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Analysis of the Role of Human Capital on Economic Growth in the Beijing-Tianjin-Hebei Region

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Abstract

This paper uses some human capital related data in the Beijing-Tianjin-Hebei region as empirical data to study the impact of human capital on the economic growth of the Beijing-Tianjin-Hebei region; based on the selected data, the principal component analysis method is used to analyze health human capital, education human capital, and comprehensive human capital. Measure and compare the human capital differences of the three places in Beijing, Tianjin and Hebei. Finally, based on the economic growth model, the three places are regression analysis, and the results of different types of human capital on the three places are obtained. The analysis results show that different types of human capital measurement values in the Beijing-Tianjin-Hebei region are indeed different. In general, the human capital in the Beijing-Tianjin-Hebei region contributes more to economic growth than physical capital, and the contribution of health human capital is better than that of education human capital.

Keywords: Human capital, Economic growth, Regression analysis, Principal component analysis, Health; Education.

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1. Introduction

As China's economy shifts from high-speed growth to high-quality development, the role of human capital is becoming increasingly prominent. As one of China's major economic regions, the Beijing-Tianjin-Hebei area is also facing transformation. However, the distribution of human resources within the region is uneven, particularly the strong "siphon effect" of Beijing and Tianjin and their poor ability to radiate influence, which further highlights the uncoordinated economic development in the region. Therefore, it is of great significance to promote coordinated development in the Beijing-Tianjin-Hebei region, continuously adapt to economic development trends, conduct in-depth studies on different types of human capital and their impact on economic growth, and provide corresponding strategies and suggestions.

1.1 Overview of Foreign Research Achievements

Grossman (1972) found through empirical research that the level of productivity is closely related to healthy human capital, and investment in healthy human capital can improve individual health levels and promote economic growth. Mankiw et al. (1992) introduced human capital accumulation into empirical analysis and used the Solow model to find that increasing population and education investment can increase income, thereby explaining the role of human capital factors in promoting economic growth. Romer (1986) introduced knowledge as a capital variable into the economic growth model, which not only has a positive effect on economic growth but also reduces the utility of material capital. Berliant and Fujita (2011) introduced the diversity of skills into the empirical analysis model, which not only has a positive effect on economic growth but also promotes the formation of new ideas. Voyvoda and Yeldan (2015) found that subsidizing research and development investments to promote the development of research teams can drive economic growth. Siddiqui and Rehman (2017) used various educational indicators and labor production models to analyze the effect of human capital on economic growth in Asian countries, thus analyzing the role of primary and secondary education in promoting economic growth in East Asia, as well as the role of high school and vocational education in South Asia.

1.2 Overview of Domestic Research Achievements

Li et al. (2017) found in her research that the marketization of human capital can lead to market failures, which may cause innovation mechanisms to fail and hinder socio-economic growth. The sharing of knowledge and information can improve the quality of human capital. Hu and Zhang (2018), based on a comparative empirical analysis of human capital between Anhui Province and Jiangsu Province, concluded that the number of personnel engaged in scientific activities has a positive impact on the stock of human capital. The lack of innovation capacity due to the absence of scientific personnel is one of the reasons for the disparities between the two provinces. Yu and Miao (2019) summarized the literature on human capital and analyzed healthy human capital from both micro and macro perspectives, noting that health is not only the foundation of a worker's learning and physical strength but also promotes national economic growth and industry progress. Wan and Li (2018) pointed out in her study on the relationship between healthy human capital and regional economic growth that investment in healthy human capital can mitigate the negative effects of the absolute reduction in material capital and also promote regional economic growth in China.

1.3 Literature Review

Based on a review of research by scholars both domestically and internationally, human capital promotes economic growth, regardless of its nature or type. Different scholars study this from various angles, using different methods, leading to different conclusions (Lu & Cai, 2016; Luo & Yin, 2013; Zeng, Li, & Wu, 2017; Xu, Zeng, & Cao, 2018; Fang & Luo, 2016; Du, Yang, & Xia, 2014; Zhou, Wu, & Yu, 2010; Guo & Guo, 2017; Fu, Zhang, & Zhang, 2010). This paper primarily focuses on the limited research concerning the impact of various types of human capital on the economic growth of the Beijing-Tianjin-Hebei region. It examines how to adjust different types of human capital to foster economic growth as the economy enters a new normal.

2. Analysis of Human Capital and Economic Growth in the Beijing-Tianjin-Hebei Region

2.1 Analysis of the Current State of Human Capital

Since entering the era of the knowledge economy, human capital has contributed more to economic growth than physical capital. Therefore, fully tapping into the potential of human capital in the Beijing-Tianjin-Hebei region plays a vital role in its economic development. This section analyzes the current state of human capital in the Beijing-Tianjin-Hebei region, focusing on two aspects: educational human capital and health human capital.

