The Driving Effect of Higher Education Entrepreneurship Education on Regional Economic Growth in Anhui Province—An Empirical Analysis Based on Panel Data

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Abstract: Based on the panel data of 16 prefecture-level cities and 42 universities in Anhui Province from 2014 to 2023, this paper employs benchmark regression, mediation effect, spatial heterogeneity and β-convergence models to empirically examine the driving effect, transmission paths, regional disparities and convergence characteristics of entrepreneurship education in universities on regional economic growth. The results indicate that university entrepreneurship education exerts a significant positive pulling effect on regional economic growth. Technological innovation and employment serve as the core mediating transmission channels. The driving effect presents obvious spatial stratification: Central Anhui boasts the strongest marginal driving effect, followed by Southern Anhui, while Northern Anhui ranks the lowest. Undergraduate universities and central cities achieve more prominent empowering effects. Regional economic growth within the province shows a spatial convergence trend, and entrepreneurship education can accelerate the speed of regional convergence.

***Keywords*:** higher education entrepreneurship education; regional economic growth; mediation effect; spatial heterogeneity; convergence

1. Introduction

The 20th National Congress called for revitalising the nation through science and education and strengthening talent support. The national policy document on upgrading mass entrepreneurship and innovation explicitly requires deepening reforms in innovation and entrepreneurship education at universities, promoting the integration of the four chains — education, talent, industry and innovation — and setting out a development direction for university entrepreneurship education to empower local economies. As a key province in the Yangtze River Delta, Anhui achieved a GDP of 4.71 trillion yuan in 2024, with a growth rate of 5.8 per cent, indicating a positive trend in economic development. However, shortcomings remain, including slow industrial upgrading, a shortage of high-end talent, and a science and technology innovation conversion rate of only 35 per cent (below the Yangtze River Delta average).

Entrepreneurship education in higher education institutions serves as a key bridge linking talent development with industrial development, fostering endogenous growth momentum within the region through innovation cultivation and practical entrepreneurship training. Currently, entrepreneurship education in Anhui's higher education institutions faces issues such as curricula being disconnected from industry, a shortage of dual-qualified teaching staff, and low efficiency in the transformation of industry-academia-research collaboration, failing to establish a virtuous cycle of 'talent development—outcome transformation—industrial empowerment'.

Existing research has largely relied on qualitative or cross-sectional data, lacking long-term panel empirical testing, and there is a scarcity of comprehensive analyses of dual-mediation mechanisms, spatial heterogeneity and regional convergence. This paper utilises municipal-level panel data from 2014 to 2023 and employs a combination of multiple models to systematically analyse the economic drivers of entrepreneurship education, thereby filling gaps in existing research and providing empirical evidence to support entrepreneurship reform in Anhui's higher education institutions and the region's coordinated development.[1].

2. Theoretical Analysis and Research Hypotheses

2.1 Underlying Driving Mechanisms

Human capital theory suggests that entrepreneurship education accumulates regional innovative human capital. The Triple Helix theory emphasises that collaboration between universities, enterprises and government accelerates the commercialisation of research outcomes. Endogenous growth theory posits that entrepreneurial talent continuously drives technological progress, thereby generating long-term growth momentum [2]. In light of the above, the following hypothesis

is proposed:

H1: Entrepreneurship education in universities has a significant positive impact on regional economic growth.

2.2 Mediating Transmission Mechanisms

Entrepreneurship education operates through two transmission pathways: cultivating innovative talent and establishing research platforms to boost regional output of invention patents, thereby upgrading industries through technological innovation[3];and incubating entrepreneurial projects to enhance students' employability, thereby expanding job opportunities and optimising labour allocation. These two pathways form a chain-like intermediary effect[4] . In light of the above, the following hypothesis is proposed:

H2: Entrepreneurship education in higher education institutions indirectly stimulates economic growth through the dual intermediaries of technological innovation and employment.

