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The Development of Higher Education and Regional Economic Growth: The Mediating Effects of Regional Innovation Capacity and Human Capital

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Abstract: Based on provincial panel data from 2001 to 2020, this paper empirically examines the relationship between higher education and regional economic growth, as well as the potential mediating roles of regional innovation capacity and human capital levels, using fixed-effects models and path analysis. The findings indicate that higher education can directly promote regional economic growth. Higher education not only promotes economic growth through human capital and innovation levels but also through the chain-mediating effects of human capital and innovation levels. The impact of higher education on regional economic growth exhibits regional heterogeneity, with the highest impact in the eastern region, followed by the central region, and a negative impact in the western region. Based on the analysis, this paper suggests that optimizing the employment environment in the central and western regions can leverage the role of higher education development in driving economic growth.

Keywords: Higher Education; Regional Economic Growth; Technological Innovation; Human Capital; Fixed Effects.

1. Introduction

Economic development is the core theme of development economics and the foundation for a country to achieve comprehensive social development. President Xi Jinping has repeatedly emphasized that development is the basis and key to solving all problems in China, and it must be scientific development that unwaveringly implements the concepts of innovation, coordination, green development, openness, and shared prosperity. Regional economic development, which reflects the economic conditions of provinces (municipalities directly under the central government and autonomous regions), is the foundation of national economic development. Only with a sound regional economic development can the country achieve stable economic growth.

Human capital theory and innovation theory suggest that human capital and technological innovation are key factors for economic development. To achieve sustainable economic growth, talent and innovation are indispensable. However, where do talent and innovation come from? American economist Gary Becker and Japanese economist Hirofumi Uzawa argue that education, especially higher education, is one of the important pathways for the formation of human capital. Higher education plays a significant role in enhancing a country's human capital level and regional innovation capacity. Therefore, promoting the development of education, particularly higher education, to cultivate talent and foster innovation can drive continuous and stable economic growth.

In China, the rapid economic and social development since the reform and opening up has been closely related to the development of higher education, which has led scholars to explore the relationship between the two and generate a rich body of literature. This literature can be divided into two main aspects: studies on the relationship between economic growth and higher education development, and studies on the mechanisms through which higher education development affects economic growth. Regarding the relationship between the two, scholars have put forward three perspectives: First, economic development comes first, and economic growth promotes the development of higher education; second, higher education development comes first, and it promotes economic growth; third, higher education development and economic growth promote each other. This paper assumes that higher education is the cause, that is, the development of higher education can promote economic growth.

Regarding the mechanisms through which higher education affects economic growth, studies have found that human capital, industrial structure, innovation, and factor mobility are all potential mechanisms through which higher education development can promote economic growth. Despite the extensive research on the relationship between higher education development and economic growth, scholars have not reached a consensus, mainly due to the following reasons: First, data selection issues—existing studies have examined the relationship between higher education development and economic growth at the national, provincial, and municipal levels, with varying data spans, which may lead to estimation biases. Second, variable selection issues—measuring higher education development is complex and varied. Some studies use single indicators such as higher education funding input or student-faculty ratio, while others construct a higher education development index using methods like entropy weight method or principal component analysis, leading to estimation deviations.

This paper selects provincial panel data from 2001 to 2020 to examine the relationship between higher education and economic development over a long time span. Using fixed-effects models, this paper controls for unobservable province-specific characteristics that vary over time and time-specific characteristics that vary across provinces to enhance the accuracy of regression results. In terms of variable selection, this paper constructs a higher education development index using four indicators (logarithm of average students per school, logarithm of average graduates per school, logarithm of average full-time faculty per school, and logarithm of average educational funding per school) through principal

component analysis to improve the rationality and representativeness of variable selection. For the mediation effect test, this paper employs path analysis for verification. The research findings are as follows: (1) Higher education can directly promote regional economic growth; (2) Higher education not only promotes economic growth through human capital and innovation levels but also through the chain-mediating effects of human capital and innovation levels; (3) The impact of higher education on regional economic growth exhibits regional heterogeneity, with the highest impact in the eastern region, followed by the central region, and a negative impact in the western region.

The remainder of this paper is organized as follows: Section II reviews the existing literature and proposes research hypotheses based on this review. Section III presents the research design, including data sources, screening, variable selection, and model specification. Section IV reports the empirical results. Section V concludes the paper.

