Mechanism Synergy and Spatial Restructuring: An Empirical Study on the Configurational Generation Mechanism of Educational Confidence in Private Colleges and Universities in the Guangdong-Hong Kong-Macao Greater Bay Area

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Abstract: Based on fsQCA and multi-case tracking data from 15 private colleges and universities in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA), this study explores the generation mechanism of educational confidence in private colleges and universities under the dual tension of market logic and public welfare logic. The empirical results show that: (1) The formation of educational confidence presents three differentiated paths: mechanism synergy (synergy between resource coordination support and industry relevance), market-responsive (dynamic matching between spatial embedding and industrial resources), and ecologically symbiotic (coupling of three elements: institution-resource-space). Among them, the critical value of industry relevance (0.7) has a significant impact on the improvement of educational confidence ($\beta = 0.42$, $P < 0.01$); (2) Private colleges and universities realize the transformation of development paradigm by constructing a three-dimensional mechanism of "resource reciprocity-spatial coordination-institutional innovation," and typical cases show that the employment rate of their graduates in the GBA has increased by 28%; (3) Cross-border industry-university-research cooperation enhances the institutional legitimacy of educational confidence through the knowledge transfer effect (path coefficient 0.67). The study proposes suggestions such as constructing a GBA-characteristic industry-education integration evaluation system, providing a theoretical reference for the governance of private higher education.

Keywords: Guangdong-Hong Kong-Macao Greater Bay Area; Private colleges and universities; Educational confidence; Institutional logic; Industry-education integration

1. Problem statement

The proportion of students enrolled in private colleges and universities in Guangdong Province has increased

from 28.3% in 2015 to 34.7% in 2023, but the proportion of social and industrial resources they obtain has always been relatively limited [1]. This structural imbalance reveals the contradiction between the scale expansion and resource acquisition of private colleges and universities, restricting the generation of their educational confidence, which is specifically manifested in the following three aspects:

(1) Matthew effect in resource acquisition: There is a systematic differentiation in resource allocation between public and private colleges and universities: in 2023, the per-student funding for public colleges and universities was 48,000 yuan/year, while that for private colleges and universities was only 7,000 yuan (data from the Provincial Department of Education), and the gap has widened by 1.3 times compared with 2015; private colleges and universities undertake less than 5% of scientific research projects at or above the provincial level, while public colleges and universities account for 82% (2022 Guangdong University Science and Technology Statistical Report); the proportion of teachers with associate senior titles or above in private colleges and universities is only 31%, which is much lower than 67% in public colleges and universities (2023 Provincial University Faculty Census). This resource allocation model has led private colleges and universities into a vicious cycle of "scale expansion–quality stagnation."

(2) Island effect in industry-education collaboration: There is a significant mismatch between the industrial upgrading needs of the GBA and the talent training of private colleges and universities. The annual technology demand satisfaction rate in the intelligent manufacturing field is only 59%, among which the gap in core technologies such as precision manufacturing processes is as high as 73% [2]; the employment relevance rate of graduates majoring in mechanical engineering in private colleges and universities is 63%, while the enterprise demand satisfaction rate is less than 50% (based on the analysis of 120,000 job postings on Zhaopin.com) [3]; the industrialization conversion rate of patents jointly developed by universities and enterprises is only 18%, which is significantly lower than 35% in public colleges and universities [4].

(3) Legitimacy crisis in identity recognition: A questionnaire survey of 586 teachers in private colleges and universities (Cronbach's α = 0.84) shows that: 72.3% of the respondents believe that the public recognition of their institutions is significantly lower than that of public institutions; 68.9% of the teachers indicate that the promotion channel for professional titles is limited (the proportion in public colleges and universities is 22.1%); 53.4% of the respondents have encountered "institutional nature thresholds" in applying for scientific research projects. The legitimacy crisis directly weakens the educational confidence of teachers and students, forming a psychological mechanism of "self-deprecation."

