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Dynamic coupling: an empirical study on the coordination degree between vocational education supply and industrial demand in emerging sectors

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Abstract: This study empirically examines the coupling coordination between vocational education supply and industrial demand in Guangdong's emerging sectors (AI, NEVs, Biomedicine, NGIT) from 2015 to 2022, using a comprehensive index system and a coupling coordination degree model. Findings indicate that overall coordination has improved from slight maladjustment to primary coordination, with significant variation across sectors—AI and IT show higher alignment than biomedicine. Granger causality tests confirm industrial demand drives educational supply, albeit with a lag. Regression analysis highlights that deeper industry-institution collaboration, frequent curriculum updates, and a higher share of dual-qualified teachers significantly enhance coordination. The study offers evidence-based insights for optimizing vocational education and supporting industrial upgrading.

Keywords: vocational education; emerging industries; supply-demand coordination; coupling coordination degree; Guangdong province; empirical study

1 Introduction

The rapid advancement of the global technological revolution is establishing emerging industries such as AI and biotechnology as critical drivers of regional and national competitiveness. In China, strategic emerging industries are central to modern industrial system building. As a key economic and manufacturing province aiming for world-class clusters, Guangdong faces immense and evolving demand for skilled technical talent, primarily supplied by vocational education [1]. However, a persistent structural imbalance exists: industries report skill shortages while vocational graduates encounter employment challenges, indicating a misalignment between supply and demand. Current literature lacks empirical, quantitative studies assessing the dynamic coordination between vocational education and specific emerging industrial clusters.

Addressing this gap, this study focuses on Guangdong, constructing a comprehensive index system for vocational education supply and industrial demand across four representative emerging sectors. It employs a coupling coordination degree model to empirically measure their synergistic relationship over time and identify influencing factors. The research specifically investigates: (1) the evolutionary trajectory of this coordination, (2) variations across different industries, and (3) key determinants of the coordination degree. The findings aim to provide evidence-based insights for refining vocational education policies and industrial talent strategies in Guangdong and comparable regions.

2 Literature review

2.1 Theoretical frameworks

The synergy between vocational education and industrial development is informed by established economic theories. Human Capital Theory identifies education as an investment that boosts worker productivity and economic growth. Skill-Biased Technological Change theory clarifies that modern industrial upgrading increases demand for high-skilled labor [2]. Complementing these, "New Institutional Economics" argues that structured collaborations (e.g., school-enterprise partnerships) lower transaction costs and enhance knowledge transfer. Together, these frameworks provide a multi-dimensional basis for analysis.

2.2 Empirical research

Existing empirical work primarily addresses education-labor market alignment at a macro level, examining skill mismatch and policy models like Germany's dual system. While studies such as those by Shi et al. (2024) have begun applying quantitative models like coupling coordination to assess vocational education-regional economy alignment [3], they seldom focus on specific emerging sectors. Research on talent forecasting for these dynamic industries remains largely qualitative or based on limited surveys [4], indicating a methodological gap.

2.3 Research gap and contributions

Three key gaps are evident: a lack of focus on dynamic emerging industries, scarcity of systematic longitudinal quantitative studies, and insufficient empirical testing of influencing factors. This study addresses these by: (1) focusing on four key emerging industries in Guangdong; (2) constructing a dual-system index and applying a coupling coordination degree model for dynamic and comparative assessment; and (3) empirically testing determinants of coordination via panel data models to enhance policy relevance.

3 Research design

3.1 Index system construction and data sources

Guided by principles of scientific rigor, systematic structure, operability, and data availability, this study constructs a dual-system evaluation index system.

Vocational Education Supply (VES) is measured through: (1) Scale: enrolled students (VES1) and graduates (VES2) in relevant programs; (2) Quality: proportion of "dual-qualified" teachers (VES3), per-student equipment value (VES4), and number of key specialties (VES5); (3) Structure: program distribution-industry structure matching index (VES6); (4) Input/Reform: special financial investment (VES7), number of cooperating enterprises (VES8), and jointly developed courses (VES9).

Industrial Demand (IDS) is measured through: (1) Scale/Growth: main business income (IDS1), added-value growth rate (IDS2), number of enterprises (IDS3); (2) Innovation: R&D intensity (IDS4) and valid invention patents (IDS5); (3) Talent Demand: skill shortage rate (IDS6), proportion of job postings requiring associate degrees (IDS7), and average salary growth for technical positions (IDS8).

