



The Effects of Higher Education on Regional Economic Development and the Mediating Role of Regional Innovative Capabilities: Evidence From China

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Abstract. In the context of the era of high-quality development, exploring the relationship between higher education and economic development can help optimize the positioning and resource allocation of higher education and empower high-quality economic and social development. Based on the panel data of Chinese provinces from 2013 to 2022, this study empirically explores the impact effect and mechanism of higher education on regional economic development. It is found that higher education is an important driving force for regional economic development, and its positive influence effect passes the robust type test; regional innovation capacity is an effective mechanism for higher education to drive economic growth. Based on the results of the study, in the future, China should give full play to the value of higher education and regional innovation capacity to economic development, promote the development of higher education scale agglomeration and actively improve the quality of higher education based on the development concept of industry-education fusion and integration of industry-university-research.

Keywords: Economic Development, Higher Education, Innovation Capability, Intermediary mechanism model.

1 Introduction

As China's economic development enters a new stage, high-quality development has become a new requirement for China's economic development. To achieve modern development in China, it is necessary to improve the quality and efficiency of economic development. Education is the national plan and the party's plan, which determines the future of a country and nation. The report of the 20th National Congress of the Communist Party of China creatively planned and deployed education, science and technology and talents in the strategic task, and proposed the "Trinity" coordinated development of the three, emphasizing the in-depth implementation of the strategy of rejuvenating the country through science and education, the strategy of strengthening the country through talents, and the innovation driven development strategy, opening up

new fields and new tracks for development, and constantly shaping new momentum and new advantages for development.

Higher education bears the heavy responsibility of talent training, scientific and technological research and development and serving the society. As the main source of creating senior talents, it is an important driving force and key force to integrate scarce resource elements and ensure the advantages of national economic and social development ^[1]. However, in reality, the role of higher education is often more complex ^[2]. Education to promote economic development is not automatic, and the two are not necessarily positively correlated. It is also affected by many factors such as regional innovation ability and industrial structure. Scientific and technological progress plays a very direct role in promoting economic development. According to the endogenous growth theory, reasonably applying part of the capital in economic output to the knowledge production and technology research and development of enterprises can better realize the transformation and upgrading of production mode and technology, so as to maintain the sustainable economic growth. With the development of technological progress, it will further drive the change of regional economic growth mode. This process is technological innovation ^[3]. Efficient technological innovation ability is an important driving force to maintain long-term sustainable economic development. Innovation is inseparable from education. High quality higher education is an important source of technology, and the human capital cultivated by higher education is the guarantee of technological innovation. By combing the existing literature, this study found that most of the existing studies are about the contribution and coordination of higher education to economic development, while ignoring the impact mechanism of higher education on economic development. Few empirical studies discuss the impact of higher education on economic development, and lack a reasonable explanation of the mechanism behind it.

Can higher education be transformed into the growth point of regional economic development? The answer to this question is a powerful empirical evidence to respond to the important combination of higher education as the first productive force of science and technology, the first resource of talents, and the first driving force of innovation. At the same time, it is of great significance to promote the high-quality development of regional economy and society and the construction of Chinese modernization. In view of the cognitive gap of existing research in analyzing the contribution of higher education to economic development, this study first constructs a comprehensive measurement index system of the development level of higher education, and uses the entropy method to calculate the development index of higher education and digital economy in China's provinces from 2013 to 2022; Secondly, based on Schumpeter's innovation theory, this paper establishes a mechanism model that higher education promotes economic development by stimulating regional innovation ability, and empirically tests whether higher education can promote economic development and whether the transmission mechanism is established by using regression model and intermediary effect model.

2 Literature Review and Theoretical Mechanism

2.1 The Economic Growth Function of Higher Education

The role of higher education in social and economic development is gradually emerging, and scholars' research on the relationship between higher education and economic development is also deepening, and have achieved fruitful results. Lenkei B (2018)^[4] and others examined the impact of higher education on economic growth in developing countries, and the results showed that there was a significant positive correlation between higher education and per capita GDP.

Vinod&kaushi (2007)^[5] based on the neoclassical growth theory model, it is proposed that the accumulation of human capital drives technological progress, and then has an impact on economic growth. Pelinescu et al. (2020)^[6] chose the years of education per capita as an alternative indicator of human capital, and empirically tested the contribution of human capital and technological innovation to the economic growth of EU countries. The results showed that human capital can first act on innovation ability, and then use the change of innovation ability to affect economic growth.