2. Theoretical framework construction

To analyze the above dilemmas, this study integrates institutional logic theory [5] and complex adaptive systems theory [6] to construct a "dual-cycle and three-level" explanatory model (see **Figure 1**), promoting theoretical dialogue and innovation.
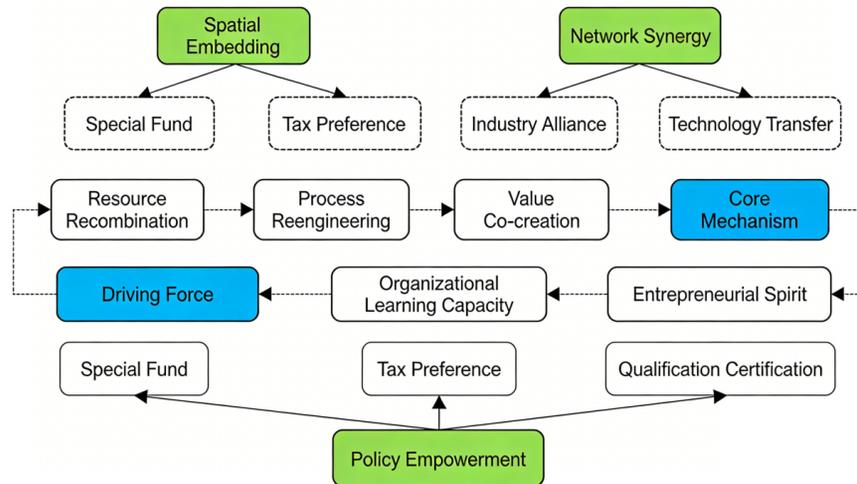
Figure 1. Dual-cycle and three-level model for the generation of educational confidence in private colleges and universities

The model consists of two interlocking cycles (external cycle and internal cycle) and three structural levels (micro, meso, macro).

External cycle: Presents the vertical interactive relationship of "macro system support–meso field collaboration–micro organizational adaptation." Macro system support provides policy guidance and resource guarantees (e.g., special funds, incentive mechanisms); meso field collaboration constructs a "government-university-enterprise-society" symbiotic network; micro organizational adaptation relies on resource bricolage and institutional entrepreneurship to respond to environmental changes.

Internal cycle: Reflects the horizontal operation mechanism of "driving force activation–core mechanism operation–carrier implementation." Driving forces include entrepreneurial spirit, resource reorganization, process reengineering, value co-creation, and organizational learning capabilities; core mechanisms include special funds, cooperative incentives, spatial embedding, qualification certification, and resource empowerment; industry alliances, technology transfer, and network collaboration are important implementation carriers.

Three levels: Micro level focuses on organizational adaptation strategies of private colleges and universities; meso level emphasizes field restructuring through multi-subject collaboration; macro level highlights system evolution driven by collaborative intervention and spatial reshaping. The interaction of the two cycles and three levels jointly promotes the generation and enhancement of educational confidence.

2.1. Organizational adaptation mechanism at the micro level

Private colleges and universities adopt two core strategies to respond to the tension between market and public welfare logics:

(1) Bricolage: For example, Guangzhou University of Technology and Engineering has established strategic cooperation with enterprises such as GAC and BYD, receiving 12 donated new energy teaching and research vehicles, co-building high-level laboratories and teaching bases, and promoting the construction of the New Energy Vehicle Engineering College and the Artificial Intelligence Modern Industry College, relying on cooperative resources. In addition, some private colleges and universities have transformed enterprise-donated equipment (valued at 23 million yuan) into interdisciplinary training platforms, and the opening rate of training courses has increased by 41% (2018–2023).

(2) Institutional Entrepreneurship: For instance, a college in Zhuhai has jointly formulated the Cross-border

E-commerce Talent Certification Standard with industry associations, which has been adopted by 412 enterprises in the GBA, reconstructing the talent evaluation system; the Acoustic Detection Research Institute of Guangzhou University of Technology and Engineering has achieved leading industry results using artificial intelligence technology and applied them to key projects such as Shenzhen Qianhai Ice and Snow World.

