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COUPLING-COORDINATION AND DYNAMIC INTERACTION BETWEEN HIGHER VOCATIONAL EDUCATION QUALITY AND NEW-QUALITY PRODUCTIVITY

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Abstract: Driven by the new round of technological revolution, new-quality productivity has experienced accelerated growth. As a core provider of technical-skilled talents, higher vocational education exhibits mutually-influencing and dynamically-evolving intrinsic links with new-quality productivity. Based on provincial panel data covering 30 Chinese provinces from 2018 to 2023, this study constructs a comprehensive evaluation index system for higher vocational education quality and new-quality productivity. Employing the entropy-weight method, coupling-coordination model and panel vector autoregressive (PVAR) model, empirical analyses are conducted from three dimensions: synergy level, dynamic interaction and spatial correlation. The results reveal a positive overall correlation between provincial-level higher vocational education quality and new-quality productivity in China, yet prominent regional divergence exists: the eastern region achieves substantially higher synergy between the two systems compared with the central and western regions. Bidirectional interactions between the two systems demonstrate asymmetric characteristics: new-quality productivity effectively promotes improvements in higher vocational education quality, whereas bottlenecks persist in translating higher vocational education quality into new-quality productivity. This paper enriches empirical evidence regarding how higher vocational education supports new-quality productivity, and provides practical references for context-specific higher vocational education reform and coordinated advancement of the two systems across regions.
Keywords: Higher vocational education quality; New-quality productivity; Coupling-coordination; PVAR model

1 INTRODUCTION

Against the backdrop of high-quality economic development in China, innovation-driven new-quality productivity has become a core driver of industrial transformation and upgrading. Human capital serves as a fundamental factor for developing new-quality productivity. Higher vocational education undertakes the mission of cultivating technical-skilled talents for the real economy. It acts not only as a source of new-quality talent supply but also facilitates iterative industrial technological upgrading through technical services. Conversely, shifts in industrial forms and job requirements induced by new-quality productivity force higher vocational education to carry out institutional adjustments concerning specialty configuration, practical-training conditions and faculty development, forming an interdependent complex relationship between the two systems. Clarifying their synergy status, dynamic action paths and regional spatial correlations carries practical significance for advancing the integrated development of education, science-technology and talent.

Existing literature has yielded abundant findings on how higher vocational education empowers regional economic and industrial upgrading, which mainly follow three threads: value interpretation, practical dilemmas and optimization pathways. From the value perspective, higher vocational education underpins high-quality regional industrial development by supplying skilled human capital and delivering technology-transfer services, making it an indispensable educational force for fostering new-quality productivity [1-2].

Regarding practical dilemmas, several studies note that specialty settings in some higher vocational colleges fail to keep pace with industrial transformations, leading to homogeneous specialty clustering and mismatch between talent supply and industrial demand [3]. Other research indicates that industry-education integration and college-enterprise cooperation remain superficial, hindering in-depth multi-party resource linkage [4]. Furthermore, insufficient matching between talent output quality and job requirements weakens the supporting capacity of vocational education for industries [5]. In addition, uneven inter-provincial allocation of higher vocational education resources is salient, with high-quality resources concentrated in eastern China and widening inter-regional gaps [6]. Less-developed regions even face vicious cycles of fiscal shortages and brain drain [7].

Correspondingly, scholars have proposed targeted optimization strategies. Regional industrial demands should guide dynamic adjustments to specialty layouts so as to realize precise alignment between educational supply and local pillar industries [8]. Institutional mechanisms need innovation to build college-enterprise platforms and foster an integrated development paradigm linking vocational education and regional economy [9]. Priority should also be given to developing "dual-competency" teachers and strengthening the technical-service capacity of higher vocational colleges [10], alongside improving multi-level operational systems for industry-education integration covering macro, meso and micro dimensions [11].

Nevertheless, prior research leaves room for further exploration. First, most existing work examines the unidirectional impact of higher vocational education on industries and economy. Although a small body of literature adopts coupling-coordination models to investigate interactions between higher vocational education and new-quality productivity [12-13], such studies are limited and largely confined to static coordination measurement; dynamic identification of shock transmission paths and time-lag effects remains inadequate. Second, some empirical studies adopt overly simplistic indicators, relying on single scale metrics to proxy higher vocational education development, lacking multi-dimensional comprehensive evaluation frameworks incorporating school-running conditions, faculty and educational outputs [14].

