper, we can summarize the experience and shortcomings in education and health in recent years, and better explore the correct, efficient and meaningful methods to promote the comprehensive and high-quality development of China 's economy.

Zhang Jin[3] used panel data for empirical research to demonstrate the impact of education investment and human capital stock on economic growth. Wang Guiqun[4] studied the regional heterogeneity of the impact of educational human capital on economic growth by establishing an economic growth model. Through transnational data analysis, Schmidt et al.[5] showed that once the health level of a developed economy reaches a certain level, the extension of life expectancy will have a negative impact on economic development, showing a negative correlation trend.

In the domestic research on education human capital, health human capital and economic growth, most of the data used in the literature are mostly cross-sectional data or time series data, and rarely use panel data. Considering that human capital is limited by people 's life span, this paper adds health factors on the basis of educational factors to comprehensively measure human capital.

2. Introduction to the principle of Topsis entropy weight method and individual time point double fixed effect model

2.1. Introduction of Topsis entropy weight method principle

The common methods for calculating the comprehensive score of the index system are the main analytic hierarchy process and the entropy weight method. The Topsis entropy weight method, which combines the Topsis method and the entropy weight method, is used to analyze the impact of health human capital on economic growth in various provinces across the country. More objective and reasonable. Therefore, this paper uses the Topsis entropy weight method to analyze the health human capital index system of each province in the country.

This article refers to Wei Min[6] and other Topsis entropy weight method, the specific implementation steps are as follows :

In the first step, in order to eliminate the inconsistency of different measurement indicators in terms of order of magnitude and dimension, the indicators of the range method are first standardized :

$$Y_{ij}=\begin{cases}\dfrac{X_{ij}-\min(X_{ij})}{\max(X_{ij})-\min(X_{ij})}, X_{ij} \text{ is a positive indicator}\\ \dfrac{\max(X_{ij})-X_{ij}}{\max(X_{ij})-\min(X_{ij})}, X_{ij} \text{ is a negative indicator}\end{cases} \tag{1}$$

Where, X_{ij} and Y_{ij} represent the initial and processed values of the j indexes of the original i object, respectively, $\max(X_{ij})$ and $\min(X_{ij})$ represent the maximum and minimum values of X_{ij} , respectively.

The second step is to calculate the information entropy of each index :

$$E_j=\ln\frac{1}{n}\sum_{i=1}^{n}\left[(Y_{ij}/\sum_{i=1}^{n}Y_{ij})\ln(Y_{ij}/\sum_{i=1}^{n}Y_{ij})\right] \tag{2}$$

The third step is to obtain the weight value of each index :

$$W_j=(1-E_j)/\sum^{n}(1-E_j) \tag{3}$$

Where m represents the total number of indicators, and W_j represents the weight value of the r th indicator.

The fourth step is to construct the weighted matrix R of each index :

$$R=(r_{ij})_{n\times m} \tag{4}$$

Among them, $r_{ij}=W_j\times Y_{ij}$.

In the fifth step, the Euclidean distance d_i^+ and d_i^- of the optimal scheme Q_j^+ and the worst Q_j^- are determined according to the weighted matrix R :

$$d_i^+=\sqrt{\sum_{j=1}^{m}(Q_j^+-r_{ij})^2} \tag{5}$$

$$d_i^-=\sqrt{\sum_{j=1}^{m}(Q_j^--r_{ij})^2} \tag{6}$$

The sixth step is to determine the relative proximity of each observation object to the ideal scheme C_i :

$$C_i=\frac{d_i^-}{d_i^++d_i^-} \tag{7}$$

Among them, $C_i \in [0,1]$, the larger C_i indicates the higher level of development.

2.2. Introduction to the principle of individual time point double fixed effect model

The two-way fixed effect model is a method of analyzing panel data, which aims to estimate the causal relationship in panel data. In panel data, the two-way fixed effect model usually performs causal estimation on the fixed effects of control units and time points to avoid missing variable bias and exogenous problems. The following is the establishment of individual time point double fixed effect model :

$$Y_{it} = \alpha_0 + \alpha_i + \gamma_t + X_{it}^{\mathrm{T}}\beta + \varepsilon_{it}, i = 1,2,...N; t = 1,2,...T \tag{8}$$

Among them, α_0 is a fixed value, α_i and γ_t are the fixed effects of individuals and time points, which change with the change of variable x_{it} .