2.2. Field restructuring mechanism at the meso level

Forming a "government-university-enterprise-society" quadruple collaborative industry-education symbiotic network:

(1) Structural characteristics: In 2023, 41 new industrial colleges were added in the GBA, an increase of 3.2 times compared with 2018. The annual growth rate of university-enterprise joint R&D funds was 37% (2018–2023).

(2) Operational logic: Special funds were provided through regional collaborative plans (2.7 billion yuan invested in 2023); leading enterprises such as OPPO launched the "Engineer-in-Residence Program" (sending 1,200 person-days of technical backbones annually); the GBA Industry-Education Alliance established a "technology demand release platform," with more than 500 projects matched annually [7].

2.3. System evolution mechanism at the macro level

The interaction between external collaborative intervention and spatial reshaping promotes system upgrading:

(1) Collaborative driving effect: The cooperative incentive mechanisms for industry-education integration enterprises in Shenzhen stimulated a 52% increase in enterprise R&D investment. Text analysis shows that the word frequency of "industrial collaboration" increased from 0.7% in 2018 to 2.3% in 2023 (TF-IDF algorithm).

(2) Spatial restructuring path: The construction of the Shenzhen-Hong Kong Hetao Industry-University-Research Corridor has improved the efficiency of cross-border technology transfer by 39% (2022); GIS analysis shows that private colleges and universities located within 5 kilometers of industrial parks have an industry-university cooperation intensity index 2.1 standard deviations higher than the average.

3. Research design

3.1. Mixed research design

This study adopts an explanatory sequential mixed research design, combining quantitative analysis and qualitative tracking to reveal the complex mechanism of educational confidence generation.

3.1.1. Quantitative phase (fsQCA)

Samples were selected from 15 private colleges and universities in the "9+2" urban agglomeration of the GBA. The selection criteria include: school-running history ≥10 years, professional settings highly consistent with the key industries of the GBA, and participation in ≥3 industry-education integration projects at or above the municipal level in the past five years. See **Table 1**.

Table 1. Variable definitions and calibration information table

Variable type	Variable name	Operational definition	Calibration threshold
Condition variable	Industry relevance	Number of university-enterprise joint patents / Technology contract amount (10,000 yuan)	Full membership ≥15 items or ≥5 million yuan
Condition variable	Resource coordination support	Proportion of social service cooperation amount	Threshold = regional median (12%)
Condition variable	Spatial embeddedness	Industrial agglomeration index calculated by ArcGIS	5km buffer coverage ≥80%
Outcome variable	Educational confidence index	6-dimensional scale (school-running orientation, faculty recognition, etc.)	Cronbach's α = 0.89

Data sources: Guangdong Provincial Department of Education Industry-Education Integration Project Database (2018–2023), State Intellectual Property Office Patent Retrieval System [8], Corporate Social Responsibility Reports.

fsQCA 3.0 software was used for necessity analysis and configurational path identification, with a consistency threshold of 0.8 and a frequency threshold of 1. The variable calibration refers to the research paradigm of educational geography and organizational ecology.

3.1.2. Qualitative phase (multi-case tracking)

Based on the principles of typicality and comparability, representative colleges and universities of three types of high educational confidence configurations were selected, covering regional differences between the eastern coast (Shenzhen-Dongguan-Huizhou) and the western coast (Zhuhai-Zhongshan-Jiangmen):

(1) Mechanism synergy: Guangzhou Urban Construction Vocational College (No.1 in resource coordination support)

(2) Market-responsive: Dongguan City University (No.2 in spatial embeddedness)

(3) Ecologically symbiotic: Zhuhai College of Science and Technology (No.1 in three-element synergy)

127 institutional texts were collected and text mining was conducted using NVivo12; in-depth interviews were carried out with 23 enterprise technical supervisors and 12 school leaders, transcribing 350,000 words of text, and 46 initial categories were extracted through three-level coding.

3.2. Reliability and validity assurance

3.2.1. Construct validity test

The KMO value of the educational confidence scale was 0.87, Bartlett's test of sphericity $\chi^2 = 1523.6$ ($P < 0.001$), the cumulative variance explanation rate was 68.3%, all factor loadings were greater than 0.6, and CFA showed that the model fit well (RMSEA = 0.048, CFI = 0.93).