To fill these research gaps, this paper draws panel data from 30 provincial-level administrative units across China for 2018-2023 and establishes composite indicators for the two systems. Coupling-coordination calculation and PVAR-based dynamic interaction identification are implemented to address the following questions: What is the current status of coordinated development between higher vocational education quality and new-quality productivity across provinces, and what disparities exist among eastern, central and western China? What are the dynamic shock and feedback mechanisms between the two systems? Empirical results are expected to provide empirical foundations for optimizing higher vocational education supply and advancing new-quality productivity construction in different regions.

2 RESEARCH DESIGN AND DATA PROCESSING

2.1 Data Sources

The initial sample consists of provincial panel data for 30 Chinese provinces over 2018-2023. Xizang, Hong Kong region, Macao region and Taiwan region are excluded due to data availability constraints. Higher-vocational-education-related statistics are obtained from China Educational Statistics Yearbook and provincial annual quality reports on higher vocational education. Regional economic indicators are extracted from the EPS Database and CSMAR Database. Missing values are first imputed via province-specific linear interpolation; remaining missing observations are supplemented using within-group mean imputation.

2.2 Construction of Indicator System

Table 1 Evaluation Indicator System for Higher Vocational Education Quality

Dimension	Indicators	Attribute
School-running conditions	Full-time student enrollment, Equipment expenditure per student, Practical-training workstations per student	Positive
Teaching faculty	Proportion of dual-competency teachers, Proportion of senior-title teachers, Teacher-student ratio	Positive
Training process	Fiscal appropriation per student, horizontal and vertical research funding	Positive
Output performance	Employment rate, Graduate monthly salary, Entrepreneurship rate, Three-year promotion rate of graduates	Positive

Table 2 Evaluation Indicator System for New-Quality Productivity

Dimension	Indicators	Attribute
Innovation-driving capacity	Number of granted domestic patents, Business revenue of high-technology industries, Innovation expenditure of large-scale industrial enterprises	Positive
Technical efficiency	Labor productivity of large-scale industrial enterprises, Full-time equivalent of R&D personnel in large-scale industrial enterprises, Density of installed industrial robots	Positive
Digital economy	Integrated-circuit output, Total telecommunication business volume, Internet broadband access ports, Software business revenue, E-commerce sales	Positive
Green low-carbon transition	Energy consumption per unit GDP, Fossil-energy consumption per unit GDP, Industrial water consumption per unit GDP, Industrial wastewater discharge per unit GDP, Industrial SO_2 emission per unit GDP	Negative

Following principles of systematicness, data availability and representativeness, two comprehensive evaluation systems are constructed for higher vocational education quality and new-quality productivity respectively. The higher vocational education quality system includes 12 indicators across four dimensions: school-running conditions, teaching faculty, training process and output performance (Table 1), covering scale, hardware input, faculty structure and talent-training outcomes to comprehensively measure provincial higher vocational education quality. The new-quality productivity system comprises four dimensions: innovation-driving capacity, technical efficiency, digital economy and green low-carbon transition (Table 2), incorporating indicators reflecting innovation output, industrial technology, digital-industry growth and green transformation. Logarithmic transformation is applied to indicators with skewness greater than 2 before entropy-weight calculation, mitigating biases caused by extreme values.

2.3 Research Methods and Model Specification

2.3.1 Entropy-weight method

The entropy-weight method assigns objective weights according to indicator dispersion, avoiding artificial bias from subjective weighting. Standardized and log-transformed indicators are used to compute composite indices for higher vocational education quality (U_1) and new-quality productivity (U_2).

2.3.2 Coupling-coordination model

Coupling degree captures interaction intensity between two systems, while coupling-coordination degree further accounts for their overall development level:

$$C = 2\sqrt{\frac{U_1U_2}{(U_1+U_2)^2}} \tag{1}$$

$$D = \sqrt{C \times T},\ T = \alpha U_1 + \beta U_2 \tag{2}$$

where U_1 is composite index of higher vocational education quality; U_2 is composite index of new-quality productivity; C is coupling degree; T is comprehensive development index; D is coupling-coordination degree; both α and β are set to 0.5.