3. Results

The data of one second-level indicator (years of education per capita) and five third-level indicators (birth rate, mortality rate, number of health technicians per thousand people, number of beds in medical and health institutions per thousand people, total population at the end of the year) in the comprehensive system of education human capital and the data of five third-level indicators in the comprehensive system of health human capital measured in this paper are all panel data, covering 31 provinces (cities) across the country, ranging from 1997 to 2021. The data are derived from ' China Statistical Yearbook ', ' China Environmental Statistics Yearbook ', ' China Population and Employment Statistics Yearbook ', ' China Education Statistics Yearbook ', ' China Health Statistics Yearbook '. As shown in Table 1, due to space reasons, only part of the display.

Table 1. Per capita GDP of some provinces from 2013 to 2021

	2013	2014	2015	2016	2017	2018	2019	2020	2021
Beijing	93213	99995	106497	118198	128994	140211	164220	164889	183980
Tianjin	99607	105231	107960	115053	118944	120711	90371	101614	113732
Hebei	38716	39984	40255	43062	45387	47772	46348	48564	54172
Shanxi	34813	35070	34919	35532	42060	45328	45724	50528	64821
Liaoning	61686	65201	65354	50791	53527	58008	57191	58872	65026
Jilin	47191	50160	51086	53868	54838	55611	43475	50800	55450
Shanghai	90092	97370	103796	116562	126634	134982	157279	155768	173630

3.1. Index system establishment

3.1.1 Educational human capital evaluation index

The evaluation index of education human capital has been widely used at home and abroad. For measuring the human capital formed by education, it can be divided into two categories : one is to measure from the perspective of educational output, and the other is to measure from the perspective of input. Domestic scholars have done a lot of work in this area, but they are not perfect enough. One of the indicators of educational human capital is the number of years of education per capita. This indicator reflects the level of education development in a region and the education status of a certain population group. Therefore, this paper uses the number of years of education per capita to measure educational human capital, as shown in Table 2.

Table 2. Indicators for evaluating human capital in education

name (of a thing)	notation	Meaning of the indicator	Data sources
Years of schooling per capita	edu_{it}	Indicates the average number of years of formal academic education for the population group aged 6 and over in year t in province i.	China Education Statistics Yearbook

3.1.2 Health human capital evaluation index

At present, there is no uniform standard for the measurement of health human capital at home and abroad. In order to measure health human capital more accurately, we follow the scientific, systematic, hierarchical, comparative and operable, and comprehensively consider the existing relevant research results at home and abroad to select indicators. This paper mainly refers to the relevant research of Yang Rui[7] and Liu Yicong[8].Finally, three second-level indicators and five third-level indicators are selected, and the weight of each third-level indicator is calculated by Topsis entropy weight method. The specific indicators are shown in Table 3.

Among them, the health status index selects the first to second third-level indicators ; the third to fourth third-level indicators were selected for health and medical indicators ; the population index selects the fifth third-level index.

Table 3. Health Human Capital Evaluation Indicators

Secondary indicators	Tertiary indicators	notation	Meaning of the indicator	Data sources
health status	birth rate	$birthrt_{it}$	denotes the birth level of the population of province i in year t	China Statistical Yearbook
	mortality rate	$deathrt_{it}$	denotes the level of deaths of the population of province i in year t	China Statistical Yearbook
health care	Health technicians per 1,000 population	HT_{it}	denotes the level of supply of health personnel in province i in year t	China Health Statistics Yearbook
	Beds in health-care facilities per 1,000 population	HB_{it}	denotes the size of health hardware facilities in province i in year t	China Health Statistics Yearbook
size of population	Total population at the end of the year	$popularity_{it}$	denotes the number of people in province i at the end of year t.	China Statistical Yearbook

3.1.3 Evaluation index of economic growth level

Economic growth is a process of continuous expansion of production capacity in a country or region, which is directly reflected in the increase of social output level in real life. Therefore, when evaluating the level of economic growth in a country, region or an economic region, the most used indicator is the per capita gross domestic product, that is, per capita GDP. This paper uses per capita GDP to measure economic growth, as shown in Table 4.