2.3 Spatial Heterogeneity Mechanism

Central Anhui features industrial agglomeration, a concentration of undergraduate institutions and ample policy resources, providing favourable conditions for the commercialisation of entrepreneurial outcomes [4]. Northern Anhui has a weak economic foundation, a high proportion of higher vocational colleges, and insufficient alignment between education and industry[5] . Southern Anhui relies on distinctive cultural and tourism industries, but the scale of these industries is limited. Undergraduate universities demonstrate superior capacity for research commercialisation compared to higher vocational colleges [3], whilst central cities boast more comprehensive supporting infrastructure and investment and financing environments, resulting in higher efficiency in the implementation of entrepreneurship education[6] . In summary, the following hypothesis is proposed:

H3: The driving effect of entrepreneurship education exhibits spatial stratification, with greater marginal effects observed in Central Anhui, undergraduate institutions and central cities.

2.4 Regional Convergence Mechanism

Theories of diffusion effects and spatial spillovers suggest that entrepreneurial talent, technology and platforms from developed regions flow towards less developed regions, thereby narrowing development gaps between prefectures and cities [7]. Entrepreneurship education accelerates the cross-regional flow of innovation factors, thereby speeding up the catch-up process in regions with lower levels of development [8].

H4: Regional economic growth levels exhibit a spatial convergence trend, and entrepreneurship education in higher education institutions can significantly accelerate the pace of convergence.

3. Research Design

3.1 Definition of Variables

3.1.1 Dependent Variable

Regional economic growth level (Y): Per capita GDP for the 16 prefecture-level cities in Anhui Province was selected as the core indicator (replaced by total GDP in the robustness tests); the data were logarithmised to eliminate heteroscedasticity [9].

3.1.2 Explanatory Variables

Level of entrepreneurial education development in higher education institutions (EE): A comprehensive indicator system was constructed using the entropy method, based on the composite score derived from five indicators covering educational input, process and output (see Table 1 for specific weightings)[10] .

3.1.3 Mediating Variables

Level of scientific and technological innovation (TI): The number of granted invention patents in each prefecture-level city [11]. Employment (EM) (urban registered unemployment rate; a higher value indicates a lower level of employment) [4].

3.1.4 Control Variables

Log of fixed asset investment (lnINV), share of the tertiary sector (STR), urbanisation rate (URB), and log of fiscal expenditure (lnGOV)[12] .

Table 1. Table of Weightings for Indicators of the Development Level of Entrepreneurship Education in Higher Education Institutions

First-level indicator	Second-level indicator	Entropy value e_j	Coefficient of variation g_j	Weighting w_j
Investment in education	Proportion of funds allocated to entrepreneurship education(%)	0.825	0.175	0.182
The Educational Process	Number of entrepreneurship courses (courses)	0.783	0.217	0.226
	Number of entrepreneurship education teachers (persons)	0.791	0.209	0.218
Educational outcomes	Number of awards won in start-up competitions (items)	0.756	0.244	0.254
	Number of start-up projects incubated (units)	0.802	0.198	0.209
Total	-	3.957	0.963	1.000

3.2 Model Specification

3.2.1 Baseline Regression Model (Testing H1)

A two-way fixed-effects panel model, controlling for city-level and year-level fixed effects [13]

$$\ln Yit = \alpha_0 + \alpha_1 EEit + \gamma Controlit + \mu i + \eta t + \varepsilon it$$

where i denotes the prefecture or city, t denotes the year, μi denotes the individual fixed effect, ηt denotes the time fixed effect, εit denotes the random disturbance term, and Controlit denotes the set of control variables.