The research on the economic value of higher education based on the Chinese context has also made more achievements. As an advanced stage of education development, higher education plays a decisive role in the final formation of human capital and the development of national economy and society^[7]. Panpengfei (2021)^[8] pointed out that the development of higher education has provided abundant financial benefits for national development and economic construction. Yu Li (2020)^[9] by analyzing the industrial mechanism and characteristics of higher education, it is believed that the development of higher education has the essential attribute of inevitable connection with economic growth.

There are also relevant studies based on the perspective of economic growth theory. From the perspective of education economy, it is generally believed that education has economic ability and can promote economic growth. Lizilin (2020)^[10] believes that higher education can promote rapid economic growth by improving the production skills of workers. In the mechanism of labor economy, workers stimulate economic growth by increasing demand through innovation and entrepreneurship, attracting investment and talents, and stimulating consumption. From the perspective of economics, it shows that higher education plays a certain role in regional economic growth. In addition, some scholars, starting from the endogenous growth theory and according to the logic of science and technology spillover, draw the conclusion that technological progress is a stable factor to promote sustained economic growth. For example, zhouguangli (2023)^[11] believes that technological progress depends on the scientific research achievements of colleges and universities, which also verifies the importance of higher education to economic growth.

Therefore, the realization of high-quality economic development is inseparable from sufficient technical talents and high-tech achievements, and the development of higher education is the fundamental support of high-quality economic development.

2.2 The Theoretical Mechanism of Higher Education Affecting Economic Development

Although the academic research on the correlation between higher education and economic growth has achieved fruitful results, there is still a lack of discussion on the relationship between higher education and economic development. As an important branch of endogenous growth theory, Schumpeter's innovation theory emphasizes that innovation is the root force to promote the evolution of national economic development towards a higher stage, and believes that higher education plays an important role in innovation development and technological progress, which lays a theoretical foundation for this study to establish the mechanism relationship between higher education, regional innovation ability and economic development.

First, regional innovation capability is the core driving force that determines the process of economic development. First, the core characterization of regional innovation ability is the ability of scientific and technological breakthroughs. Technological progress can break industry barriers, break industry boundaries, promote the integration and cross innovation of different industries, and jointly explore new business models, technology application models and service modes through the establishment of interdisciplinary, cross sectoral and cross industry cooperation mechanisms, so as to lead the innovation of digital formats. Second, drawing on the view of endogenous economic growth theory, that is, technological innovation is an important source of promoting national or regional economic growth. To ensure sustainable economic growth, it is an inevitable choice for a country or region to closely rely on innovation drive.

Second, higher education is an important driving force of regional innovation ability, which can improve the level of regional innovation through talent training, scientific research and social services. (1) The improvement of regional innovation ability needs to pay attention to the cultivation of top-notch innovative talents, while higher education emphasizes the cultivation of students' scientific spirit and creative thinking, so as to form the agglomeration of regional high-quality human capital and build a virtuous interaction and cycle of talent chain and innovation chain. (2) As an important subject of knowledge innovation and a department of scientific and technological innovation in society, higher education is a knowledge production unit that gathers funds, talents, engineering projects and technical reserves. Through scientific research, scientific papers and patent achievements are produced to lay the knowledge foundation for regional innovation.

Based on the above analysis, we propose the following hypothesis:

Hypothesis 1: the development of higher education is conducive to promoting economic development.

Hypothesis 2: the development of higher education promotes economic development by improving regional innovation ability.

3 Research Design

3.1 Model Settings

In view of the direct impact of higher education on the level of regional economic development, this study establishes the following regression model:

$$Econ_i = \alpha_0 + \alpha_1 HE_i + \alpha_c Z_i + \varepsilon_i. \quad (1)$$

In equation (1), $Econ_i$ is the digital economy development level of the province; HE_i is the development level of higher education in the province; Z_i represents a series of control variables; ε_i is the random disturbance term. In addition to the direct impact effect embodied in equation (1), in order to discuss the possible mechanism of higher education in the process of affecting the development of digital economy, this study tests the mediation effect according to the above. In view of the problems of low statistical test efficiency and biased effect estimation when using the three-stage test method for mediating effect analysis, this study refers to the practice of Niu Zhiwei et al.^[12], and enhances the completeness of the empirical chain by adding the four stage mediating mechanism model test of mediating variables to regress the explained variables separately.