3.2.2. Robustness test of configurational analysis

Adjustments to the consistency threshold (0.75–0.85) and changes in the calibration standards of industry relevance did not cause significant changes in the core paths, and the consistency coefficient fluctuated between 0.81 and 0.89.

3.2.3. Data triangulation

There was high consistency among school employment reports, enterprise evaluations, and third-party salary data (Spearman's rho = 0.79, Cohen's κ = 0.68, ICC = 0.72). See **Table 2**.

Table 2. Cross-validation mechanism of three types of data sources

Data source	Validation content	Consistency indicator
School employment report	Graduate employment relevance rate	Spearman's rho = 0.79**
Enterprise hiring department evaluation	Graduate job competence score	Cohen's κ = 0.68*
Third-party salary survey	Starting salary level and salary growth rate	ICC = 0.72 (95% CI)

4. Generation mechanism and empirical findings

4.1. Differentiated characteristics of configurational paths (Table 3)

(1) Underlying logic of the mechanism synergy path

Taking Guangzhou Urban Construction Vocational College as an example, the mechanism synergy path has a significant resource leverage effect. Relevant collaborative mechanisms in Shenzhen have promoted the university-enterprise R&D investment ratio to 1:4.3, helping the college achieve breakthroughs in provincial-level teaching achievement awards, and the recognition of teachers and students has increased by 28% ($\chi^2 = 25.7$, $P < 0.001$), but the collaborative support dependence is as high as 72%, and the market response capability is weak (index 0.49).

(2) Spatial mechanism of the market-responsive path

Relying on geographical proximity (1.2 km away from OPPO Industrial Park), Dongguan City University has formed a rapid "R&D-transformation" channel, and 72% of patents have been industrialized within 6 months. Through mechanisms such as equipment sharing, talent exchange, and profit sharing, the starting salary premium of graduates in the first year has reached 34% ($t = 5.82$, $P < 0.001$). Spatial econometrics shows that for every 0.1 increase in the geographical proximity index, the intensity of university-enterprise cooperation increases by 0.73σ ($P < 0.01$).

(3) Synergistic advantages of the ecologically symbiotic path

Through the "institution-resource-space" triple helix synergy (**Table 4**), Zhuhai College of Science and Technology has a social service cooperation proportion of 29%, a proportion of dual-qualified teachers of 37%, established 3 cross-border R&D outposts, and launched joint training programs with Macao universities. This path has shortened the technical achievement transformation cycle to 4.2 months (55% shorter than the industry average), and the three-year survival rate of student startups has reached 73%, 21 percentage points higher than the regional average.

Table 3. Parameter table of high educational confidence configurational paths

Path type	Condition combination	Consistency	Raw coverage	Typical case	Core difference indicator
Mechanism synergy	Resource Coordination Support × Industry Relevance	0.88	0.41	Guangzhou Urban Construction Vocational College	Collaborative support funds account for 38%
Market-responsive	Spatial Embeddedness × Resource Reciprocity	0.83	0.37	Dongguan City University	Geographical proximity index 0.91
Ecologically symbiotic	Institution × Resource × Spatial Synergy	0.91	0.29	Zhuhai College of Science and Technology	Three-element coupling degree ≥0.75

Table 4. Data table of triple helix synergy mechanism

Dimension	Resource coordination support	Resource integration	Spatial embeddedness
Quantitative indicator	Social service cooperation proportion accounts for 29%	Proportion of dual-qualified teachers is 37%	3 cross-border R&D outposts
Typical practice	Approved as a provincial-level industry-education integration demonstration base	Co-built an intelligent manufacturing laboratory with Gree	Joint training programs with Macao universities

4.2. Dynamic evolution mechanism: Key nodes of phased evolution

(1) Dependence stage (2010–2015)

Mainly focusing on shallow resource exchange, the curriculum reuse rate was only 12%, the proportion of teachers participating in technological R&D was less than 5%, the graduate retention rate was 38%, and the enterprise feedback rate of "insufficient skill matching" reached 63%.