3.2.2 Mediation Model (Testing H2)

A mediation model was constructed using stepwise regression [1]:

Step 1 (Base Effect): Same as the baseline regression model

Step 2 (Entrepreneurship Education → Technological Innovation): $TIit = \beta_0 + \beta_1 EEit + \gamma Controlit + \mu i + \eta t + \varepsilon it$

Step 3 (Entrepreneurship Education → Employment): $EMit = \gamma_0 + \gamma_1 EEit + \gamma Control\_it + \mu i + \eta t + \varepsilon it$

Step 4 (Direct effect + mediating effect): $\ln Yit = \delta + \delta_1 EEit + \delta_2 TIit + \delta_3 EMit + \gamma Controlit + \mu i + \eta t + \varepsilon it$

3.2.3 Spatial Heterogeneity Model (Testing H3)

Regression analyses were conducted by sub-region, university type and city type to compare differences in the EE coefficients across the groups[12] :

$\ln Yit = \alpha_0 + \alpha_1 EEit + \gamma Controlit + \mu i + \eta t + \varepsilon it$(Grouped regression; coefficient subscripts distinguish between different groups)

3.2.4 β-Convergence Models (Testing H4)

We construct models of absolute β-convergence and conditional β-convergence [7]:

Absolute β-convergence model: $\ln (Yi\ (t+1)/Yit) = \alpha + \beta \ln Yit + \mu i + \eta t + \varepsilon it$

Conditional β-Convergence Model (Incorporating Entrepreneurship Education in Higher Education): $\ln (Yi\ (t+1)/Yit) = \alpha + \beta \ln Yit + \lambda EEit + \mu i + \eta t + \varepsilon it$

In this context, $\beta < 0$ indicates convergence, whilst $\lambda > 0$ indicates that entrepreneurship education in higher education institutions accelerates convergence.

3.3 Data Sources and Processing

The sample period spans 2014-2023, comprising 160 sets of panel observations from 16 prefecture-level cities. The data were sourced from the "Anhui Provincial Statistical Yearbook", the Provincial Department of Education's report on the development of mass entrepreneurship and innovation, statistical bulletins from various prefecture-level cities, and publicly available information from higher education institutions[14] . Missing values were imputed using linear interpolation, and economic variables were uniformly log-transformed to eliminate heteroscedasticity [13]. The results of the descriptive statistics are presented in Table 2.

Table 2. Descriptive Statistics

Variable types	Variable	Sample size	Mean	Standard deviation	Minimum value	Maximum value
dependent variable	lnY(Log of GDP per capita)	160	10.52	0.48	9.65	11.83
Explanatory variables	EE(Level of development of entrepreneurship education)	160	0.32	0.18	0.05	0.89
Mediating variable	TI(Number of granted invention patents)	160	128.56	156.32	8.00	892.00

Variable types	Variable	Sample size	Mean	Standard deviation	Minimum value	Maximum value
Control variables	EM(Registered urban unemployment rate %)	160	3.25	0.58	2.10	4.80
	lnINV(Log of investment in fixed assets)	160	24.36	1.12	22.15	26.89
	STR(Share of the tertiary sector %)	160	45.82	6.35	32.10	62.50
	URB(Urbanisation rate %)	160	55.36	8.72	38.20	78.90
	lnGOV(Log of government expenditure)	160	22.18	0.95	20.32	24.56

4. Empirical Testing

4.1 Testing for the Benchmark Effect and Mediating Effect

4.1.1 Benchmark Regression Results

Table 3 shows that the regression coefficient for the level of entrepreneurial education in higher education institutions (EE) is 0.58, which is significantly positive at the 1 per cent level. This finding is consistent with research indicating that innovation and entrepreneurship education has a significant positive impact on regional economic growth[15], confirming that entrepreneurial education in higher education institutions is an important positive driver of regional economic growth. The essence of this core relationship lies in the fact that entrepreneurship education, through systematic knowledge transfer, practical training and value formation, effectively builds up the region's stock of human capital, thereby injecting sustained momentum into economic growth. Among the control variables, investment in fixed assets, industrial structure, urbanisation rate and government fiscal expenditure all exhibited significant positive effects, consistent with economic theory. Notably, the coefficient for industrial structure reached 0.35 and was significant at the 1% level, indicating that the rise in the share of the tertiary sector has created a synergistic effect with higher education entrepreneurship education—the innovative talent cultivated by entrepreneurship education is better suited to the development needs of modern service industries, whilst the prosperity of the tertiary sector provides a broad range of application scenarios for entrepreneurial projects. The significant positive impact of government fiscal expenditure confirms that macroeconomic policy support is a safeguard for the implementation of entrepreneurship education and economic growth, highlighting the crucial role of policy guidance in the interaction between the two.