Data for 2015-2022 are sourced from authoritative yearbooks (Guangdong Statistical Yearbook, Guangdong Education Statistics Yearbook, Guangdong Science and Technology Statistics Yearbook), official government reports on skill talent, industry operation reports, college quality reports, and major recruitment platforms (e.g., 51job, Zhaopin). Missing data are addressed using moving average or trend extrapolation. All monetary values are deflated to 2015 constant prices.

3.2 Research methods

3.2.1 Entropy method for determining weights

To avoid subjective weighting bias, the entropy method is employed to objectively determine the weight wj of each indicator. This involves standardizing the original data, calculating the information entropy of each indicator, and subsequently deriving its weight.

3.2.2 Calculation of comprehensive evaluation functions

The comprehensive development level indices for the Vocational Education Supply system U1 and the Industrial Demand system U2 are calculated separately:

$U_1 = \sum_{j=1}^{m} w_j \times X'_{ij}$, $U_2 = \sum_{j=1}^{n} w_j \times Y'_{ij}$, where X′ij, Y′ij are the standardized indicator values.

3.2.3 Coupling coordination degree model (CCDM)

The coupling degree CC reflects the intensity of interaction between the two systems, while the coordination degree DD measures the level of their benign interaction.

$C = 2 \times \sqrt{\frac{U_1 \times U_2}{(U_1 + U_2)^2}}$, $D = \sqrt{C \times T}$, $T = \alpha U_1 + \beta U_2$

Here, T is the comprehensive evaluation index. Considering both systems are equally important, α and β are both set to 0.5. Drawing on relevant research (Liao Chongbin, 1999), the coordination degree D is classified into 10 levels (see Table 1).

Table 1. Classification criteria for coupling coordination degree

D-value range	0.00~0.09	0.10~0.19	0.20~0.29	0.30~0.39	0.40~0.49	0.50~0.59	0.60~0.69	0.70~0.79	0.80~0.89	0.90~1.00
Coordination Level	Extreme Maladjustment	Serious Maladjustment	Moderate Maladjustment	Slight Maladjustment	On the Verge of Maladjustment	Barely Coordinated	Primary Coordination	Intermediate Coordination	Good Coordination	Quality Coordination
Coupling Stage	Low-Level Coupling		Antagonistic Stage		Running-in Stage		Coordinated Stage		High-Level Coupling	

3.2.4 Panel regression model for influencing factors

To investigate the factors influencing the coordination degree, the following panel data model is established:

$D_{it} = \beta_0 + \beta_1 CoopDepth_{it} + \beta_2 CurriculumUpdate_{it} + \beta_3 DualTeacher_{it} + \beta_4 GovPolicy_{it} + \beta_5 IndR\&D_{it} + \mu_i + \lambda_t + \epsilon_{it}$

where Dit is the coupling coordination degree for industry i in year t. Core explanatory variables include: Depth of School-Enterprise Cooperation (measured by enterprise participation in cooperative R&D projects), Frequency of Curriculum Updates, Proportion of "Dual-Qualified Teachers", Government Policy Support for Industry-Education Integration (dummy variable), and Industrial R&D Intensity. μi represents individual fixed effects, λt time fixed effects, and ϵit the random error term.

4 Empirical results and analysis

4.1 Temporal changes and industrial comparison of coupling coordination degree

The coupling coordination degree DD is calculated according to the model (Table 2). The overall coordination degree for emerging industries in the province steadily improved from 0.38 (Slight Maladjustment) in 2015 to 0.65 (Primary Coordination) in 2022, suggesting the interaction between vocational education and industry is transitioning from the "Running-in Stage" to the "Coordinated Stage".