2.1.1 Educational Human Capital

Humans are the primary factor in productivity, and education is a key component of human capital. Among the Beijing, Tianjin, and Hebei regions, the "siphon effect" is particularly evident in Beijing and Tianjin, with talent from across the region gravitating towards Beijing. As the industries in the Beijing-Tianjin-Hebei region upgrade, if talent does not shift accordingly, it can hinder the implementation of the region's integrated talent strategy. This also reduces the effectiveness of industrial transfer and structural optimization in the region. Educational human capital is the most dynamic factor in the coordinated development of the Beijing-Tianjin-Hebei area. The degree of coordination of educational human capital in the region determines the depth of integration in the Beijing-Tianjin-Hebei area. The basic situation of educational human capital in the Beijing-Tianjin-Hebei region is as follows:

(1) Investment in Educational Funding.

Educational funding primarily refers to the government's investment in education, which is crucial for the formation of educational human capital. The following table presents the investment in educational funding in the Beijing-Tianjin-Hebei region from 2013 to 2018.

Table 1: Investment in Education Funding in the Beijing-Tianjin-Hebei Region

		2013	2014	2015	2016	2017	2018
Beijing	Funding	9998366	10937374	11171250	11934724	12512746	13525400
	Average	4727.36	5082.42	5145.67	5492.28	5763.59	6279.2
	Proportion	4.73	4.77	4.51	4.41	4.19	4.09
Tianjin	Funding	5699615	6326265	5605736	5365129	5850624	6351712
	Average	3872.02	4170.28	3623.62	3434.78	3757.63	4071.61
	Proportion	5.73	5.95	5.15	4.67	4.70	4.75
Hebei	Funding	10298143	10861672	12861641	14203834	15938479	17389625
	Average	1404.37	1470.97	1732.21	1901.45	2119.48	2301.43
	Proportion	4.24	4.31	4.87	4.99	5.20	5.35

Note: Data source: China Statistical Yearbook

From Table 1, it is evident that:

First, in the Beijing area, educational funding increased from 99.98366 billion yuan in 2013 to 135.254 billion yuan in 2018, growing by 35.28% over nearly six years. The annual growth rates of educational funding were 9.39%, 2.14%, 6.83%, 4.84%, and 8.09% respectively. The proportion of educational funding to GDP was 4.73%, 4.77%, 4.51%, 4.41%, 4.19%, and 4.09%, showing a general yearly decrease but maintaining around 4.00%, which is at the national level, where the national average proportion of educational funding to GDP is roughly between 4%-5%.

Second, in the Hebei region, educational funding grew from 102.98143 billion yuan in 2013 to 173.89625 billion yuan in 2018, an increase of 68.86% over nearly six years. The annual growth rates were 5.47%, 18.41%, 10.44%, 12.21%, and 9.10% respectively. The proportion of educational funding to GDP progressively increased from 4.24% to 5.35%, placing it among the highest at the national level.

Third, in the Tianjin area, educational funding increased from 56.99615 billion yuan in 2013 to 63.51712 billion yuan in 2018, a rise of 11.44% over nearly six years. The annual changes in educational funding from 2013 to 2018 were 10.99%, -11.39%, -4.29%, 9.05%, and 8.58% respectively. The proportion of educational funding to GDP was 5.73%, 5.95%, 5.15%, 4.67%, 4.70%, and 4.75%.

Regarding per capita educational funding, Hebei had the lowest, Beijing the highest, and Tianjin was in between. Beijing's per capita educational funding far exceeded that of Tianjin and Hebei. Although educational funding in Beijing has been rising annually, its proportion of GDP has been decreasing, indicating that the rate of increase in educational human capital is slower than the GDP growth rate, and the utilization rate of educational human capital is relatively high. In Hebei, both the per capita educational funding and its GDP proportion have been increasing, showing a growing emphasis on education. In Tianjin, the slow growth of educational funding and its decreasing GDP proportion suggest a lack of emphasis on education, which has begun to change with the implementation of the "Haihe Talent" policy by the Tianjin government.

(2) Development of Different Educational Institutions.
To meet the growing demand for talent and improve educational standards, a large number of educational institutions are needed. This section primarily analyzes the number of institutions at the elementary, middle, high school, and university levels in the Beijing-Tianjin-Hebei region.

Table 2: Development of Different Educational Institutions in the Beijing-Tianjin-Hebei Region

		2013	2014	2015	2016	2017	2018	2019
Beijing	Elementary School	1093	1040	996	984	984	970	941
	Middle School	347	337	340	341	345	335	336
	High School	291	306	306	305	304	309	318
	University	89	89	91	91	92	92	93
Tianjin	Elementary School	12538	12529	12126	11944	11697	11545	11604
	Middle School	2381	2391	2378	2379	2375	2367	2405
	High School	563	567	578	598	630	655	679
	University	118	118	118	120	121	122	122
Hebei	Elementary School	838	842	849	857	857	879	877
	Middle School	325	326	329	334	338	347	340
	High School	193	181	180	182	187	189	187
	University	55	55	55	55	57	56	56

Note: Data source: China Statistical Yearbook

As society enters the economic era, the demand for high-quality talent inevitably increases, and corresponding educational facilities must also be enhanced. According to Table 2, over a span of seven years, the number of higher education institutions increased by four in Beijing, four in Hebei, and one in Tianjin. Overall, the number of higher education institutions in the Beijing-Tianjin-Hebei region remains relatively stable. Regarding elementary schools, the number of institutions in Tianjin has been increasing annually, while there has been a significant decrease in both Beijing and Hebei. For middle and high schools, the number of institutions in the Beijing-Tianjin-Hebei region is overall stable. Although Hebei has a much larger number of basic educational institutions compared to Beijing and Tianjin, when analyzing in conjunction with population size, Hebei significantly lags in per capita availability of educational institutions.