2.3.3 Panel vector autoregressive (PVAR) model

The PVAR model treats all variables as endogenous and suits the identification of bidirectional dynamic relationships within panel datasets. Model specification:

$$Y_{it} = A_0 + \sum_{j=1}^{p} A_j Y_{i,t-j} + \mu_i + \varepsilon_{it} \tag{3}$$

where Y_{it} contains U_1 and U_2; μ_i denotes province-specific fixed effects. Impulse-response functions characterize dynamic evolution triggered by one-unit shocks; variance decomposition quantifies the contribution share of distinct shocks.

2.3.4 Spatial econometric model

Global spatial autocorrelation is first tested via annual Moran's I statistics. Addressing endogeneity, a cross-sectional spatial-lag 2SLS model using multi-year averages is adopted to estimate spatial spillover effects. Regression outcomes are decomposed into direct and indirect effects to distinguish local impacts from spillover effects on neighboring provinces.

3 EMPIRICAL RESULTS AND ANALYSIS

3.1 Descriptive Statistics of Variables

The sample contains 180 observations from 30 provinces for 2018-2023. Composite indices U_1 and U_2, coupling degree *C,* comprehensive development index *T* and coupling-coordination degree *D* are computed as described above. Descriptive statistics for key variables are summarized in Table 3.

Table 3 Descriptive Statistics of Major Variables

Variable	Obs.	Mean	Std.Dev.	Min	Median	Max
Educational quality(U_1)	180	0.2760	0.0767	0.1363	0.2589	0.5250
New-quality productivity(U_2)	180	0.1351	0.1096	0.0346	0.1015	0.6366
Coupling degree (C)	180	0.8918	0.0748	0.6844	0.901	0.9993
Comprehensive development index (T)	180	0.2056	0.0813	0.1013	0.1856	0.5101
Coupling-coordination degree (D)	180	0.4222	0.0877	0.287	0.4086	0.7098

U_1 averages 0.2760 with moderate cross-provincial dispersion. The mean value of U_2 (0.1351) is markedly lower, while its standard deviation reaches 0.1096 alongside a large gap between maximum and minimum values, indicating severe regional imbalance in new-quality productivity. The mean coupling degree *C* equals 0.8918, reflecting strong overall interaction between the two systems. Nevertheless, the average coupling-coordination degree *D* is merely 0.4222 (moderate coordination level), implying that insufficient overall development constrains coordination quality despite intense system-to-system interactions.

3.2 Spatiotemporal Evolution of Coupling-Coordination Degree

3.2.1 Coordination levels and development patterns

Coupling-coordination degree *D* is categorized into four tiers: low coordination (D<0.3), moderate coordination (0.3<=D<0.5), high coordination (0.5<=D<0.8) and extreme coordination (0.8<=D<1.0). Development patterns are further classified as educational-quality lag ($U_1<U_2$) and new-quality-productivity lag ($U_1>U_2$). Sample distributions are reported in Table 4.

Table 4 Distribution of Coupling-Coordination Tiers and Development Patterns

Classification	Category	Obs.	Percentage (%)
Coordination tier	Low coordination	3	1.67
	Moderate coordination	149	82.78
	High coordination	27	15.00
	Extreme coordination	1	0.56
Development pattern	Educational-quality lag	10	5.56
	New-quality-productivity lag	170	94.44

Most observations (82.78%) fall within the moderate-coordination tier, with only 15.00% achieving high coordination. China's higher vocational education and new-quality productivity are transitioning from moderate toward high coordination. 94.44% of samples belong to the new-quality-productivity-lag pattern, meaning higher vocational education quality outperforms local new-quality-productivity development in most provinces; underdeveloped new-quality productivity constitutes the primary bottleneck for joint advancement.

3.2.2 Regional disparities and provincial rankings

Mean values grouped by eastern, central and western regions are presented in Table 5. The eastern region outperforms central and western China in U_1, U_2 and *D*. All three regions remain within the moderate-coordination range, yet eastern provinces approach the threshold for high coordination (D=0.5).