Table 4. Indicators for evaluating the level of economic growth

Name((of a thing)	notation	Meaning of the indicator	Data sources
GDP per capita	gdp_{it}	denotes GDP per capita in province i in year t	China Statistical Yearbook

3.2. The comprehensive evaluation score results based on Topsis entropy weight method

3.2.1 The comprehensive evaluation results of education human capital

This paper adopts the academic mainstream average years of education method to measure the education human capital, the calculation formula of per capita years of education is :

$$H = \frac{\sum_{i=1}^{n} p_i h_i}{p} \tag{9}$$

Among them, H is the average years of education of a population aged 1 and above ; i is the level of education, p_i is the number of people with education at the i-th level in the population of this age and above, h_i is the number of years of education at the i-th level, and p is the total number of people

of this age and above. Chen Peng[9] and others use the average years of education method to measure the stage development level of vocational education through quantitative relations, summarize the development experience and shortcomings of vocational education in the past period of time, and show the contribution of vocational education in the high-quality development of China 's education.

Considering the availability and unity of data, this paper calculates the average years of education of the population aged 6 and over, and defines the years of education of primary school, junior high school, senior high school, junior college, undergraduate and graduate students as 6 years, 9 years, 12 years, 15 years, 16 years and 19 years respectively. Considering that the empirical analysis needs to eliminate the impact of data on the dimension, the average number of years of education in each province is divided by 10 to obtain the educational human capital of province i in year t, and the evaluation results of educational human capital are visualized, as shown in Figure 1.