2. Literature Review and Research Hypotheses

(1) Research on Higher Education Development Indicators

The construction of higher education development indicators is the foundation for studying the relationship between higher education development and regional economic growth. Existing studies have constructed various indicator systems from the perspectives of higher education input and output. Cui Yuping used 22 quantifiable indicators related to higher education development to construct an evaluation index system for provincial higher education development from the aspects of input, output, efficiency, and speed. Based on this, he ranked and classified the higher education development of 31 provinces (municipalities directly under the central government and autonomous regions). Zhan Zhengmao selected six quantifiable indicators, including gross enrollment ratio, number of people with higher education per ten thousand, total building area, student-faculty ratio, average school size, and proportion of full-time teachers. Using the AHP method to determine the weights of these indicators, he calculated the comprehensive rating index of higher education development. Liu Liusheng, Feng Yongjun, Lv Jiaolan, and others chose seven indicators, including the number of regular colleges and universities, the number of college students, the number of "211 Project" institutions, the number of "985 Project" institutions, the number of associate degree students, the number of bachelor's degree students, and the number of graduate students. Using principal component analysis, they constructed the higher education development index for each province (municipality directly under the central government and autonomous region). Zhang Nanxing et al. used seven dimensions of higher education development, including overall scale, faculty strength, internationalization, informatization, social service, funding input, and diversified participation. Using the PLS structural equation model, they calculated the comprehensive development level of higher education in each province. Chen Bin constructed the higher education development evaluation index for each province and city in China from three dimensions: higher education input index, opportunity index, and quality index. He selected four quantifiable indicators, including the per capita expenditure index of higher education institutions, the gross enrollment ratio index of higher education, the index of the proportion of full-time teachers with doctoral degrees in higher education institutions, and the index of the proportion of key institutions in the total number of colleges and universities in the province.

(2) Research on the Relationship Between Higher Education Development and Regional Economic Growth

Since the 1960s, when Schultz and Becker proposed the human capital theory, higher education, as an important pathway for the formation of human capital, has attracted significant attention from scholars both domestically and internationally regarding its relationship with economic development. Extensive research results have been achieved in this area. Schultz, using post-World War II America as a case study, found that a substantial increase in higher education investment could lead to rapid national economic growth. In contrast, Blankenau, who selected higher education investment data from both developed and developing countries, concluded through empirical analysis that increased investment in higher education in developing countries did not significantly promote economic growth. Domestic research has reached two different conclusions: either higher education has limited contribution to economic development or it can effectively promote economic development. Scholars such as Cui Yuping and Wang Sha hold the former view. Cui Yuping calculated the contribution of higher education development to economic growth in China from 1982 to 1990 and found that, compared with developed countries, the contribution rate of higher education to economic growth in China was very low. Wang Sha used panel data from 285 cities above the prefecture level in China from 2003 to 2012 to examine the impact of higher education on regional economic growth from both scale and quality perspectives. The study found that the impact of higher education scale on economic growth varies across regions, while the promoting effect of higher education quality on regional economic growth is limited. Scholars such as Ye Maolin, Zhou Caiyun, Zhou Xia, and Wang Lika hold the latter view. Ye Maolin, based on data on gross domestic product (GDP), investment, and labor force with different education levels from 1981 to 2000, used econometric methods to analyze the relationship between education and economic growth. The results showed that education is an important factor in promoting economic growth. Zhou Caiyun, using provincial panel data from 2006 to 2010, analyzed the role of higher education in driving regional economic growth. The results indicated that educational investment is conducive to promoting economic growth, while the number of faculty members in higher education institutions was negatively correlated with economic development. Chen Xia, based on data from China from 1994 to 2009, used the Granger causality test method to empirically analyze the relationship between China's GDP, higher education funding, the number of full-time teachers, and the number of students. The results showed that higher education funding has a strong positive effect on the economy, while the effect of the number of full-time teachers is weaker, and the number of students has a negative impact on economic growth. Wang Lika, using the Yangtze River Delta region as a case study, empirically examined the impact of higher education development on regional economic growth using statistical analysis methods. The study found that higher education has a significant positive effect on economic growth in the Yangtze River Delta region.