Table 5 Mean Coupling-Coordination Indicators across Three Regions

Region	Educational quality (U_1)	New-quality productivity (U_2)	Coupling-coordination degree (D)	Coordination tier
Eastern China	0.3137	0.2067	0.4816	Moderate coordination
Central China	0.2604	0.0961	0.3937	Moderate coordination
Western China	0.2496	0.0920	0.3834	Moderate coordination

Top-ranking provinces for coupling-coordination degree are Guangdong, Jiangsu, Zhejiang, Shandong and Beijing — all eastern coastal provinces reaching high coordination. Provinces at the bottom include Hainan, Yunnan, Heilongjiang, Jilin and Qinghai, trapped in low-end moderate coordination due to weak economic foundations and single industrial structures.

3.2.3 Visualization of spatiotemporal patterns

As illustrated in Figure 1, the Pearson correlation coefficient between U_1 and U_2 is 0.5088 (p<0.01), confirming significant positive association. Eastern observations cluster in the upper-right section of the scatter plot (Figure 1a), while central-western observations concentrate in the lower-left zone, demonstrating clear regional stratification. The ranking bar chart (Figure 1b) further confirms the inter-provincial gap. The box-plot (Figure 1c) reveals higher median and quartile values of *D* in eastern China, together with larger intra-regional variance. The time-series plot (Figure 1d) shows steady growth for eastern China's coupling-coordination degree during 2018-2023. The central region peaked in 2019 and subsequently stabilized at a lower level. The western region exhibits boom-and-bust fluctuation and declines after 2019, widening gaps versus the east.

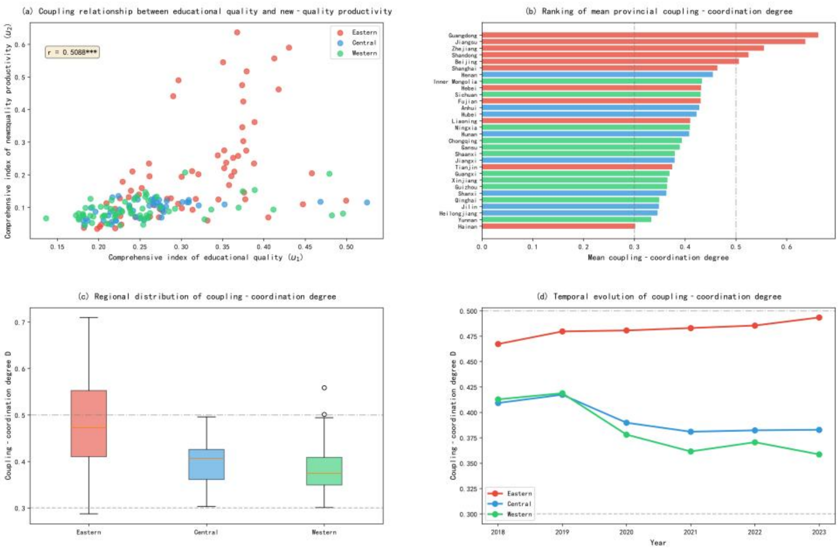

Figure 1 Spatiotemporal Evolution of Coupling-Coordination Degree between Higher Vocational Education Quality and New-Quality Productivity

Figure 2 presents the entropy-weight distribution of higher vocational-education-quality indicators and the coupling-coordination classification matrix. As shown in Figure 2a, practical-training workstations per student, total full-time enrollment and equipment expenditure per student account for nearly 60% of total weight, suggesting that hardware conditions and scale dominate provincial differences in higher vocational education quality. By contrast, weights for employment rate, research funding and dual-competency teacher ratio are relatively low, indicating limited discriminatory power of these metrics across provinces. The quadrant classification matrix in Figure 2b partitions provinces into four groups: high-education-high-productivity (mainly eastern advanced provinces), low-education-high-productivity (educational lag), high-education-low-productivity (productivity lag, most central-western provinces) and low-education-low-productivity (disadvantaged western provinces). This matrix visualizes the structural contradiction observed across most provinces: relatively advanced vocational education paired with lagging new-quality productivity.