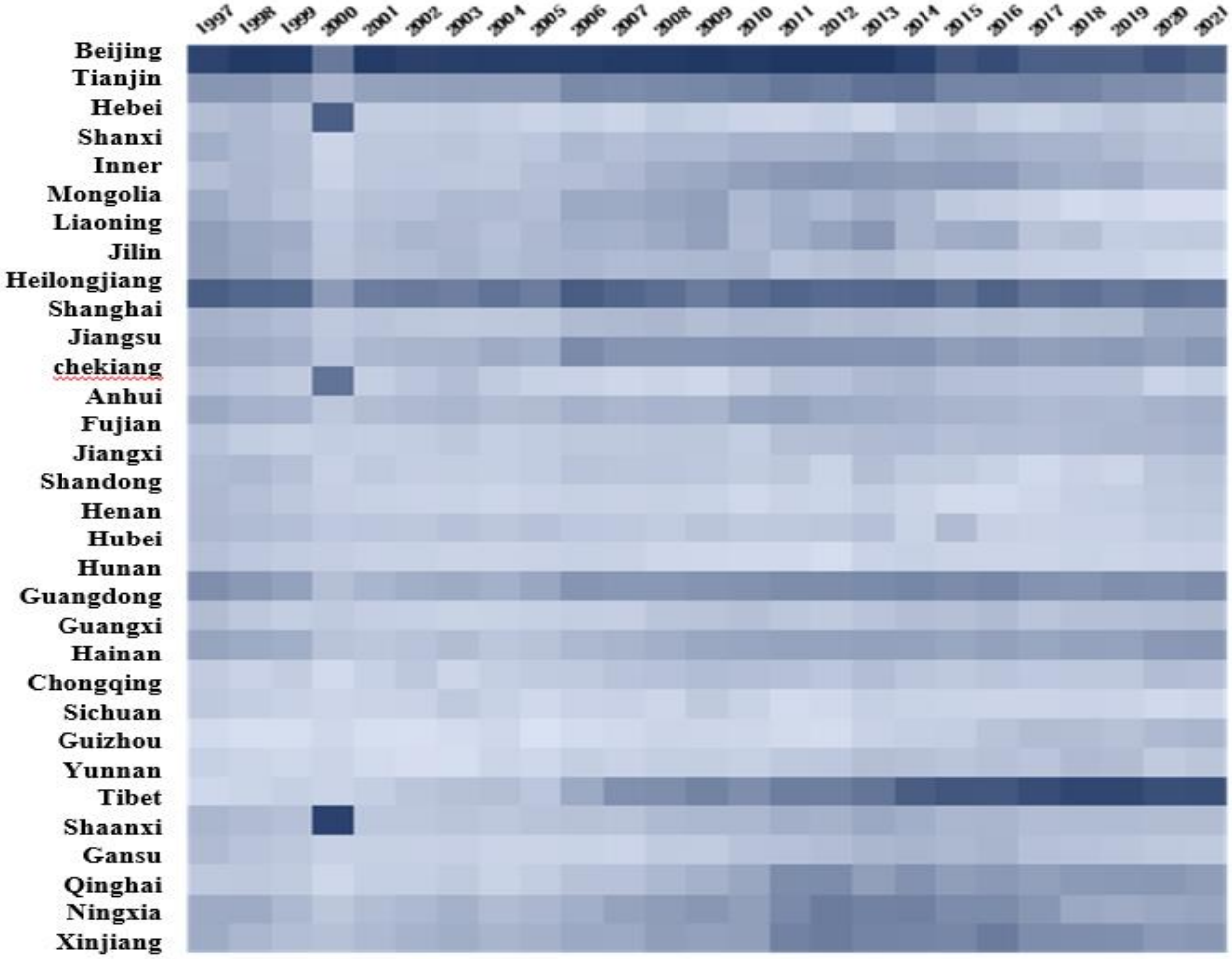


Figure 1. Results of the Comprehensive Evaluation of Educational Human

3.2.2 Comprehensive evaluation results of health human capital

The existing literature shows that the traditional methods of constructing health human capital indicators are mainly single index substitution and comprehensive index measurement. The former is one-sided, can not be fully measured, and is not convincing. The latter is affected by the subjectivity of index selection. There are also some defects[10]. Considering comprehensively, this paper uses the Topsis entropy weight method to measure the comprehensive index of health human capital.

Through the Topsis entropy weight method, the information entropy, information utility value and weight of each index are obtained as shown in Table 5.

Table 5. Weighting information obtained by entropy weighting method

Term (in a mathematical formula)	The information entropy value e	Information utility value d	Weight (%)
$birthrt_{it}$	0.986	0.014	11.88
HT_{it}	0.969	0.031	25.568
HB_{it}	0.968	0.032	26.144
$popularity_{it}$	0.963	0.037	30.663
$deathrt_{it}$	0.993	0.007	5.746

Finally, the comprehensive score of health human capital in the t year of i province can be obtained, and the evaluation results of health human capital can be visualized, as shown in Figure 2.