The reduction in the number of elementary schools in the Beijing and Hebei areas, the decrease in middle schools in the Beijing and Tianjin areas, and the decrease in high schools in Tianjin are believed to stem mainly from strengthened management of these institutions and supply-side reforms in education. The institutions that remain are more competitive and standardized, providing a better educational environment for students.

2.1.2 Health Human Capital

Health is a prerequisite for labor output and an important cornerstone for the stable economic development of a country. The role of public health in economic growth is increasingly evident and is a major factor in promoting economic growth. The following is an analysis of the investment in health in the Beijing-Tianjin-Hebei region.

(1) Total Health Expenditure.

Total health expenditure is used to measure the country's investment in medical and health services, which is closely related to the investment in health human capital. Increasing total health expenditure can enhance the level of health human capital.

Table 3: Healthcare Expenditure in the Beijing-Tianjin-Hebei Region

		2013	2014	2015	2016	2017	2018
Beijing	Funding	1349.6	1594.6	1834.8	2049.0	2193.8	2500.8
	Average	6381.09	7409.85	8451.4	9429.36	10105.02	11610.03
Tianjin	Funding	552.09	650.91	752.79	827.02	864.74	888.72
	Average	3034.87	3750.10	4866.32	5294.21	5554.36	5698.41
Hebei	Funding	658.84	770.44	904.88	940.96	1081.08	1198.28
	Average	898.46	1043.39	1218.69	1259.65	1437.61	1585.87

Note: Data source: China Statistical Yearbook

From Table 3, it is evident that the total healthcare expenditure in the Beijing-Tianjin-Hebei region has been increasing year by year, indicating a growing emphasis on medical and healthcare services in the region. Specifically, Beijing's total healthcare expenditure nearly doubled in the last six years, with per capita healthcare expenditure also nearly doubling from 6,381.09 RMB in 2013 to 11,610.03 RMB in 2018. While the growth rate in Tianjin and Hebei did not match Beijing's, it still increased by nearly 60%. In Tianjin, per capita healthcare expenditure rose from 3,034.87 RMB in 2013 to 5,698.41 RMB in 2018, and in

Hebei, per capita healthcare funding increased from 898.46 RMB in 2013 to 1,585.87 RMB in 2018. Beijing's per capita healthcare expenditure has been growing at an annual rate of 12.72%, Tianjin at 13.43%, and Hebei at 12.04%, with Tianjin experiencing the fastest growth rate.

(2) Number of Healthcare Institutions.

The number of healthcare institutions directly impacts the level of healthcare services and, indirectly, the health status of the population.

Table 4: Number of Healthcare Institutions per 10,000 People in the Beijing-Tianjin-Hebei Region

	2013	2014	2015	2016	2017	2018
Beijing	4.58	4.48	4.5	4.5	4.6	4.7
Tianjin	3.19	3.29	3.38	3.48	3.56	3.64
Hebei	10.7	10.68	10.59	10.55	10.76	11.26

Note: Data source: China Statistical Yearbook

According to Table 4, the number of healthcare institutions per 10,000 people in the Beijing-Tianjin-Hebei region has been increasing annually, with Hebei having the most per capita, likely due to the large number of medical and health institutions in the region. In Beijing, the number of healthcare institutions per 10,000 people has not changed significantly over the past six years. The increase in the number of healthcare institutions per 10,000 people in both Tianjin and Hebei is around 0.5, indicating that these areas are intensifying their investments in healthcare.

2.2 Analysis of Economic Growth Status

The Gross Domestic Product (GDP) of the Beijing-Tianjin-Hebei region has been rising annually, but the share of the region's GDP in the national GDP has been declining from 9.41% in 2013 to 8.64% in 2018, suggesting that the economic growth of the Beijing-Tianjin-Hebei region is lagging behind the national level. This section analyzes the economic status of the Beijing-Tianjin-Hebei region from the following aspects.

2.2.1 GDP of the Beijing-Tianjin-Hebei Region

Table 5: GDP Situation in the Beijing-Tianjin-Hebei Region

		2013	2014	2015	2016	2017	2018	2019
Beijing	GDP	21134.6	22926.0	24779.1	27041.2	29883.0	33106.0	35445.1
	Average	101023	107472	114662	124516	137596	153095	164563
Tianjin	GDP	9945.4	10640.6	10879.5	11477.2	12450.6	13362.9	14055.5
	Average	68937	71198	71021	73830	79837	85757	90058
Hebei	GDP	24259.6	25208.9	26398.4	28474.1	30640.8	32494.6	34978.6
	Average	33187	34260	35653	38233	40883	43108	46182

Note: Data source: China Statistical Yearbook

According to Table 5, the economy of the Beijing-Tianjin-Hebei region is in a phase of steady and continuous growth, with both GDP and per capita GDP increasing annually. Among the three regions, Beijing has the highest overall GDP growth rate and the fastest per capita GDP growth. Beijing also has the highest per capita GDP, followed by Tianjin, with Hebei having the lowest. Notably, the per capita GDP generally increases annually, and at a rate surpassing that of GDP growth, which indirectly indicates that, with a stable population size, the Beijing-Tianjin-Hebei region is focusing more on per capita metrics and seeking quality development.