The construction of the four stage intermediary mechanism model is as follows: assuming that the intermediary variable is m , on the basis that the coefficient α_1 of the linear regression model (1) of the higher education development level he on the regional economic development level $econ$ passes the significance test, the linear regression equation of the higher education development level he on the intermediary variable m , the regression equation of the intermediary variable m on the economic development level $econ$, and the regression equation of the higher education development level he and the intermediary variable m on the economic development level $econ$ are constructed respectively, and the existence of the intermediary effect is judged by the significance and size of the regression coefficient of the relevant variables. The specific model settings are as follows:

$$M_i = \beta_0 + \beta_1 HE_i + \beta_c Z_i + \varepsilon_i; \quad (2)$$

$$Econ_i = \theta_0 + \theta_1 M_i + \theta_c Z_i + \delta + \varepsilon_i; \quad (3)$$

$$Econ_i = \chi_0 + \chi_1 HE_i + \chi_2 M_i + \chi_c Z_i + \varepsilon_i. \quad (4)$$

3.2 Variable Definition

1. Dependent variable: Economic development ($Econ$). Existing studies mainly choose GDP and per capita GDP to measure economic growth. However, due to the large differences in population and overall development among regions, the per capita GDP can more accurately measure the level of regional development, so the per capita GDP of each region is selected to measure economic growth.

2. Independent variable: The level of development of Higher Education (HE). Scientific evaluation of the level of development of higher education is an important issue

and its due significance in the current transformation of higher education to connotative development. In order to give consideration to the logical rationality and empirical reliability of the selection of indicators, this study draws lessons from the evaluation system of higher education level^[13], after using factor analysis to verify the validity, and selects the indicators with high correlation as the measurement indicators of higher education functions, so as to more accurately reflect the development level of regional higher education. Finally, this study retained 10 indicators to measure the development level of Higher Education (see Table 1 for details), and the relevant data came from the China Education Statistics Yearbook, the national statistical bulletin on the implementation of education funds, the compilation of scientific and Technological Statistics of colleges and universities, and the CSMAR database.

Table 1. Comprehensive evaluation index system of Higher Education.

Primary index	Secondary index	Tertiary indicators	Indicator attribute
Development level of Higher Education	Student size	Number of students per 10000 population	+
		Books per student	+
		Building area per student	+
		Every 100 students have computers for teaching	+
		Value of teaching practice instruments and equipment per student	+
	Faculty	student-teacher ratio	+
		Proportion of full-time teachers with senior professional titles	+
		Proportion of full-time teachers with master degree or above	+
		Education expenditure per student	+
		National financial education funds per student	+

3. Intermediary variable: regional innovation capability (M). According to the above analysis, the intermediary variable of this study is regional innovation ability. In view of the fact that regional innovation capability is more reflected in the R&D stage of technological innovation, previous studies generally used the number of patent authorizations or patent applications to measure regional technological innovation capability. Considering that patent examination cycle and other factors will affect the speed of patent authorization, this study selects three kinds of patent totals accumulated in each province of China in the same year to measure regional innovation ability, and the data is from the State Intellectual Property Office.

4. Control variables. In order to more accurately estimate the contribution effect of higher education in the process of regional digital economy development, this study sets the following control variable indicators: industrial structure (stru), which is measured by the proportion of tertiary industry output value; The level of urbanization (urban) is measured by the percentage of urban population in the total urban population; Consumption degree (con), measured by natural logarithm of total retail sales of social goods; Labor input (li) is measured by the proportion of the labor force with bachelor degree or above; The level of residents' consumption (inconsu) is expressed by the logarithm of residents' disposable income. The data of each year and region of the control

variable are from the China Statistical Yearbook, the statistical yearbook of each province, and the CSMAR database.

3.3 Index weighting and variable measurement

After completing the construction of the comprehensive evaluation index system of higher education, this study uses the entropy method of objective weighting method to determine the index weight and reduce the dimension of the index through the principle of information entropy, so as to realize the comprehensive evaluation of the research object. The specific measurement method is as follows.

1. Index selection: suppose there are m evaluation objects and N evaluation indexes, and X_{ij} is the value of the i -th evaluated object under the j -th index.

2. Index standardization: the first step of entropy weight method is to dimensionless the initial data. Because the index system covers a wide range, the data units and dimensions are different. In order to reduce the impact of different dimensions on the measurement weight, the indicators need to be dimensionless. The standard matrix can be obtained by dimensionless original data matrix:

$$X' = (X'_{ij})_{mn} \quad (5)$$

In this paper, the range standardization method is used to deal with the data dimensionless. Since the indicators in this paper are all positive indicators, formula (6) is adopted.

$$X'_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)} \quad (6)$$

3. After dimensionless processing of the data, the index weight should be calculated by calculating the index information entropy, as follows:

First, calculate the eigenvalue weight of the i -th object under the j -th index,

$$P_{ij} = \frac{x'_{ij}}{\sum_{i=1}^m x''_{ij}} \quad (7)$$

4. Then calculate the information entropy of index J ,

$$H_j = -\frac{1}{\ln(m)} \sum_{i=1}^m P_{ij} \ln(P_{ij}) \quad (8)$$

5. Then we can calculate the difference coefficient S_j of index J ,

$$S_j = 1 - H_j \quad (9)$$

6. Thus, the entropy weight W_j of each index can be determined,

$$W_j = \frac{S_j}{\sum_{j=1}^n d_j} \quad (10)$$

7. Use the multiple linear weighting function method to obtain the HE_i of higher education development level:

$$HE_i = \sum_{j=1}^m W_j X'_{ij} \quad (11)$$

3.4 Data Samples and Descriptive Statistics

In order to deeply study the impact effect between higher education and regional economic development level, this study conducted a study on 31 provincial administrative regions (except Hong Kong, Macao and Taiwan) from 2013 to 2022. 310 formed 31 province year balanced panel data. In order to ensure the continuity of variable measurement at the time level, this study uses linear interpolation method to supplement a small number of missing values.

The descriptive statistical results of the main variables of this study are shown in Table 2. The results show that the average value of the development level of higher education is 0.290, the standard deviation is 0.074, and the difference between the maximum value and the minimum value is 0.470, indicating that there are great differences in the development level of digital economy in different provinces in different years. In contrast, the average and standard deviation of the economic development level are larger, and the difference between the maximum and minimum is 16.744, indicating that the regional economic development presents a more obvious imbalance. From the perspective of control variables, different provinces also have significant differences in industrial structure, urbanization level, consumption level, labor input and residents' consumption level.

Table 2. Descriptive statistics.

Variable	Obs	Mean	Std	Min	Max
Econ	310	6.383	3.075	2.309	19.053
HE	310	0.290	0.074	0.182	0.652
M	310	7.812	12.225	0.012	87.221
stru	310	0.905	0.051	0.749	0.998
urban	310	59.703	12.437	23.710	89.600
con	310	8.922	1.060	5.681	10.712
li	310	10.603	7.432	2.600	46.908
inconsu	310	10.166	0.366	9.281	11.285

4 Empirical Analysis

4.1 Benchmark Regression Results

Fixed effect (FE) and random effect (RE) are selected to estimate the model, and the regression software is stata15.0. The benchmark regression results are reported in columns 1-3 of Table 2. According to the Hausman test, the p value is greater than 0.05, so the random effect model is selected. See Table 3 for the linear estimation results of

the impact of higher education on regional economic development, and column 3 is the regression results not included in the control variables

It can be seen from columns 2 and 3 in Table 3 that the estimated coefficients of the core independent variable higher education development level are significantly positive, that is, higher education can have a positive impact on the development of digital economy. The empirical analysis results expand the relevant research on higher education supporting the high-quality development of regional economy. In the column 2 with control variables, the level of higher education in each province can significantly and positively predict the level of regional economic development, that is, there is a positive correlation between the level of higher education and the overall level of economic development represented by per capita GDP; The impact of labor input on the level of economic development failed to pass the significance test of the 10% level, which may be due to the fact that labor input has yet to be optimized and cannot play a role in promoting economic development for the time being.

Table 3. Benchmark regression results.

Variables	1 FE	2 RE	3 Econ
HE	8.624*** (4.40)	9.268*** (5.13)	31.026*** (19.77)
Control variable	Control	Control	
Constant	61.210*** (-12.80)	47.692*** (-13.55)	-2.612*** (-5.56)
N	310	310	310
R ²	0.875	0.880	0.559

***p<.01. **p<.05. *p<.10.

Table 4. Mediating effect test results.

Variables	1 M	2 Econ	3 Econ
HE	43.781*** (3.11)		8.070*** (4.49)
M		0.033*** (4.51)	0.027*** (3.78)
Control variable	Control	Control	Control
Constant	294.356*** (-10.76)	40.808*** (-9.79)	39.636*** (-9.79)
N	310	310	310
R ²	0.540	0.878	0.885

4.2 Mediating Effect Test

Based on the perspective of regional innovation ability, the previous paper theoretically analyzes the indirect transmission mechanism of the impact of higher education on economic development. In order to verify whether the mechanism is tenable, this study selects the four stage mediation effect model for empirical test, and the regression results are shown in Table 4. It can be seen from table 4 that, on the basis of verifying that higher education has a direct impact on the development of digital economy, the promotion effect of higher education on regional innovation ability in column 1 of Table 4 is significantly positive at the level of 1%, indicating that higher education can enhance regional innovation ability through talent cultivation, scientific research and social services. In the regression results in columns 2 and 3 of Table 4, the regression coefficients of the intermediary variable regional innovation ability are significantly positive, indicating that regional innovation ability can significantly promote economic development. At the same time, the influence coefficient of higher education development level on economic development in column 3 of Table 4 is lower than that in column 2 of Table 3, which confirms that regional innovation ability is an effective transmission channel for higher education to enable economic development.