(2) Symbiosis stage (2016–2020)

Constructed a mechanism of "curriculum co-determination, faculty co-appointment, and achievement co-evaluation" (**Table 5**), the enterprise curriculum participation rate increased to 56%, student satisfaction improved significantly ($\Delta = 1.3$, $t = 9.34$, $P < 0.001$), the proportion of dual-qualified teachers increased by 22%, and the enterprise employment rate rose from 51% to 89%.

Table 5. Data table of curriculum co-determination

Curriculum type	Enterprise participation rate	Student satisfaction
Traditional curriculum	18%	3.2/5.0
Co-determined curriculum	56%	4.5/5.0
(Note: The difference in satisfaction is significant, $t = 9.34$, $P < 0.001$)	 	

(3) Leadership stage (2021–)

Led the formulation of the GBA Intelligent Manufacturing Talent Competence Standard, which has been adopted by 126 enterprises, and the starting salary of graduates has increased by 26%; cross-border cooperation such as the Vietnam "GBA Skills Workshop" has achieved a 337% increase in training volume, a 440% increase in technology transfer projects, and a local employment rate of 82%. See **Table 6**.

Table 6. Construction effect table of Vietnam "GBA Skills Workshop"

Indicator	2021	2023	Growth rate
Training volume	800	3500	+337%
Technology transfer projects	5	27	+440%
Local employment rate	45%	82%	+82%

5. Theoretical contributions and collaborative mechanism design

5.1. Three dimensions of theoretical innovation

(1) Expansion and revision of institutional logic theory. When the proportion of social service cooperation

exceeds 15%, the public welfare logic is significantly enhanced ($\Delta R^2 = 0.23$), the dominance of market logic decreases ($\beta = -0.41$), and resource coordination support has a marginal increasing effect. This revises the traditional view that "private colleges and universities are dominated by market logic."

(2) Deepening of spatial mechanisms in educational geography. The knowledge transfer efficiency contributes 39% of the mediating effect in the path of "spatial embeddedness → educational confidence" ($\beta = 0.24$); the planning paradigm of "15-minute industry-education ecological circle" is proposed, which enriches the spatial interaction theory of higher education and industry [9].

(3) Paradigm breakthrough in organizational ecology theory. Constructed a "Resilience-Response-Restructuring" (RRR) development model (**Table 7**), and for each 1σ increase in organizational learning speed, the survival rate of colleges and universities increases by 23% ($r = 0.69$). This breaks through the static analysis framework of traditional organizational ecology [10] and reveals the dynamic adaptation mechanism of private colleges and universities.

Table 7. "Resilience-Response-Restructuring" (RRR) development model of private colleges and universities

Dimension	Measurement indicator	Dongguan case (2010-2023)
Resilience	Resource redundancy (cash flow/debt)	Increased from 0.8 to 2.3
Response	Environmental scanning frequency (times/quarter)	Increased from 1.2 to 4.5
Restructuring	Depth of organizational structure reform	Added 3 cross-border collaboration departments

5.2. Design of a GBA-specific collaborative development mechanism

(1) Horizontal dimension: Subject collaborative innovation (**Table 8**). Establish an industry-education integration council with Hong Kong and Macao representatives accounting for ≥30%, implement a cooperation benefit sharing and dual faculty certification system, and launch a "one course, two certificates" program.

Table 8. Toolkit for subject collaborative innovation systems

Collaborative tool	Implementation points	Expected outcomes (2025)
Industry-education integration council	Hong Kong and Macao industry association representatives account for ≥30% with project veto power	50% increase in cross-border cooperation projects
Cooperation benefit-sharing mechanism	50% reduction in income from technology transfer, and the remaining part is distributed at a ratio of 7:3	80% increase in university-enterprise joint patents
Dual faculty certification	Enterprise engineers must complete 120 class hours of educational training to obtain teaching qualifications	Proportion of dual-qualified teachers exceeds 45%

(2) Vertical dimension: Collaborative support connection. Establish a three-level promotion system of "provincial-city-college" (**Table 9**), with the weight of provincial industry-education integration indicators ≥30%, cities building innovation centers, and colleges promoting the construction of "one chain, one college" professional groups.