2.2.2 Industrial Structure

Table 6: Industrial Structure of the Beijing-Tianjin-Hebei Region (Unit: %)

		2013	2014	2015	2016	2017	2018	2019
Beijing	Primary	0.76	6.94	0.57	0.48	0.41	0.36	0.32
	Secondary	19.72	19.34	17.84	17.25	16.90	16.55	15.99
	Tertiary	79.52	79.97	81.60	82.27	82.69	83.09	83.69
Tianjin	Primary	1.56	1.49	1.49	1.47	1.36	1.31	1.31
	Secondary	44.31	43.38	41.23	38.06	36.66	36.18	35.20
	Tertiary	54.13	55.13	57.24	60.47	61.98	62.50	63.38
Hebei	Primary	12.95	12.55	11.75	10.83	10.22	10.27	10.06
	Secondary	46.08	45.53	43.64	43.31	41.70	39.71	38.29
	Tertiary	40.97	41.92	44.62	45.86	48.08	50.01	51.65

Note: Data source: China Statistical Yearbook

Table 6 indicates that the industrial structure in the Beijing-Tianjin-Hebei region is undergoing optimization and upgrading, with the proportion of both the primary and secondary industries declining annually, while the share of the tertiary sector is increasing. Among these, Hebei has the lowest proportion of the tertiary sector, while Beijing has the highest. Since President Xi Jinping proposed the coordinated development of the Beijing-Tianjin-Hebei region in 2014, Beijing has been transferring low-end and high-pollution industries, focusing on the development of high-tech industries, leading to significant results in high-end industrial growth, a decline in the share of primary and secondary industries, and a rise in the tertiary sector. Tianjin, leveraging the advanced transportation links between Beijing and Tianjin, strategically undertakes new industries from Beijing, enhances inter-regional collaboration between schools and enterprises, and establishes a "1+11" acceptance model, significantly raising its tertiary sector. In recent years, Hebei has faced overcapacity, leading to a year-on-year decline in the proportion of the primary and secondary industries. However, as a recipient of industrial transfer in the coordinated development of the Beijing-Tianjin-Hebei region, Sun (2017) said that Hebei is integrating resources and accepting transfers as a pathway to sustainable development in the future.

3. Empirical Analysis

3.1 Measurement of Human Capital

This section selects five related indicators each for educational human capital and health human capital.

3.1.1 Selection of Related Indicators

The measurement of human capital cannot be accomplished with a single indicator; this chapter uses multiple sets of data from 2013 to 2018 from the Beijing, Tianjin, and Hebei regions, categorizing human capital into educational, health, and comprehensive human capital for measurement. Among these, educational human capital is a key component, and the selected influencing factors include: per capita educational funding (x1), number of regular higher education institutions (x2), number of full-time faculty per 10,000 people at regular higher education institutions (x3), number of graduates per 10,000 people from regular higher education institutions (x4), and the current year's educational funding as a percentage of GDP (x5).

Health human capital deepens human capital, and the selected influencing factors include: number of healthcare institutions per 10,000 people (y1), number of healthcare personnel per 10,000 people (y2), number of institutional beds per 10,000 people (y3), average life expectancy (y4), and per capita medical expenses (y5).

Comprehensive human capital reflects both health and educational human capital; hence, when measuring comprehensive human capital, the above ten variables are selected. The data sources for the selected indicators all come from the China Statistical Yearbook.

3.1.2 Empirical Measurement

(1) Educational Human Capital.

An analysis of the related data on educational human capital using SPSS yields a KMO test value of 0.523 and a Bartlett's test of sphericity significance of 0.000, indicating sufficient samples for principal component analysis. Through principal component analysis, the five previously defined indicators impacting educational human capital (x1, x2, x3, x4, x5) are transformed into two composite indicators A1 and A2, i.e., the principal components. These two principal components explain 89.906% of the information, having economic significance. Empirical results are shown in Tables 7, 8, and 9.

Using the component coefficient score matrix, we obtain:

$$A1=0.294*x1-0.267*x2+0.284*x3+0.299*x4-0.02*x5 \tag{1}$$

$$A2=0.234*x1+0.36*x2+0.289*x3-0.223*x4-0.609*x5 \tag{2}$$

Using the eigenvalues of the two principal components as weights, a comprehensive evaluation function for educational human capital is constructed. The coefficients are as follows:

$$a1=t1/(t1+t2) = 3.043/ (3.043+1.452) = 0.677 \quad (3)$$

$$a2=t2/(t1+t2) = 1.452/ (3.043+1.452) = 0.323 \quad (4)$$

Therefore, the comprehensive evaluation function for educational human capital is:

$$jy=0.677*A1+0.323*A2 \quad (5)$$

Table 7: KMO and Bartlett's Test

KMO Sampling Adequacy Measure		.523
Bartlett's Test of Sphericity	Approximate Chi-Square	120.965
	Degrees of Freedom	10
	Significance	.000

Table 8: Explanation of Total Variance

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.043	60.856	60.856	3.043	60.856	60.856
2	1.452	29.050	89.906	1.452	29.050	89.906
3	.476	9.527	99.433			
4	.024	.471	99.904			
5	.005	.096	100.000			

Note: Extraction Method: Principal Component Analysis.