(3) Research on the Mechanisms Through Which Higher Education Development Promotes Regional Economic

Growth

By reviewing the relevant literature, three main perspectives can be identified regarding the mechanisms through which higher education drives economic development:

Human Capital Mechanism: Higher education is an important pathway for cultivating talent. Human capital, as a factor of production, directly participates in economic activities and promotes economic growth through continuous accumulation. Lucas, using econometric models, demonstrated that investment in higher education indirectly promotes economic growth by increasing the accumulation of human capital. Li Dehuang et al. constructed a measurement system for human capital stock from four dimensions—education, retraining of the labor force, physical and mental health, and rational mobility. Their empirical analysis showed that human capital is an important factor in promoting economic growth in China.

Technological Innovation Mechanism: The development of higher education can enhance regional innovation capacity, thereby promoting regional economic growth. Nelson et al. argued that government investment in higher education can promote economic growth through knowledge spillover and technology diffusion effects. Barro et al. also pointed out that the expansion of higher education can effectively influence innovation, drive technological progress, and thus impact economic growth.

Hybrid Mechanism: The development of higher education can promote economic growth both by enhancing human capital and by driving technological innovation. Moreover, human capital can also promote economic growth by facilitating technological innovation. Yang Yi, Hu Junnan, and Tan Ning, using provincial panel data from China (2000–2017) and applying the spatial Durbin model, found that higher education investment and high-level human capital exhibit strong spatial autocorrelation. The direct and indirect spillover effects of technological innovation associated with high-level human capital can drive economic growth. Du Wei et al., using data from 29 provinces and cities (2002–2020), pointed out that human capital directly promotes economic growth and also drives economic growth through technological imitation and innovation brought about by the accumulation of human capital.

(4) Research Hypotheses

Based on the review of existing literature, this paper proposes the following research hypotheses:

Hypothesis 1: Regional higher education development can promote regional economic growth.

Hypothesis 2a: Regional innovation capacity mediates the relationship between higher education development and regional economic growth.

Hypothesis 2b: Regional human capital level mediates the relationship between higher education development and regional economic growth.

Hypothesis 2c: Higher education can promote economic growth through the chain-mediating effects of regional human capital level and regional innovation capacity.

Hypothesis 3: The impact of higher education development on regional economic development exhibits regional heterogeneity.

3. Research Design

Table 1. The main sources of the sample data

Data/Variable	Source
Regional Gross Domestic Product (GDP) (in billion yuan) Number of Higher Education Institutions (institutions) Number of Teachers (persons) Number of Enrolled Students (in ten thousand persons) Number of Patent Applications and Authorizations (items) Local Government General Budget Expenditure (in billion yuan) Local Government Science and Technology Expenditure (in billion yuan) Total Import and Export of Goods (in billion US dollars) Urban Population Proportion Technical Market Transaction Volume (in billion yuan)	China Statistical Yearbook
Higher Education Institutions' Revenue by Region (in billion yuan)	China Education Finance Statistical Yearbook
Total Fixed Asset Investment in the Whole Society (in billion yuan)	China Fixed Asset Investment Statistical Yearbook China Investment Sector Statistical Yearbook
Employment in Various Industries of the Whole Society (in ten thousand persons)	Statistical Yearbooks of Provinces (Municipalities Directly under the Central Government, Autonomous Regions)
Proportion of Personnel with Higher Education in the Employed Population	China Population and Employment Statistical Yearbook China Employment Statistical Yearbook

(1) Data Sources and Processing

The primary data for this study are derived from the China Statistical Year book covering the period from 2002 to 2021.Due to missing data on the educational attainment of the labor force and total employment across provinces for the years 2001–2020, the China Population and Employment Statistical Year book and the China Labor Statistical Year book are used as supplementary sources for these variables. Table 1 lists the main variables and their respective data sources. Additionally, due to the absence of data for Hong Kong, Macau, and Taiwan in the statistical year books, and the significant data gaps for the Tibet Autonomous Region, this study ultimately selects 30 provinces, municipalities directly under the central government, and autonomous regions (excluding the Tibet Autonomous Region, Hong Kong, Macau, and Taiwan) as the sample for analysis. The time span of the study is from 2001 to 2020, resulting in a dataset of 600 observations based on 30 samples. The China Statistical Year book, China Population and Employment Statistical Year book, and China Labor Statistical Year book are national-level statistical publications released by the National Bureau of Statistics, and thus they possess good representativeness and are suitable as the foundation for this study.