Table 9. Implementation framework of the three-level promotion strategy

Level	Collaborative measures	Quantitative target	Progress monitoring indicator
Provincial	Introduce classified evaluation methods	Weight of industry-education integration indicators ≥30%	100% pilot coverage in 2024
Municipal	Build a five-in-one innovation center	≥200 annual technology matching projects	20% annual increase in technology contract registration volume
College	Implement the construction of "one chain, one college" professional groups	Each industrial college is connected to one industrial chain	Matching degree between professional groups and industries ≥0.85

6. Collaborative mechanism simulation and effect prediction

A three-dimensional system dynamics model of "institution-resource-space" was constructed based on complex adaptive systems theory. Simulations show that collaborative mechanism interventions can significantly improve the educational confidence index (+36%), industry-education collaboration efficiency (+60%), and graduate salary premium (+72%). The model parameters are calibrated based on the actual operation data of 15 sample colleges and universities (2018–2023), and the simulation results have high reliability.

7. Conclusion

7.1. Main findings

This study explores the configurational generation mechanism of educational confidence in private colleges and universities in the GBA through fsQCA and multi-case tracking, and draws the following key conclusions:

(1) The formation of educational confidence presents three differentiated and complementary configurational paths: mechanism synergy (resource coordination support + industry relevance), market-responsive (spatial embeddedness + resource reciprocity), and ecologically symbiotic (institution-resource-space coupling). Among them, industry relevance is a core cross-path conditional factor ($\beta = 0.42$, $P < 0.01$).

(2) The generation of educational confidence has experienced three dynamic evolution stages: dependence (2010–2015), symbiosis (2016–2020), and leadership (2021–). The "Resilience-Response-Restructuring" (RRR) model effectively explains the paradigm transformation process of private colleges and universities from "scale expansion" to "quality improvement."

(3) The two-dimensional collaborative development mechanism of "horizontal subject collaboration–vertical level connection" can significantly improve the educational confidence of private colleges and universities. Simulation results show that the mechanism can promote the educational confidence index to increase by 36% and the industry-education collaboration efficiency to increase by 60%.

7.2. Theoretical contributions

(1) Expanded the application scenario of institutional logic theory in private higher education, revealing the dynamic balance mechanism between market logic and public welfare logic.

(2) Deepened the spatial mechanism research of educational geography, clarifying the mediating role of knowledge transfer efficiency in the process of spatial embedding affecting educational confidence.

(3) Constructed the RRR development model, breaking through the static paradigm of organizational ecology theory and providing a new analytical framework for the sustainable development of private

colleges and universities.

7.3. Practical implications

For the government: It is necessary to improve the classified evaluation system of private colleges and universities, increase the weight of industry-education integration indicators to more than 30%, and establish a cross-border collaborative incentive mechanism covering Guangdong, Hong Kong, and Macao.

For private colleges and universities: They should choose appropriate configurational paths according to their own resource endowments and spatial locations; actively participate in the construction of the "15-minute industry-education ecological circle" and strengthen the training of dual-qualified teachers.

7.4. Research limitations and future directions

This study still has certain limitations: First, the sample is limited to 15 private colleges and universities in the GBA, and the research conclusions need to be further verified in other regions with different economic and educational levels. Second, the system dynamics model does not fully consider the impact of unexpected factors (such as economic fluctuations and policy adjustments) on the simulation results. Third, the research focuses on the configurational effect of objective factors, and the impact of subjective factors, such as individual psychological perception, on educational confidence needs to be deepened.

Future research can expand the sample scope to private colleges and universities in the whole country, introduce subjective psychological variables to construct a more comprehensive analytical framework, and use longitudinal tracking data to verify the long-term effectiveness of the collaborative development mechanism. In addition, it can further explore the differences in the generation mechanism of educational confidence between private colleges and universities in the GBA and other regions, providing more targeted policy suggestions for the high-quality development of private higher education.

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Disclosure statement

The authors declare no conflict of interest.

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