Table 9: Component Score Coefficient Matrix

	Component	
	1	2
x1	.294	.234
x2	-.267	.360
x3	.284	.289
x4	.299	-.223
x5	-.020	-.609

Note: Extraction Method: Principal Component Analysis and Component Scores.

(2) Health Human Capital.

An SPSS analysis of the data related to health human capital results in a KMO test value of 0.523 and a Bartlett's test of sphericity significance of 0.000, indicating that the sample is sufficient for principal component analysis. Through principal

component analysis, the five previously defined indicators affecting health human capital (y1, y2, y3, y4, y5) are transformed into two composite indicators, B1 and B2, which are the principal components. These two principal components explain 97.853% of the information, which has economic significance. The empirical results can be seen in Tables 10, 11, and 12.
Using the component coefficient score matrix, the formulas for B1 and B2 are:

$$B1 = -0.216*y1 + 0.263*y2 + 0.139*y3 + 0.27*y4 + 0.286*y5 \tag{6}$$

$$B2 = 0.452*y1 + 0.268*y2 + 0.596*y3 - 0.244*y4 + 0.036*y5 \tag{7}$$

Using the eigenvalues of the two principal components as weights, a comprehensive evaluation function for health human capital is constructed. The coefficients are:

$$b1 = t1 / (t1 + t2) = 3.448 / (3.448 + 1.445) = 0.705 \tag{8}$$

$$b2 = t2 / (t1 + t2) = 1.445 / (3.448 + 1.445) = 0.295 \tag{9}$$

Therefore, the comprehensive evaluation function for health human capital is:

$$jk = 0.705*B1 + 0.295*B2 \tag{10}$$

Table 10: KMO and Bartlett's Test

KMO Sampling Adequacy Measure		.523
Bartlett's Test of Sphericity	Approximate Chi-Square	166.761
	Degrees of Freedom	10
	Significance	.000

Table 11: Explanation of Total Variance

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.448	68.952	68.952	3.448	68.952	68.952
2	1.445	28.901	97.853	1.445	28.901	97.853
3	.070	1.390	99.243			
4	.037	.741	99.984			
5	.001	.016	100.000			

Note: Extraction Method: Principal Component Analysis.

Table 12: Component Score Coefficient Matrix

	Component	
	1	2
x1	-.216	.452
x2	.263	.268
x3	.139	.596
x4	.270	-.244
x5	.286	.036

Note: Extraction Method: Principal Component Analysis and Component Scores.

(3) Comprehensive Human Capital.

An SPSS analysis of the data for comprehensive human capital, drawing from health and educational human capital data, resulted in a KMO test value of 0.656 and a Bartlett's test of sphericity significance of 0.00, indicating that the sample is sufficient for principal component analysis. The analysis transformed the composite variables affecting human capital into three comprehensive variables, or principal components D1, D2, D3. These three principal components explain 98.099% of the information, which has economic significance. The empirical results can be found in Tables 13, 14, and 15.

Using the component score coefficient matrix, the formulas for D1, D2, and D3 are:

$$D1 = 0.156*x1 - 0.099*x2 + 0.154*x3 + 0.123*x4 - 0.004*x5 - 0.142*y1 + 0.126*y2 + 0.042*y3 + 0.158*y4 + 0.151*y5 \tag{11}$$

$$D2 = 0.049*x1 + 0.267*x2 + 0.064*x3 - 0.211*x4 - 0.222*x5 + 0.161*y1 + 0.211*y2 + 0.301*y3 - 0.039*y4 + 0.103*y5 \tag{12}$$

$$D3 = 0.213*x1 + 0.087*x2 + 0.097*x3 - 0.165*x4 + 1.067*x5 + 0.021*y1 + 0.113*y2 + 0.48*y3 + 0.029*y4 - 0.082*y5 \tag{13}$$

Using the eigenvalues of the three principal components as weights, a comprehensive human capital evaluation function is constructed. The coefficients are:

$$d1 = t1 / (t1 + t2 + t3) = 6.23 / (6.23 + 2.903 + 0.676) = 0.635 \tag{14}$$

$$d2 = t2 / (t1 + t2 + t3) = 2.903 / (6.23 + 2.903 + 0.676) = 0.296 \tag{15}$$

$$d3 = t3 / (t1 + t2 + t3) = 0.676 / (6.23 + 2.903 + 0.676) = 0.069 \tag{16}$$

Therefore, the comprehensive human capital evaluation function is:

$$rl = 0.635*D1 + 0.296*D2 + 0.069*D3 \tag{17}$$

Table 13: KMO and Bartlett's Test

KMO Sampling Adequacy Measure		.656
Bartlett's Test of Sphericity	Approximate Chi-Square	513.285
	Degrees of Freedom	45
	Significance	.000