(2) Variable Selection

• Dependent Variable

The research topic of this paper is the impact of higher education development on regional economic growth. Therefore, the dependent variable in this study is regional economic growth. Regarding the selection of variables, different scholars have varying understandings of economic growth. This paper draws on the research of Jin Tong and Wu Min, using the logarithm of per capita regional gross domestic product (GDP) (in billion yuan) for each province to represent regional economic growth.

• Explanatory Variable

The core explanatory variable in this paper is higher education development, which indicates the level of higher education development in a province. Existing studies mainly measure higher education development from two aspects: scale and quality. The primary indicators include the number of students enrolled in higher education institutions, the number of admissions, the number of graduates, the student-faculty ratio in higher education institutions, and the educational funding input for higher education. Considering the insufficiency of single indicators in representing the overall situation, this paper selects four quantitative indicators based on data availability and research needs: the logarithm of average number of students per institution, the logarithm of average number of graduates per institution, the logarithm of average number of full-time faculty members per institution, and the logarithm of average educational funding input per institution. These indicators are then used to construct a composite index (FAC1_1)reflecting the development of higher education in the region using principal component analysis(PCA).Table 2 shows the results of the KMO and Bartlett's test of sphericity for the principal component analysis. The KMO coefficient is 0.706, indicating a good degree of partial correlation among the variables, which is suitable for factor analysis. The significance level of Bartlett's test of sphericity is less than 0.001,rejecting the null hypothesis. This suggests that there is a correlation among the original variables, confirming that factor analysis is appropriate.

• Mediating Variables

Regional Innovation Capacity: Ren Shenggang and Peng Jianhua argue that regional innovation capacity refers to the level of innovation input and output by various innovation entities within a specific region under certain innovation conditions. This paper defines the innovation capacity of provinces (municipalities directly under the central government and autonomous regions) from the perspective of innovation output. Specifically, drawing on the research of Yao Chen and Hu Haiyang, this paper uses the number of patent applications as a proxy variable for regional innovation capacity.

Human Capital Level: To explore the mediating role of human capital in the relationship between higher education development and regional economic development, this paper uses the proportion of employed individuals with a junior college degree or above in each province(municipality directly under the central government and autonomous region)as a proxy variable for human capital level.

• Control Variables

Considering the influence of other factors on regional economic growth, to more accurately estimate the impact of higher education development on regional economic growth, this paper selects the following seven control variables based on the research of relevant scholars:

Human Capital Investment: Measured by the number of students enrolled in higher education institutions in each province (municipality directly under the central government and autonomous region) (in ten thousand persons).

Degree of Opening Up to the Outside World: Measured by the logarithm of the total import and export volume of goods calculated by destination and source within the region (in billion US dollars).

Intellectual Property Protection: Measured by the logarithm of the transaction volume of the technology market in each region (in billion yuan).

Urbanization Rate: Measured by the proportion of urban population in the total population in each region.

Government Size: Measured by the proportion of general fiscal budget expenditure of the provincial (municipal and autonomous region) government in the regional gross domestic product.

Fixed Asset Investment: Measured by the logarithm of the total fixed asset investment in the whole society in each province (municipality directly under the central government and autonomous region) (in billion yuan).

Labor Force Population: Measured by the logarithm of the total employment in the whole society in each province (municipality directly under the central government and autonomous region) (in ten thousand persons).

(3) Model Specification

This paper employs a fixed-effects model to examine the impact of higher education development on regional economic growth. The fixed-effects model can control for differences across individuals over time and effectively eliminate the influence of unobserved omitted variables on the dependent variable. The model is specified as follows:

$$Yit=\beta0+\beta1Eduit+\beta2Xit+\mu i+\delta t+\varepsilon it \quad (1)$$

In Equation (1), idenotes the province, and tdenotes the

year. Yit represents the regional gross domestic product(GDP)of provinceiin yeart. Eduitindicates the level of higher education development in provinceiin yeart. Xitis a set of control variables. μi and δt represent the province fixed effects and year fixed effects, respectively, which control for province-specific characteristics that do not vary over time and year-specific characteristics that do not vary across provinces. εitis the random error term. The primary focus of this paper is the coefficientβ1, which represents the impact of higher education development on regional economic growth.