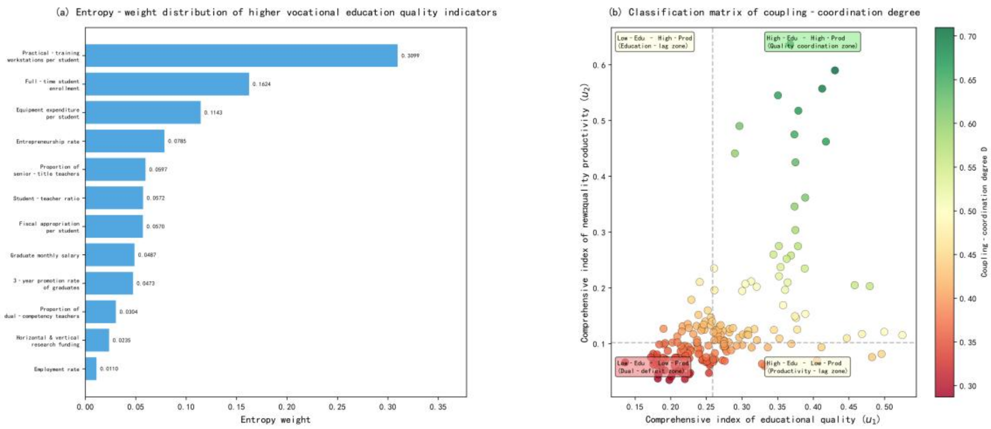

Figure 2 Entropy-Weight Distribution of Higher Vocational Education Quality Indicators and Classification Matrix of Coupling-Coordination Degree

3.3 Correlation Analysis and Regression Estimation

3.3.1 Correlation analysis

Pearson correlation coefficients are calculated for the full sample and three sub-regions (Table 6). Nationwide, U_1 correlates positively with U_2 (r=0.5088, p<0.01) and with D (r=0.7509, p<0.01). Correlation between U_1 and U_2 is strongest in eastern China (r=0.5263), followed by central (r=0.4687) and western China (r=0.4029), all statistically significant at the 1% level. The correlation between U_1 and *D* peaks in central China (r=0.8068), implying that coordination improvement in central provinces depends heavily on higher vocational education quality.

Table 6 Sub-Regional Correlation Analysis

Group	U1-U2 Correlation	U1-D Correlation	Observations
National	0.5088***	0.7509***	180
Eastern	0.5263***	0.7305***	66
Central	0.4687***	0.8068***	48
Western	0.4029***	0.7774***	66

Note: *** denotes significance at the 1% level.

3.3.2 Baseline OLS regression

Table 7 Baseline OLS Regression Results

Variable	Model 1 (U2 as dependent variable)	Model 2 (U2 as dependent variable)	Model 3 (D as dependent variable)
U1	0.7274*** (0.2688)	0.3653*** (0.1359)	0.6035*** (0.0944)
Per-capita GDP	—	0.0735* (0.0405)	0.0532** (0.0239)
Industrial structure	—	-0.0704 (0.1248)	-0.0119 (0.0748)
Openness	—	-0.0025 (0.0068)	0.0013 (0.0048)
FDI	—	0.0130 (0.0119)	-0.0010 (0.0068)
Educational fiscal expenditure	—	0.0549* (0.0284)	0.0436** (0.0177)
Constant	-0.0656 (0.0600)	-0.5841 (0.8389)	-0.5414 (0.5121)
Adjusted R2	0.2547	0.4886	0.7220
N	180	180	180

Note: Standard errors in parentheses; ***, **, * represent significance at 1%, 5%, 10% levels respectively. All control variables are log-transformed.

OLS regressions are implemented: Model 1 and Model 2 take U_2 as the dependent variable (Model 2 incorporates control variables including per-capita GDP, industrial structure, openness, FDI and educational fiscal expenditure); Model 3 uses coupling-coordination degree *D* as the dependent variable (Table 7).

Higher vocational education quality exerts significantly positive effects on new-quality productivity regardless of control-variable inclusion. In Model 2, a one-unit increase in U_1 is associated with a 0.3653-unit rise in U_2. The coefficient of U_1 for D reaches 0.6035 ($p<0.001$) with $R^2=0.7313$, confirming that higher vocational education quality serves as a core driver for coupling-coordination improvement. Among controls, per-capita GDP and educational fiscal expenditure show significantly positive coefficients, while industrial structure, openness and FDI lack statistical significance.