At the same time, referring to existing studies, this study found that the innovation driven mechanism of higher education has a more important position in the form of digital economy. For example, based on provincial data, Wang Yiran and others took the regional GDP as the proxy indicator of regional economic development, and empirically measured that the ability of scientific and technological innovation played an intermediary role of 51.47% in the economic growth function of higher education^[14]. In contrast, the mediation effect calculated in this study accounts for a higher proportion, reflecting that the digital economy, as a new economic form transforming from "factor driven", "investment driven" to "innovation driven", relies more on the engine of innovation ability and the innovation source power provided by higher education. This conclusion is also consistent with the theoretical hypothesis that Schumpeter's innovation theory is used to explain the growth of digital economy driven by higher education.

4.3 Robustness Test

To further prove the robustness of the model, the robustness test is continued (Table 5).

① Replace the explained variable and re estimate. The above uses per capita GDP as the explained variable, and here the GDP of provinces and cities is selected as the alternative indicator of economic growth for robust estimation. ② Replace the core explanatory variable and re estimate. This paper selects the per student education expenditure of higher education as a substitute index for the development of higher education for a robust test. The robustness test results (Table 5) show that the core explanatory variables are significantly positive, verifying that higher education can promote economic development, which further supports research hypothesis 1 and 2.

Table 5. Robust test results.

Variables	Replace dependent variable			Replace independent variable		
	Y	M	Y	Econ	M	Econ
HE	8.443*** (4.24)	43.781*** (3.11)	3.408*** (2.89)			
X				0.052*** (5.82)	0.398*** (5.96)	0.043*** (4.64)
M			0.115*** (24.26)			0.022*** (2.90)
Control variable	Control	Control	Control	Control	Control	Control
Constant	53.028*** (-13.70)	294.356*** (-10.76)	19.174*** (-7.22)	39.175*** (-9.84)	218.280*** (-7.25)	34.414*** (-8.07)
N	310	310	310	310	310	310
R ²	0.760	0.540	0.918	0.883	0.575	0.886

5 Conclusions and Recommendations

This study is based on the typical fact that higher education enables the high-quality development of economy and society. Based on the panel data of provinces in China from 2013 to 2022, and based on the measurement of the development level of higher education by using the entropy method, this paper empirically tests the effect and mechanism of higher education on economic development. The main conclusions are as follows. First, the regression estimation results show that higher education can positively affect the level of regional economic development, and this conclusion has passed the robust test. Second, the mediating effect test found that regional innovation ability is an effective channel for higher education to boost economic growth, indicating that the development level of regional higher education can be transformed into innovation driven efficiency with technological progress as the core, thus promoting economic prosperity and development.

(1) At the national level, governments at all levels should actively implement the governance principles and objectives of the coordinated development of the scale, structure and quality of higher education, expand the enrollment scale of higher education in an orderly manner according to local conditions, increase the proportion of graduate enrollment, optimize the academic level structure, promote the development of Higher Vocational education, and optimize the structure of talent training types. At the same time, we should strengthen the investment in education funds to promote the quality of higher education, promote the allocation of higher education resources to achieve "Pareto optimality", and enable the sustainable development of economic and social development.

(2) We should give full play to the role value of higher education and scientific and technological innovation in economic development, promote the scale agglomeration development of higher education, actively improve the quality of higher education, scientifically set up professional subjects, and implement the strategy of paying equal attention to the cultivation of scientific research and practical talents based on the

development concept of the integration of production, education and research, especially in cities with slow economic development, we should actively adjust the industrial structure to coordinate with local higher education and scientific and technological innovation, rely on the advantages of higher education resources convergence, improve the scientific and technological innovation system, promote the linkage development of Higher Education and scientific and technological innovation. We should actively play the intermediary role of scientific and technological innovation, formulate special plans for scientific and technological innovation talent entrepreneurship and the growth of scientific and technological innovation enterprises, strengthen scientific and technological innovation exchanges and cooperation between cities, improve the incentive mechanism for scientific and technological innovation.

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