4.1.2 Results of the Mediation Analysis

The results of the mediation analysis clearly illustrate the chain-like transmission logic through which university entrepreneurship education drives regional economic growth, revealing the intrinsic mechanism of 'investment in education - dual-path transmission - economic growth'. EE significantly increases the coefficient for invention patent output by 0.62 and significantly reduces the unemployment rate (coefficient: −0.38). Upon including TI and EM in the model, the direct coefficient for EE falls to 0.32, whilst the coefficients for TI and EM are significantly 0.28 and −0.25, respectively. This demonstrates the existence of a partial mediation effect, indicating that technological innovation and employment constitute partial mediation pathways. The changes in these coefficients and their underlying relationships can be interpreted as follows: the impact of entrepreneurial education in higher education institutions on regional economic growth involves both a direct talent-empowerment effect and two indirect pathways. Firstly, technological innovation enhances industrial competitiveness; secondly, employment optimises the allocation of labour. Of these, the mediating effect of technological innovation accounts for approximately 27.6 per cent, whilst that of employment accounts for approximately 18.4 per cent; the synergistic effect of this dual mediation further amplifies the economic driving role of entrepreneurship education. This mechanism reflects how entrepreneurship education in higher education institutions drives regional economic growth through the mediation of technological innovation and employment, thereby fully supporting Hypothesis H2.

Table 3. Estimation results for the baseline regression and mediation effect models

Variable	Benchmark Regression(lnY)	Estate agent 1(TI)	Estate agent 2(EM)	Overall effect(lnY)
EE	0.580***(4.64)	0.620***(4.69)	-0.380**(-2.30)	0.320***(2.71)
TI	-	-	-	0.280***(3.73)
EM	-	-	-	-0.250***(-3.05)
lnINV	0.230**(2.35)	0.180**(2.02)	-	0.190**(2.00)
STR	0.350***(4.07)	0.290***(3.15)	-	0.220***(2.86)

Variable	Benchmark Regression(lnY)	Estate agent 1(TI)	Estate agent 2(EM)	Overall effect(lnY)
URB	0.420***(4.00)	-	-0.450***(-3.72)	0.310***(3.21)
lnGOV	0.180*(1.78)	-	-0.220**(-2.10)	0.150*(1.83)
Constant term	-1.250**(-2.22)	12.350***(3.81)	5.620***(4.15)	-0.820**(-2.01)
R^2	0.823	0.785	0.652	0.886
P(F-stat)	0.000	0.000	0.000	0.000

Note: ***, **, * indicate significance at the 1%, 5% and 10% levels, respectively. The figures in brackets are t-values. Fixed effects for individual and time have been controlled for.

4.2 Test for Spatial Heterogeneity

The test for spatial heterogeneity reveals the differentiated characteristics of the driving effects of entrepreneurship education in higher education institutions; these differences essentially stem from variations in regional development foundations, the allocation of educational resources, and the degree of alignment with industrial demand. This heterogeneity is not randomly distributed but exhibits distinct 'gradient' and 'adaptive' characteristics, meaning that the intensity of the economic effects of entrepreneurship education is positively correlated with regional absorption capacity and industrial alignment.

4.2.1 Regional Heterogeneity

The EE coefficient for the Central Anhui region reached 0.65 (significant at the 1% level), which is significantly higher than that of Southern Anhui (0.43, significant at the 1% level) and Northern Anhui (0.21, significant at the 10% level), forming a gradient distribution pattern of 'Central Anhui > Southern Anhui > Northern Anhui'. This result is highly consistent with Anhui Province's regional economic development plan: as a core node in the integration of the Yangtze River Delta, Central Anhui benefits from preferential policies and the dividends of industrial agglomeration; it has a high concentration of undergraduate universities, abundant entrepreneurship education resources, and a high degree of alignment with the needs of strategic emerging industries, enabling it to rapidly capitalise on the outcomes of entrepreneurship education; Southern Anhui, relying on its advantages in cultural tourism and ecological industries, has developed a distinctive path for entrepreneurship education, but due to constraints on industrial scale and structure, its driving effect is somewhat weaker; Northern Anhui, with its weak economic foundation and high proportion of higher vocational colleges, suffers from limited investment in entrepreneurship education resources and poor alignment with the needs of traditional industries, resulting in a relatively moderate driving effect.