3.3.3 Regional heterogeneity

Grouped regressions for three regions are reported in Table 8. When predicting U_2, U_1 yields significant positive coefficients for eastern China (0.3615, $p<0.05$) and western China (0.1553, $p<0.05$), whereas the central coefficient (0.0329) is insignificant. This indicates low conversion efficiency from vocational-education quality to new-quality productivity in central China, possibly caused by structural mismatch between talent supply and industrial demand. For coupling-coordination degree *D*, coefficients of U_1 are significantly positive across all regions, with effect magnitude ranking: eastern > western > central.

Table 8 Regression Results for Regional Heterogeneity

Region	Dependent Variable	Coefficient of U1	R2	Obs.
Eastern	U2	0.3615**	0.8631	66
	D	0.5218***	0.9534	66
Central	U2	0.0329	0.5617	48
	D	0.3670***	0.8184	48
Western	U2	0.1553**	0.4810	66
	D	0.4820***	0.7793	66

Note: *** and ** denote significance at 1% and 5% levels.

3.3.4 Fixed-effects models

Entity fixed-effects and two-way fixed-effects specifications are estimated for robustness checks (Table 9). Coefficients of U_1 remain positive and highly significant, consistent with OLS outcomes. After controlling for province-specific and time-specific heterogeneity, industrial-structure upgrading and openness demonstrate significant positive associations with new-quality productivity.

Table 9 Fixed-Effects Regression Results

Variable	Entity Fixed-Effects (LSDV with clustering)	Two-Way Fixed-Effects (LSDV with clustering)
Higher vocational education quality U1	0.4544*** (0.0601)	0.4411*** (0.0601)
Per-capita GDP	-0.0540 (0.0405)	-0.2146** (0.1038)
Industrial structure	0.2911*** (0.0834)	0.1817 (0.1221)
Openness	0.0217** (0.0091)	0.0208** (0.0090)
FDI	-0.0060** (0.0030)	-0.000021
Educational fiscal expenditure	0.0878 (0.0555)	0.1138* (0.0624)
Constant	-2.3698** (0.9417)	0.3532 (2.0416)
R2	0.9689	0.9710
Adjusted R2	0.9613	0.9627
N	180	180

Note: Clustered robust standard errors in parentheses; ***, **, * denote significance at 1%, 5%, 10% levels.

3.4 PVAR Model Estimation

3.4.1 PVAR estimation and stationarity test

Table 10 PVAR Model Estimation Results

Equation	Variable	Coefficient	Std. Error	t-statistic	p-value
Equation 1: U1 (t)	Constant	-0.0031	0.0022	-1.417	0.1565
	U1 lag 1	0.1235	0.1028	1.2016	0.2295
	U2 lag 1	0.5276**	0.2101	2.5112	0.0120
	R2	0.1072	—	—	—
Equation 2: U2 (t)	Constant	0.0014	0.0021	0.6701	0.5028
	U1 lag 1	-0.025	0.0352	-0.7096	0.4779
	U2 lag 1	0.6498***	0.0390	16.6469	0
	R2	0.4508	—	—	—

Note: *** and ** represent significance at 1% and 5% levels.

A bivariate PVAR model containing U_1 and U_2 is constructed. AIC, BIC and HQIC criteria select lag order 1. Helmert forward-mean-difference transformation eliminates individual fixed effects; system-GMM is applied for parameter estimation (Table 10).

In Equation 1, the one-period lag of U_2 obtains a coefficient of 0.5276 ($p<0.05$), showing that lagged new-quality productivity significantly promotes higher vocational education quality. The auto-regressive term of U_1 is insignificant, implying weak self-accumulation for vocational education quality. In Equation 2, lagged U_2 is highly significant (0.6498, $p<0.001$), reflecting strong path dependence and self-reinforcement for new-quality-productivity development. Meanwhile, the lagged U_1 coefficient is small and insignificant, suggesting that short-run direct driving effects of higher vocational-education quality on new-quality productivity remain limited due to transformation barriers. Stationarity test confirms that both characteristic-root moduli are less than unity, satisfying PVAR stability requirements.