Table 14: Explanation of Total Variance

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.230	62.303	62.303	6.230	62.303	62.303
2	2.903	29.031	91.334	2.903	29.031	91.334
3	.676	6.765	98.099			
4	.157	1.566	99.665			
5	.027	.273	99.937			
6	.004	.040	99.978			
7	.001	.012	99.990			
8	.001	.007	99.997			
9	.000	.002	99.999			
10	.000	.001	100.000			

Note: Extraction Method: Principal Component Analysis.

Table 15: Component Score Coefficient Matrix

	Component	
	1	2
y1	-.142	.161
y2	.126	.211
y3	.042	.301
y4	.158	-.039
y5	.151	.103
x1	.156	.049
x2	-.099	.267
x3	.154	.064
x4	.123	-.211
x5	-.040	-.222

Note: Extraction Method: Principal Component Analysis and Component Scores.

3.1.3 Empirical Results Analysis

(1) Measurement Results of Educational Human Capital.

Table 16: Evaluation Values of Educational Human Capital

	2013	2014	2015	2016	2017	2018
Beijing	1309.83	1407.11	1424.60	1520.01	1594.20	1736.06
Tianjin	1075.30	1156.90	1007.37	955.82	1044.62	1130.89
Hebei	385.75	404.18	475.50	521.93	581.62	631.73

Combining the component score coefficient matrix with the constructed comprehensive evaluation function, the relationship between the comprehensive measurement value for education and each indicator can be determined:

$$jy = 0.275*x1 - 0.064*x2 + 0.286*x3 + 0.127*x4 - 0.21*x5 \quad (18)$$

From the above formula, it can be seen that the indicators for per capita educational funding (x1) and the number of full-time faculty at regular higher education institutions per 10,000 people (x3) have the greatest impact on the measured comprehensive value of educational human capital, with impacts of 0.275 and 0.286, respectively. The x5 indicator represents the current year's educational funding as a percentage of GDP, which can be used to measure the cost of educational expenditure; the higher the cost, the less favorable it is for educational human capital, hence x5 is negatively correlated with educational human capital.

Table 17: Specific Data for Indicators x1 and x3 in the Beijing-Tianjin-Hebei Region

	Indicator	2013	2014	2015	2016	2017	2018
Beijing	x1	4727.36	5082.42	5145.67	5492.28	5763.59	6279.2
	x3	31.63	31.78	31.64	32.21	32.11	33.01
Tianjin	x1	3872.02	4170.28	3623.62	3434.78	3757.63	4071.61
	x3	20.99	20.44	20.1	19.53	19.97	20.13
Hebei	x1	1404.37	1470.97	1732.21	1901.45	2119.48	2301.43
	x3	9.11	9.29	9.35	9.42	9.69	9.99

The data in the table shows that the per capita educational funding and the number of full-time faculty at regular higher education institutions per 10,000 people in the Beijing area are much higher than those in Hebei and Tianjin. This results in a higher composite value of educational human capital in Beijing compared to the other two areas. Although the number of full-time faculty at regular higher education institutions in Hebei is the highest among the three areas, the large population in Hebei results in the fewest full-time faculty per 10,000 people. This indicates that

Hebei should increase investment in educational funding and cultivate more full-time faculty at regular higher education institutions, possibly by attracting talent or encouraging graduates to stay on as faculty.
From the results of the principal component analysis, as the economy grows, educational human capital also increases, and its role in economic growth becomes increasingly apparent. This is mainly due to the increase in per capita educational funding, which leads to a rise in the level of education among employed personnel, as well as an improved student-to-teacher ratio at universities, which brings down the cost of education. With the increase in educational human capital, the quality of human capital improves, enhancing labor productivity and promoting economic growth. The data from the table show that educational human capital in the Beijing, Tianjin, and Hebei regions is increasing year by year. Among the influencing factors, per capita educational funding and the number of graduates from regular higher education institutions per 10,000 people are both increasing annually, with the most significant being the rise in educational funding. The educational human capital in the Beijing region is significantly higher than in Hebei and Tianjin, which is mainly related to the level of local economic development. Hebei has a significant potential for improvement compared to the other regions; Beijing's educational human capital is about three times that of Hebei, but from 2013 to 2018, Hebei's average annual growth rate was 10.37%, while Beijing's was 5.80%, indicating that Hebei is growing at a faster rate.

(2) Measurement Results of Health Human Capital.