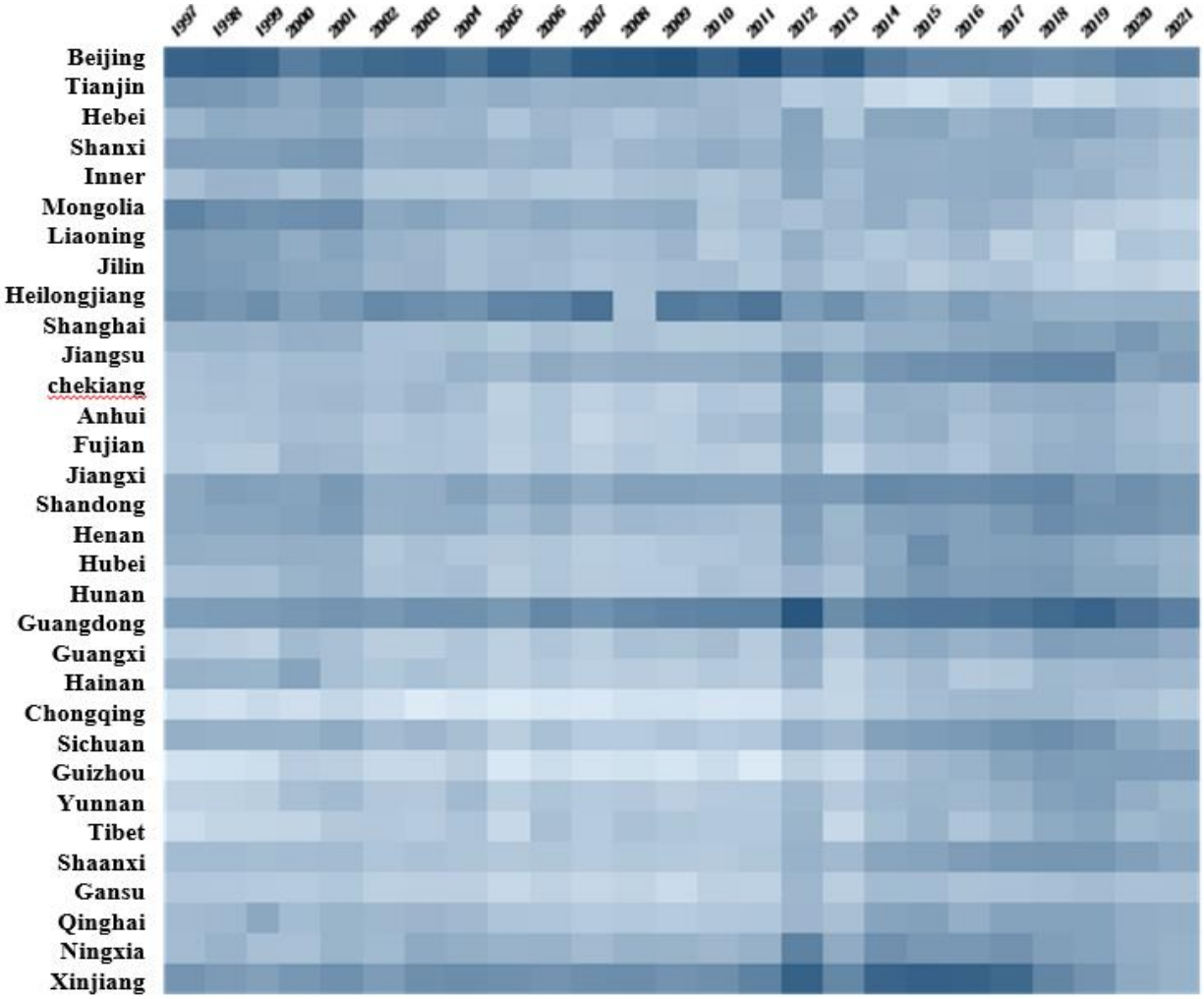


Figure 2. Heat map of the results of the comprehensive evaluation of health human capital

On the whole, the east is higher than the west, the south is higher than the north, and the economically developed areas are better than the economically backward areas, which reflects the statistical correlation between healthy human capital and economic development.

3.2.3 The evaluation results of economic growth

According to the relevant data, a thermal map of the national per capita GDP in some years is drawn, as shown in Figure 3. Only the national provincial per capita GDP histograms of 2000 and 2010 are provided.