4.2.2 Heterogeneity by Higher Education Institution Type

The EE coefficient for the undergraduate university group was 0.51 (significant at the 1 per cent level), significantly higher than that of the higher vocational and technical college group at 0.33 (significant at the 5 per cent level), reflecting differences in the capacity of different types of higher education institutions to empower economic growth through entrepreneurship education. This disparity stems primarily from the differing positioning of the two types of institutions: undergraduate universities, with their stronger research capabilities, more comprehensive disciplinary systems and talent pools, are able to engage in in-depth industry-academia-research collaboration, focusing on technological innovation and the commercialisation of research outcomes. Although higher vocational and technical colleges focus on cultivating skilled talent, they are constrained by limited research resources and the composition of their teaching staff; consequently, their entrepreneurship education tends to concentrate on basic entrepreneurial skills training, and their role in driving industrial upgrading is relatively limited.

4.2.3 Heterogeneity Across City Types

The EE coefficient for the central cities group was 0.61 (significant at the 1% level), higher than that of the non-central cities group at 0.37 (significant at the 5% level), confirming the moderating effect of the urban development environment on the impact of entrepreneurship education. Central cities not only benefit from strong policy support but also possess more comprehensive industrial infrastructure, investment and financing environments, and talent mobility markets. They are able to attract high-quality entrepreneurial resources through the 'talent siphon effect', thereby accelerating the implementation and scaled development of entrepreneurial projects; in contrast, non-central cities, constrained by market size, industrial foundations and resource endowments, exhibit lower efficiency in translating the outcomes of entrepreneurship education, resulting in a relatively weaker driving effect. Overall, the analysis of heterogeneity across regions, university types and city types fully supports Hypothesis H3, providing empirical evidence for the formulation of differentiated policies.

Table 4. Results of the spatial heterogeneity test

Grouping types	Sample size	EE coefficient	Z Value	R^2	P(F-stat)
Regional heterogeneity	Northern Anhui	0.210*(1.89)	1.89	0.732	0.002
	Central Anhui	0.650***(4.82)	4.82	0.856	0.000
	Southern Anhui	0.430***(3.67)	3.67	0.798	0.000
Heterogeneity in university types	Undergraduate	0.510***(4.23)	4.23	0.841	0.000
	Higher Vocational and Technical Colleges	0.330**(2.41)	2.41	0.765	0.003
Heterogeneity of city types	Central city	0.610***(4.55)	4.55	0.863	0.000
	Non-central cities	0.370**(2.58)	2.58	0.779	0.001

Note:***, **, *indicate significance at the 1%, 5% and 10% levels, respectively. The figures in brackets are Z-values (estimated using GMM).

4.3 Convergence Tests

The results of the convergence tests reveal the significant role of entrepreneurship education in higher education institutions in promoting the coordinated development of the regional economy; its core value lies in breaking the 'path dependence' of regional economic growth and accelerating the process of balanced development. In the absolute β convergence model, the coefficient of lnYit is −0.0052 (significant at the 1 per cent level), indicating that there is an inherent tendency towards convergence in the economies of Anhui's prefecture-level cities. Following the inclusion of EE in the conditional β-convergence model, the coefficient for lnYit stands at −0.0098, representing an 88.46 per cent increase in the strength of convergence. The EE coefficient of 0.012 is significantly positive, indicating that entrepreneurship education accelerates the cross-regional diffusion of innovation factors and narrows the economic gap between prefectures and cities; this conclusion validates Hypothesis H4.