Table 18: Evaluation Values of Health Human Capital

	2013	2014	2015	2016	2017	2018
Beijing	1410.16	1629.79	1852.52	2061.99	2207.81	2529.38
Tianjin	683.30	835.69	1073.61	1165.27	1222.23	1253.20
Hebei	228.45	260.48	298.95	308.90	348.96	382.39

Combining the component score coefficient matrix with the constructed comprehensive evaluation function, the relationship between the comprehensive measurement value for health and each indicator can be established:

$$jk = -0.019*y1 + 0.264*y2 + 0.274*y3 + 0.118*y4 + 0.212*y5 \tag{19}$$

From the above formula, it can be seen that the number of healthcare personnel per 10,000 people (y2) and the number of institutional beds per 10,000 people (y3) have the most significant impact on the measured comprehensive value of health human capital, with impacts of 0.264 and 0.274, respectively. The y1 indicator represents the number of healthcare institutions per 10,000 people, which measures the number of institutions set up to maintain the medical level for every 10,000 people. If the medical level is constant, a larger number of healthcare institutions indicates a greater investment, hence y1 is negatively correlated with health human capital.

Table 19: Specific Data for Indicators y2 and y3 in the Beijing-Tianjin-Hebei Region

	Indicator	2013	2014	2015	2016	2017	2018
Beijing	y2	124.4	127.32	133.21	137.83	145.19	151.39
	y3	49.18	51.03	51.4	53.86	55.58	57.39
Tianjin	y2	72.35	73.63	76.34	78.49	83.24	84.94
	y3	39.22	40.12	41.17	42.15	43.94	43.75
Hebei	y2	67.09	69.46	71.82	74.31	78.54	82.58
	y3	41.39	43.73	46.07	48.26	52.53	55.84

The data from the table indicates that the number of healthcare personnel per 10,000 people in the Beijing area is significantly higher than in Tianjin and Hebei, and Beijing also leads in the number of institutional beds per 10,000 people. However, Tianjin lags behind Hebei in terms of the number of institutional beds per 10,000 people. Among the three regions, Hebei has the least health human capital. It is apparent from the relationship between health human capital and various indicators that Hebei scores lower than Beijing and Tianjin on all counts, thus having less health human capital compared to the other two regions.

From the results of the principal component analysis, health human capital shows an increasing trend year by year. The improvement in health human capital is mainly reflected in the annual increase in the number of healthcare institutions, the number of healthcare personnel, and the number of institutional beds per 10,000 people, as well as the increase in average life expectancy. Health is a deepening of human capital; a healthy living state is crucial to improving labor productivity and is an important guarantee for stable economic growth. As Table 19 suggests, health human capital in the Beijing-Tianjin-Hebei region is generally on an upward trend year by year, indicating a close relationship between health human capital and economic growth. The Beijing area is far ahead of the other two regions, which is closely related to the local level of economic development. Looking at the selected indicators, the number of healthcare facilities, healthcare personnel, and institutional beds in Hebei far surpasses those in Beijing and Tianjin. However, Hebei has a larger population than the combined populations of the other two regions, which dilutes the per capita advantages for Hebei.

(3) Measurement Results of Comprehensive Human Capital.

Table 20: Evaluation Values of Comprehensive Human Capital

	2013	2014	2015	2016	2017	2018
Beijing	1415.94	1586.40	1721.21	1884.86	2002.58	2251.69
Tianjin	890.92	1015.76	1080.92	1108.76	1182.65	1240.53
Hebei	315.15	341.92	397.30	424.71	475.47	517.85

The results of the principal component analysis show that human capital is a potential factor for economic growth, especially in the knowledge economy era where human capital's utility far exceeds that of physical capital and is a key factor in China's economic transformation. From the data, between 2013 and 2018, Beijing's human capital consistently led Tianjin and Hebei. All three regions showed an annual increase in human capital, with Hebei growing the fastest, followed by Beijing, and Tianjin the slowest. According to the "catch-up effect" theory, the return on investment in human capital is higher in Hebei. Beijing's large human capital measurement can be attributed to its leading position in both educational and health human capital among the three regions. Hebei's growth rate surpasses Tianjin, and data show that Tianjin's human capital growth rate is the lowest among the three, indicating economic difficulties in Tianjin. Beijing exerts a "siphon effect," while Hebei is implementing the "Giant Plan" to foster around 100 innovative teams under the leadership of leading talents, accelerating talent development.

3.2 Regression Analysis of Human Capital's Impact on Economic Growth

3.2.1 Selection of Indicators

(1) Dependent Variable: Per Capita GDP.

(2) Independent Variables:

<u>Type 1 Variables: Human Capital</u>

Human capital is the core indicator of this section, and this part performs regressions of per capita GDP on different types of human capital (educational human capital jy, health human capital jk).

Educational Human Capital: Increasing investment in educational human capital can enhance workers' skills and their understanding of optimal production methods, thereby improving productivity. The indicators related to educational human capital include per capita educational funding (x1), number of regular higher education institutions (x2), number of full-time faculty per 10,000 people at these institutions (x3), number of graduates per 10,000 people (x4), and the proportion of current educational funding to GDP (x5).

Health Human Capital: Health is crucial for national economic development and is a deepening of human capital. Indicators related to health human capital include the number of healthcare institutions per 10,000 people (y1), the number of healthcare personnel per 10,000 people (y2), the number of institutional beds per 10,000 people (y3), average life expectancy (y4), and per capita medical expenses (y5).