For the mediation effect analysis, this paper utilizes the path analysis model provided by AMOS software (Version 24). The path analysis model offers a mechanism for testing mediation effects. The structural equation model is constructed as shown in Figure 1.

(4) Descriptive Statistics Results

Given that the values of the relevant variables are excessively large, this paper has conducted logarithmic transformations on the data to reduce the absolute differences between them. This approach helps mitigate the potential impact of extreme values on the regression results. Additionally, by logarithmically transforming both the dependent and independent variables, we can directly estimate the elasticity between the variables, that is, the percentage change in the dependent variable resulting from a one-percent change in the independent variable. The specific details of each variable are presented in Table 2.

Table 2. Descriptive Statistics Results of the Main Variables

	Obs	Mean	Std.Dev.	Min	Max
Logarithm of Per Capita GDP	600	10.23	0.828	8.001	12.01
Higher Education Development	600	0	1	-4.049	1.906
Logarithm of Average Number of Enrolled Students per Institution	600	9.032	0.319	7.610	9.711
Logarithm of Average Number of Faculty Members per Institution	600	6.268	0.238	5.205	6.784
Logarithm of Average Educational Funding per Institution	600	0.706	0.735	-1.250	2.707
Logarithm of Average Number of Graduates per Institution	600	7.535	0.479	5.526	8.349
Logarithm of Enrolled Students per Ten Thousand People	600	4.986	0.514	3.324	6.022
Logarithm of Fixed Asset Investment	600	8.626	1.339	4.621	10.99
Logarithm of Employment Population	600	7.549	0.801	5.631	8.859
Regional Innovation Capacity	600	8.438	1.817	3.689	12.29
Human Capital Level	600	0.140	0.0989	0.0200	0.630
Urbanization Rate	600	0.526	0.150	0.203	0.896
Government Size	600	0.211	0.0966	0.0772	0.643
Logarithm of Science and Technology Expenditure	600	3.242	1.587	-1.596	7.064
Degree of Opening Up to the Outside World	600	5.512	1.747	0.852	9.458
Logarithm of Technology Market Transaction Volume	600	3.841	1.908	-2.815	8.751
Logarithm of Population	600	8.168	0.755	6.260	9.443

4. Research Results

(1) Benchmark Regression Results

Table 3 reports the benchmark regression results. This paper primarily employs a stepwise regression method to explore the relationship between higher education development and regional economic growth: In column(1),no control variables are added, and it is found that a 1%increase in the level of higher education can promote economic development by approximately 0.12%.In column(2),control variables such as fixed asset investment, employment population, and degree of opening up to the outside world are included, and higher education still has a significant positive impact on economic development. In column(3),based on column(2),additional variables such as the urbanization rate, government size, and technology market transaction volume are further controlled, and the results show that higher education development still has a significant positive impact on regional economic development. By comparing the regression results of columns(1), (2), and(3), the impact of higher education level on regional economic growth first decreases and then increases as control variables are progressively added, and it remains significant at least at the 0.05 level. This indicates that the positive impact of higher education development on economic growth is relatively robust. Based on the above analysis, Hypothesis 1 of this paper is verified, that is, regional higher education development can promote regional economic growth.

(2) Mediation Effect Analysis

The mediation regression results obtained using AMOS software (Version 24) are shown in Figure 2. Four possible pathways through which higher education development promotes regional economic growth can be identified:

• Higher Education Development→Regional Economic Growth

Higher education development directly promotes regional economic growth, with a standardized coefficient of 0.28. This means that a 1%increase in higher education development can drive economic growth by 0.28%.