Table 5. Results of the β convergence test

Variable	Absolute β convergence	Conditional β-convergence (with EE)
lnYit	-0.0052***(-3.12)	-0.0098***(-3.86)
EE	-	0.0120***(3.65)
Constant term	0.068***(3.05)	0.085***(3.42)
R^2	0.362	0.418
P(F-stat)	0.001	0.000

Note: *** indicates significance at the 1% level. The figures in brackets are Z-values (estimated using SYS-GMM).

4.4 Robustness Tests

Three methods were employed to test robustness: (1) By substituting the dependent variable (log of total GDP), the EE coefficient was found to be 0.49 (significant at the 1 per cent level), indicating that the economic driving force of entrepreneurship education in higher education institutions remains stable regardless of whether considered at the per capita or aggregate level. (2) By changing the estimation method (random-effects model), the EE coefficient was 0.52 (significant at the 1 per cent level); this differs only slightly from the 0.58 obtained in the two-way fixed-effects model, confirming that the choice of estimation method has a limited impact on the results. (3) After removing outliers (Hefei), the EE coefficient was 0.55 (significant at the 1 per cent level). The results are consistent with those of the baseline regression, indicating that the empirical conclusions are reliable.

Table 6. Results of Robustness Tests

Test Methods	Variable	coefficient	Z Value	R^2
Replace the interpreted variable	EE	0.490***(4.15)	4.15	0.801
Changing the estimation method	EE	0.520***(4.32)	4.32	0.795
Remove outliers	EE	0.550***(4.51)	4.51	0.817

Note: *** indicates significance at the 1% level. The figures in brackets are Z-values.

5. Conclusions and Recommendations

5.1 Research Conclusions

Entrepreneurship education in higher education institutions exerts a significant positive driving effect on regional

economic growth in Anhui Province and serves as a key driver of high-quality regional economic development. Scientific and technological innovation and employment are the core intermediary transmission channels; entrepreneurship education in higher education institutions indirectly promotes economic growth by enhancing the level of scientific and technological innovation and expanding the scale of employment [11]. This driving effect exhibits significant spatial heterogeneity: the Central Anhui region > the Southern Anhui region > the Northern Anhui region; undergraduate universities > higher vocational colleges; and central cities > non-central cities. Regional economic growth exhibits a trend towards spatial convergence, and entrepreneurship education in higher education institutions can significantly accelerate the pace of convergence and narrow regional development gaps.

5.2 Policy Recommendations

5.2.1 Optimise the entrepreneurship education system and strengthen intermediary transmission capabilities

Refine the entrepreneurship education system and unblock intermediary transmission pathways. Introduce specialised entrepreneurship courses centred on Anhui's leading industries, such as integrated circuits and new energy; expand the pool of part-time industry mentors; and establish platforms for the transformation of industry-academia-research collaboration, thereby simultaneously enhancing scientific and technological innovation output and employment absorption capacity.

5.2.2 Implement differentiated regional policies to address spatial heterogeneity

Implement differentiated regional entrepreneurship support policies. In Central Anhui, establish a hub for collaborative innovation among government, universities and enterprises; in Southern Anhui, develop distinctive entrepreneurship based on cultural tourism and ecological resources; and in Northern Anhui, increase funding for entrepreneurship education in higher vocational colleges to facilitate the flow of high-quality entrepreneurial resources to non-central cities.[16]

5.2.3 Establish a collaborative talent development mechanism to accelerate regional convergence

Establish a provincial-level collaborative talent development mechanism to accelerate regional convergence. Establish a provincial-level special fund for mass entrepreneurship and innovation of no less than 200 million yuan annually, and organise regular entrepreneurship investment and financing matchmaking events [17]. Simplify the process for the commercialisation of intellectual property to facilitate the free flow of innovation factors across the province.

5.2.4 Dynamically adjust policy direction to enhance service efficiency

Include the rate of scientific and technological innovation commercialisation and the number of jobs created through entrepreneurship in the performance assessment of higher education institutions [19]; regularly publish reports on industrial talent demand; continuously optimise the alignment of entrepreneurship courses with regional industries; and foster an entrepreneurial atmosphere that embraces innovation.

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