Table 2 Coupling coordination degree (D-value) for four major emerging industries in Guangdong, 2015-2022

Industry / Year	2015	2016	2017	2018	2019	2020	2021	2022
AI	0.41	0.45	0.50	0.55	0.58	0.61	0.66	0.71
NEV	0.35	0.39	0.44	0.51	0.53	0.56	0.62	0.67
Biomedicine	0.30	0.33	0.36	0.40	0.43	0.45	0.49	0.54
NGIT	0.46	0.48	0.53	0.57	0.60	0.63	0.67	0.70
Overall Average	0.38	0.41	0.46	0.51	0.54	0.56	0.61	0.65

Cross-industry analysis reveals distinct coordination patterns. The New Generation Information Technology (NGIT) and Artificial Intelligence (AI) sectors demonstrate the highest coordination, nearing the Intermediate/Good Coordination threshold by 2022. This advantage stems from their strong ICT foundations and the relatively mature, adaptable base of related vocational programs. In contrast, the New Energy Vehicle (NEV) industry exhibits the most significant improvement, rising from Slight Maladjustment to Primary Coordination, underscoring the rapid, policy-driven adaptation of vocational institutions through new programs and industry partnerships. Conversely, the Biomedicine sector shows the lowest coordination, remaining in the Barely Coordinated range. This lag is attributed to the industry's stringent requirements for advanced academic and regulatory knowledge, which pose substantial challenges for vocational education in terms of high-investment infrastructure, specialized faculty, and lengthy curriculum development cycles, resulting in a slower supply response.

4.2 Granger causality test results

To explore the dynamic causal relationships between the two systems, a Granger causality test was conducted on the panel data. Results show that, at the 5% significance level, the Industrial Demand Index (IDS) is the Granger cause of the Vocational Education Supply Index (VES), but not vice versa. This indicates that changes in vocational education supply in Guangdong are, to a considerable extent, a reaction to changes in industrial demand (i.e., a "demand-pull" model). The proactive or leading role of vocational education supply in creating demand in emerging industries is not yet fully evident, indicating a certain degree of lag.

4.3 Regression analysis of influencing factors on coordination degree

The results of the panel fixed-effects model regression (Table 3) show that, after controlling for individual and time effects:

The regression results indicate that several factors positively and significantly influence the coordination degree at conventional levels. A deeper level of school-enterprise collaboration (CoopDepth) enhances the relevance of talent cultivation. A higher frequency of curriculum updates (CurriculumUpdate) is crucial for reducing the skills gap in fast-evolving sectors. A greater proportion of "dual-qualified" teachers (DualTeacher) effectively bridges theoretical knowledge and practical industrial application. Supportive government policy (GovPolicy) also shows a significant positive effect, highlighting the importance of institutional incentives. In contrast, industrial R&D intensity (IndR&D) has a positive but statistically insignificant coefficient, suggesting its demand pull for higher vocational talent may be more indirect or lagged compared to its demand for bachelor's degree holders.

Table 3. Panel fixed-effects model regression results

Variable	Coefficient	Robust Std. Err.	t-value	P>|t|
CoopDepth	0.125***	0.032	3.91	0.000
CurriculumUpdate	0.098**	0.041	2.39	0.019
DualTeacher	0.086**	0.035	2.46	0.016
GovPolicy	0.042*	0.022	1.91	0.059
IndR&D	0.057	0.038	1.50	0.138
Constant	0.211***	0.045	4.69	0.000
Individual FE	Yes			
Time FE	Yes			
R^2 (within)	0.673			
F-test	22.15***			

Note: *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.

5 Conclusion and policy recommendations

This study empirically assesses the coupling coordination between vocational education supply and industrial demand in Guangdong's emerging sectors from 2015 to 2022. Results indicate a general transition from slight maladjustment to primary coordination, though significant inter-industry heterogeneity persists, with biomedicine lagging behind ICT-related fields. Industrial demand acts as the primary Granger cause for changes in educational supply, revealing a reactive adjustment pattern. Regression analysis identifies the depth of industry-institution collaboration, curriculum update frequency, and the proportion of dual-qualified teachers as key positive drivers of coordination.

To foster higher-level coupling, a multi-pronged strategy is recommended. First, establish a dynamic industry-talent monitoring platform to enable proactive program planning. Second, implement differentiated ("one industry, one policy") support, particularly for lagging sectors like biomedicine, to boost high-standard training capacity. Third, deepen school-enterprise collaboration beyond resource-sharing to co-create curricula and teaching resources. Finally, strengthen institutional incentives by incorporating coordination metrics into performance evaluations and funding allocations, thereby creating a sustainable feedback loop for synergistic development.

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Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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