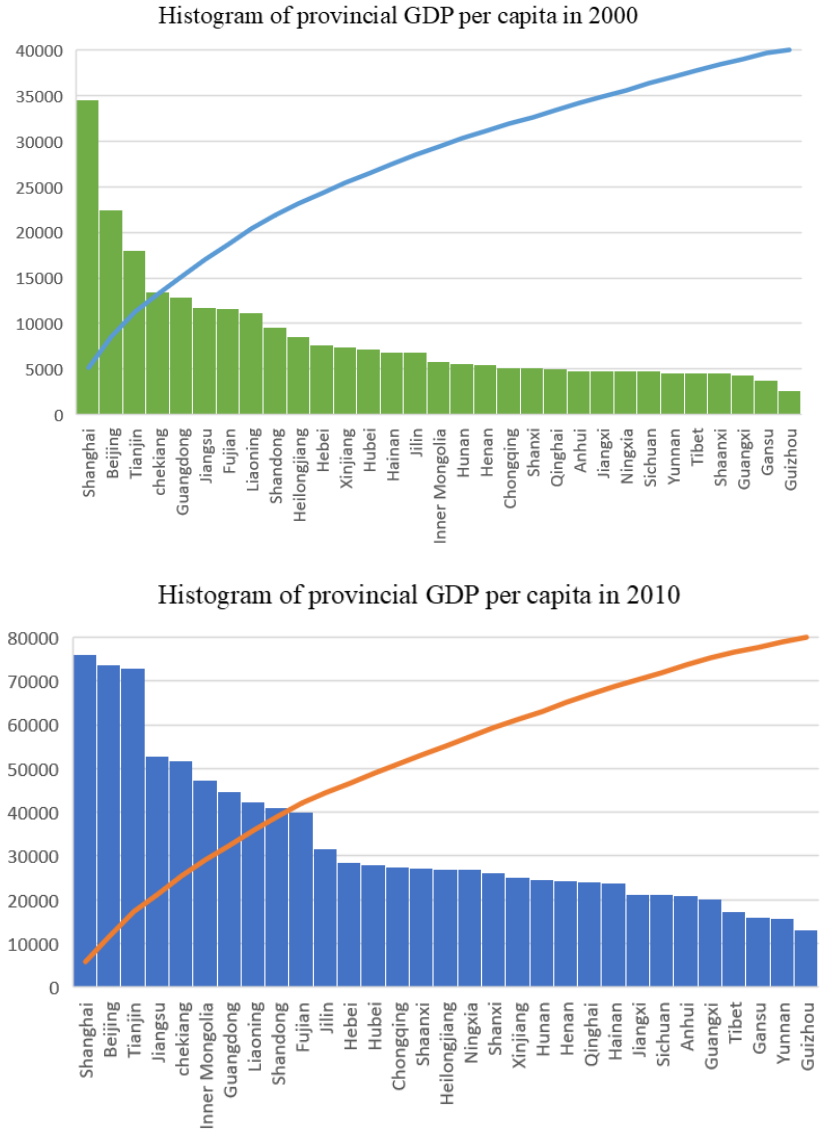


Figure 3. National per capita GDP histogram

It can be seen from Figure 3 that in the past 20 years, the per capita GDP of China 's provinces has shown great differences and changes. According to the data analysis, the economic development level of the eastern region has been ahead of the central and western regions. Among them, Beijing, Shanghai, Tianjin, Zhejiang, Jiangsu, Guangdong and other places have higher GDP, while Tibet, Qinghai, Gansu, Ningxia and other places are relatively low. At the same time, many provinces have also experienced fluctuations in economic growth, such as Henan, Shandong and other places have experienced cyclical changes in economic growth. Sichuan Province has been in a backward gradient since 2000, but in 2010, compared with the same gradient provinces 10 years ago, the economic growth was more significant.

3.3. The results of individual time point double fixed effect model

In this paper, a total of 775 samples were involved in the regression analysis of individual time point double fixed effect. The significant P value of the model was 0.000, and the model was significant. In the model, the P values (Prob > F) of the core explanatory variables education human capital and health human capital are both 0.000, and the P values of the control variables are also 0.000, which are all less than 0.05, indicating that the four variables have a significant impact on the explained variables. The absolute value of the t value of each variable is greater than 2, and the variable is significant at the 95 % confidence level. The specific regression results are shown in Table 6.

Table 6. Individual time-point double fixed regression results

$\ln gdp_{it}$	**ratio**	**standard error**	**z-value**	**P-value**	**95% confidence interval**
Edu_{it}	0.105	0.023	4.54	0.000	(0.059, 0.151)
$Heal_{it}$	0.096	0.009	10.19	0.000	(0.073, 0.108)
$greenland_{it}$	-0.055	0.008	-6.62	0.000	(-0.071, -0.039)
$road_{it}$	-0.001	0.000	-3.30	0.001	(-0.001, -0.000)

It can be seen from Table 6 that the influence coefficient of education human capital and health human capital is positive, indicating that both education human capital and health human capital can promote economic growth, which is consistent with the research conclusions of most scholars. The coefficient of education human capital in the regression equation is larger, indicating that the level of education currently contributes more to the economy.