• Higher Education Development→Human Capital Level→Regional Economic Growth

Table 3. Benchmark Regression Results

	(1)	(2)	(3)
	Per Capita GDP	Per Capita GDP	Per Capita GDP
Higher Education Development	0.1191***	0.0284**	0.0474***
	(0.0191)	(0.0135)	(0.0137)
Logarithm of Fixed Asset Investment		0.2754***	0.2405***
		(0.0179)	(0.0200)
Logarithm of Employment Population		-0.1402***	-0.1087**
		(0.0504)	(0.0486)
Level of Opening Up to the Outside World		0.0519***	0.0141
		(0.0131)	(0.0133)
Urbanization Rate			0.8826***
			(0.2740)
Urbanization Rate			-0.7275***
			(0.1521)
Logarithm of Technology Market Transaction Volume			0.0102
			(0.0066)
Year Fixed Effects	Y	Y	Y
Province Fixed Effects	Y	Y	Y
_cons	10.0892***	9.0921***	8.6930***
	(0.0527)	(0.4095)	(0.4596)
R^2	0.9804	0.9902	0.9912
N	600	600	600

Note: Robust standard errors are reported in parentheses; *,**,*** significance levels are indicated at 10%, 5%, and 1% respectively.

Higher education development indirectly promotes regional economic growth through an increase in human capital levels. Specifically, a 1%increase in higher education development leads to a 0.4%increase in human capital levels, which in turn drives economic growth by approximately 0.48%. The calculated indirect effect of higher education development on economic growth through human capital is 0.19%.

• Higher Education Development→Regional Innovation Capacity→Regional Economic Growth

Higher education development also promotes regional economic growth by enhancing regional innovation capacity. A 1%increase in higher education development leads to a 0.72%increase in regional innovation capacity, which then drives economic growth by approximately 0.29%. The calculated effect of higher education development on economic growth through enhanced innovation capacity is 0.21%.

• Higher Education Development→ Human Capital Level → Regional Innovation Capacity→ Regional Economic Growth

Higher education development can also influence regional economic growth through a chain-mediating effect involving human capital levels and regional innovation capacity. Specifically, a 1%increase in higher education development leads to a 0.4%increase in human capital levels, which in turn enhances regional innovation capacity by 0.3%, ultimately driving economic growth by approximately 0.29%. The calculated chain-mediating effect of higher education development on economic growth through human capital and innovation is 0.03%.

Based on the above analysis, Hypotheses 2a,2b, and 2c of this paper are verified. Higher education not only promotes economic growth through human capital and innovation capacity but also through the chain-mediating effects of human capital and innovation capacity.

(3) Heterogeneity Analysis

Table 4 reports the grouped regression results by dividing provinces into eastern, central, and western regions. For the eastern region, higher education development has a strong positive impact on regional economic growth. A 1%increase in higher education development can promote economic growth by approximately 0.16%. For the central region, the impact of higher education development on regional economic growth is limited. A 1%increase in higher education development can drive economic growth by about 0.03%. For the western region, higher education development has a significant negative impact on regional economic growth. A 1%increase in higher education development leads to a 0.06%decrease in regional economic growth.

It can be observed that the impact of higher education development on regional economic growth in the central and western regions is limited, and even negative in the western region. One possible reason is that the employment environment in the central and western regions, especially the western region, is relatively poor, resulting in a weak capacity to absorb college graduates. Graduates are more likely to seek employment in the eastern coastal cities. Studies by Sun

Junhua, Wei Li, and others have also found that there is a spatial mismatch between talent cultivation and employment resources in China. In 2018,the talent loss rate of college graduates and above from Hebei University, which is close to Beijing and Tianjin, reached 55.6%,while the talent loss rate in Guangxi, which is adjacent to Guangdong, reached 57.8%.This implies that we need to further optimize the employment environment in the central and western regions, formulate various preferential policies, and attract college graduates to work in the central region, especially the western region, to promote economic development in these areas.

Table 4. Regional Heterogeneity Analysis

	(1)	(2)	(3)
	Eastern	Central	Western
Higher Education Development	0.1618***	0.0269*	-0.0639***
	(0.0266)	(0.0159)	(0.0165)
Logarithm of Fixed Asset Investment	0.1113***	0.0815***	0.3234***
	(0.0289)	(0.0252)	(0.0336)
Logarithm of Employment Population	-0.3039***	-0.1888***	-0.2774***
	(0.0457)	(0.0438)	(0.0373)
Degree of Opening Up to the Outside World	0.0577***	-0.0376	0.0493***
	(0.0221)	(0.0271)	(0.0146)
Urbanization Rate	1.4956***	1.6439***	2.6521***
	(0.2792)	(0.2369)	(0.2531)
Government Size	-2.5028***	-3.4013***	0.0635
	(0.3202)	(0.2329)	(0.1461)
Logarithm of Technology Market Transaction	0.0320**	0.0096	0.0199***
Volume	(0.0153)	(0.0116)	(0.0065)
Year Fixed Effects	Y	Y	Y
_cons	10.3625***	9.7426***	7.6236***
	(0.3188)	(0.3459)	(0.2456)
R^2	0.9799	0.9923	0.9880
N	220	160	220

Note: Robust standard errors are reported in parentheses; *,**,*** significance levels are indicated at 10%, 5%, and 1% respectively.