<u>Type 2 Variables: Physical Capital</u>

Physical capital draws on the research findings of Xu and Xie (2018), represented by the amount of fixed asset investment, denoted as wz.

Type 3 Variables: Degree of External Dependence

The degree of external dependency is mainly used to measure the level of openness and is quantified by the proportion of imports and exports to GDP, denoted as jck.

Type 4 Variables: Per Capita Consumption Level

The per capita consumption level is determined by the level of household consumption. As a country's economy develops and per capita GDP increases, the consumption level of residents also rises, denoted by xf.

3.2.2 Empirical Analysis

The traditional economic growth model, the Cobb-Douglas, which includes labor quantity L and capital input K, is not suitable for today's societal development; therefore, modifications have been made.

The selected model is:

$$y_{it}=Arl_{it}^{b1}wz_{it}^{b2}jck_{it}^{b3}xf_{it}^{b4}u_{it} \quad (20)$$

In the model, y represents per capita GDP, A represents the level of technology, rl represents the comprehensive level of human capital, wz represents physical capital, jck represents the degree of external dependency, xf represents the per capita consumption level, u represents the random disturbance, i represents the regional dimension, and t represents the time dimension. The coefficients b1, b2, b3, and b4 respectively represent the elasticity of the corresponding variables to y.

The core variables of this article are educational human capital, health human capital, and comprehensive human capital. Considering the variability in the data, after standardizing the model, a linear model is obtained:

$$lny_{it}=lnA + b1lnrl_{it} + b2lnwz_{it} + b3lnjck_{it} + b4lnxf_{it} + lnu_{it} \quad (21)$$

3.2.3 Regression Results Analysis

(1) Regression of Per Capita GDP on Comprehensive Human Capital, Physical Capital, Per Capita Consumption Level, and External Dependency.

Using data from the Beijing-Tianjin-Hebei region, the regression model shows that all variables are significant. The adjusted goodness of fit reached 99.2%. Overall, human capital has a positive effect on economic growth in the region. An increase of one unit in comprehensive human capital can lead to an economic growth of 5.1 units. This is primarily due to increased investments in education and health, which enhance understanding of the best production methods and improve productivity. The enhancement of human capital can indirectly participate in economic production by improving people's innovative capabilities and can also directly contribute as a factor of production.

(2) Regression of Per Capita GDP on Health Human Capital, Physical Capital, Per Capita Consumption Level, and External Dependency.

Based on data from the Beijing-Tianjin-Hebei region, the regression model shows that all variables are significant. The adjusted goodness of fit reached 99.2%. Overall, human capital has a positive effect on economic growth in the region. An increase of one unit in health human capital can promote economic growth by 2.69 units. This is mainly because health human capital ensures the physical quality of workers, and an increase in life expectancy can extend working hours, thereby enhancing the accumulation of human capital.

(3) Regression of Per Capita GDP on Educational Human Capital, Physical Capital, Per Capita Consumption Level, and External Dependency.

Using data from the Beijing-Tianjin-Hebei region, the regression model shows that all variables are significant. The adjusted goodness of fit reached 97.4%. Overall, human capital has a positive effect on economic growth in the region. An increase of one unit in educational human capital can lead to economic growth of 1.91 units. This is primarily due to an enhancement in educational levels, which improves people's innovative abilities and thus enhances the total factor productivity, leading to economic growth. Particularly in the era of the knowledge economy, education can provide workers with the knowledge and skills needed to adapt to contemporary competitive environments, transforming education into a productive force.

(4) Comparison of Comprehensive Human Capital and Physical Capital

Empirical research shows that one unit of physical capital contributes to economic growth by 0.3 units, one unit of educational human capital contributes 1.91 units, one unit of health human capital contributes 2.69 units, and one unit of comprehensive human capital contributes 5.1 units. The contribution of human capital to economic growth in the Beijing-Tianjin-Hebei region is greater than that of physical capital. This indicates that as the economy and society develop, the role of human capital becomes increasingly evident. The previous development model, which relied solely on the input of physical capital for economic growth, is no longer applicable. For sustained and long-term economic development, the input of human capital is necessary.

4. Conclusion

Different regions yield varying evaluation values of human capital types when applying principal component analysis. The Tianjin and Hebei regions should focus on enhancing their educational funding and the number of full-time faculty in universities. The Beijing area should adjust the scale of its universities appropriately, retaining those with core competitive strengths to enhance educational human capital. The Tianjin and Hebei regions should also focus on the training and introduction of medical and healthcare personnel and on increasing basic medical infrastructure, such as medical units and the number of institutional beds. Regression analysis shows that human capital promotes economic growth in the

Beijing-Tianjin-Hebei region, but the elasticity of different types of production factors to economic growth varies. The output elasticity of human capital in the region exceeds that of physical capital. However, when examined separately, the differences in human capital conditions are quite severe. The output elasticity of human capital in the Tianjin and Hebei regions is less than that of physical capital, while in Beijing, the output elasticity of human capital is greater than that of physical capital. This is primarily due to Beijing's strong attraction for talent, leading to uneven distribution of human capital across the region. In response, Hebei could adopt a complementary and coordinated approach among the three regions to enhance talent introduction.

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