The coefficient of determination is the ratio of the variation explained by the model to the total variation. It represents the numerical characteristics of the relationship between a random variable and multiple random variables. It is used to reflect the regression model and is a statistical index to explain the reliability of the dependent variable change. The coefficient of determination (R-squared) of the model is 0.979, which is very close to 1, indicating that the variation explained by the model accounts for a high proportion of the total variation. As shown in Figure 4, the regression line is very close to the observed value, the goodness of fit of the model is better, and the interpretation ability of the model is better.

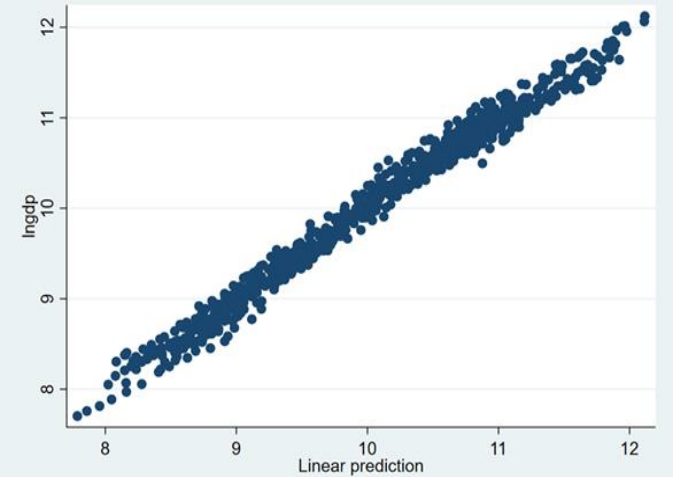


Figure 4. Regression results fitted plot

The influence of control variables $greenland_{it}$ and $road_{it}$ on $\ln gdp_{it}$ is negatively correlated. Combined with the regional characteristics of China, it can be seen that economically developed provinces are usually densely populated and have a large proportion of construction land. Although in recent years, they have focused on improving the living environment, due to the large population base, the per capita green space area and per capita highway mileage are small. At the same time, economically backward provinces (mainly western provinces) are generally sparsely populated, and the proportion of construction land is relatively small, resulting in a large per capita green area and per capita highway mileage.

The regression coefficient of education human capital is 0.105, indicating that when education human capital changes by 1 unit, China 's economic growth will change by 0.105 units. The regression coefficient of health human capital is 0.096, indicating that when health human capital changes by 1 unit, China 's economic growth will change by 0.096 units. The difference between health human capital and education human capital is 0.015 percentage points, indicating that

education human capital has a greater impact on economic growth, but the role of health human capital in economic growth cannot be ignored.

Education human capital and health human capital have a significant positive impact on economic growth. At the macro level, educational human capital promotes economic development by promoting technological progress and industrial structure optimization. Health human capital mainly affects individual labor ability and efficiency. Health human capital mainly affects economic growth by affecting individual labor ability and efficiency, which is a micro-level impact.

4. Conclusions

Through the solution of the individual time point double fixed effect model, it is found that both education human capital and health human capital have a significant role in promoting economic growth, but the role of education human capital is more obvious. When education human capital changes 1 unit, China 's economic growth will change 0.105 units. When health human capital changes 1 unit, China 's economic growth will change 0.09 units.

In order to further improve the educational human capital, the government can improve the educational human capital by increasing education investment, promoting education reform, promoting education digitization, increasing scholarships and subsidies, and promoting vocational education. Take health education and publicity, provide basic medical services, prevent disease control to enhance health human capital.

This paper also has some limitations. For example, although the selection of indicators has determined more scientific and reasonable indicators by looking up a large number of documents, it still has certain subjectivity and imperfection. When establishing the individual time point double fixed effect model, only the national level research was carried out, and no detailed discussion by province was carried out.

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