(4) Robustness Test

Table 5 lists the results of the robustness test. Column(1) uses the logarithm of regional GDP as the dependent variable, while Column(2) excludes the samples of Beijing and Shanghai, two municipalities directly under the central government. Column(1) shows that, with the logarithm of GDP as a proxy for economic growth, a 1%increase in higher education development can drive regional economic growth by 0.07%. Column (2) Indicates that, after excluding the samples of Beijing and Shanghai, which have high levels of higher education and economic development, a 1%increase in higher education development can drive economic growth by approximately 0.04%.

5. Conclusions and Discussion

Based on provincial panel data from 2000 to 2020, this paper employs fixed-effects models and path analysis models to empirically examine the relationship between higher education and regional economic growth, as well as the potential mediating roles of regional innovation capacity and human capital levels. The findings indicate that higher education can directly promote regional economic growth. Higher education not only drives economic growth through human capital and innovation levels but also through the chain-mediating effects of human capital and innovation levels. Additionally, the impact of higher education on regional economic growth exhibits regional heterogeneity, with the highest impact in the eastern region, followed by the central region, and a negative impact in the western region.

Based on these conclusions, the following recommendations are proposed:

Further Promote the Development of Higher Education in China: Higher education development has a significant positive impact on economic growth. Currently, the level of education in various regions of China still needs to be improved. Calculations based on the student-faculty ratio (the ratio of students to faculty members, with a smaller value indicating fewer students per teacher) in higher education institutions nationwide from 2000 to 2020 show that this ratio has not decreased but rather increased, indicating a potential shortage of faculty members in higher education institutions. Policies should be developed to attract more talented individuals to join the higher education sector.

Increase Transfer Payments to Central and Western Regions and Optimize Employment Environments: Efforts should be made to attract more college graduates to work in the central and western regions to leverage the economic growth potential of higher education in these areas. This can be achieved by enhancing transfer payments and improving

the employment environment in these regions.

Table 5. Results of Robustness Tests

	(1) Logarithm of GDP	(3) Excluding Shanghai and Beijing samples
Higher Education Development	0.0656***	0.0422***
	(0.0163)	(0.0134)
Logarithm of Fixed Asset Investment	0.2120***	0.2093***
	(0.0179)	(0.0219)
Logarithm of Employment Population	0.2128***	-0.0693
	(0.0670)	(0.0455)
Degree of Opening Up to the Outside World	0.0144	0.0169
	(0.0145)	(0.0130)
Urbanization Rate	0.8122***	1.4150***
	(0.2794)	(0.3615)
Government Size	-1.0209***	-0.6709***
	(0.1863)	(0.1458)
Logarithm of Technology Market Transaction	0.0106	0.0157**
Volume	(0.0066)	(0.0068)
Year Fixed Effects	Y	Y
Province Fixed Effects	Y	Y
_cons	5.0217***	8.1022***
	(0.5953)	(0.4406)
R^2	0.9954	0.9911
N	600	560

Note: Robust standard errors are reported in parentheses; *, **, *** significance levels are indicated at 10%, 5%, and 1% respectively.

Limitations of This Study: Provincial Panel Data Limitations: This study uses provincial panel data as the basis for empirical analysis. However, there are significant differences in higher education development within each province. Although the analysis employs data on average students and faculty per institution, this may still lead to some estimation biases. Data Availability and Indicator Construction: Due to data availability issues, the construction of education development indicators in this study only considers data on education input and output, which may limit the representativeness of the indicators for higher education development.

Future Research Directions: Incorporate More Variables and Data: Future research could include additional variables and data related to higher education development to construct a more precise index of higher education development levels. Use City-Level Data: Future studies could employ city-level data to enhance the accuracy of the estimates.

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