3.4.2 Granger causality test

Granger causality tests based on PVAR are presented in Table 11. The null hypothesis that new-quality productivity does not Granger-cause higher vocational-education quality is strongly rejected ($p<0.001$). By contrast, we cannot reject the null hypothesis that higher vocational-education quality does not Granger-cause new-quality productivity ($p=0.2268$). This finding corroborates asymmetric interactions: new-quality productivity drives improvements in vocational education quality, yet the reverse causal channel remains underdeveloped.

Table 11 Granger Causality Test

Null Hypothesis H0	F-statistic	p-value	Conclusion
New-quality productivity does not Granger-cause higher vocational-education quality	15.5676***	0.0000	Reject H0
Higher vocational-education quality does not Granger-cause new-quality productivity	1.5030	0.2268	Fail to reject H0

Note: *** denotes significance at the 1% level.

3.4.3 Impulse-response function

Impulse-response functions are computed with 500 Monte-Carlo simulations for confidence intervals over a 10-period horizon, as visualized in Figure 3. After a positive shock to higher vocational-education quality, its own response peaks contemporarily and decays rapidly, indicating short-lived self-reinforcement. A positive shock to new-quality productivity generates a continuously rising positive response in higher vocational-education quality over time, demonstrating persistent, growing forcing-driven effects of industrial-technological progress on educational reform. Conversely, the response of new-quality productivity to a positive shock in higher vocational-education quality stays small and fluctuates near zero, confirming feeble short-term impacts. New-quality productivity exhibits self-propelled cumulative growth following its own positive shock.

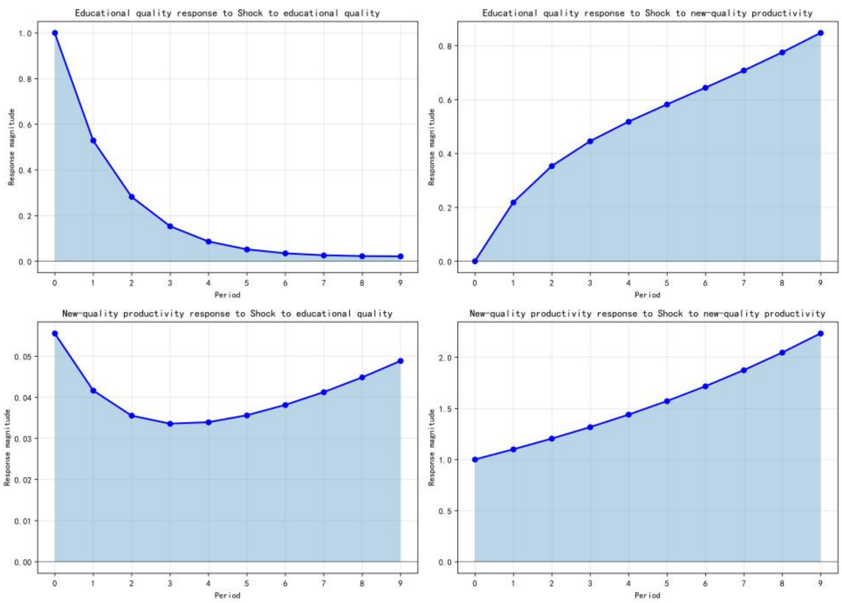

Figure 3 Impulse-Response Functions of the PVAR Model

3.4.4 Variance decomposition

Variance-decomposition outcomes quantify shock contributions to forecast error variance (Table 12). For higher vocational-education quality, the share attributed to new-quality-productivity shocks rises gradually from 0.21% in period 1 to 35.58% in period 9, highlighting the increasing long-run importance of new-quality-productivity changes for vocational-education quality. For new-quality productivity, its own shocks dominate forecast-error variance across all horizons, accounting for 99.33% by period 9. The contribution from higher vocational-education-quality shocks stays persistently below 1%, further demonstrating low conversion efficiency from vocational-education quality toward new-quality productivity.

Table 12 Variance Decomposition for Selected Horizons

Response Variable	Horizon (Period)	Contribution from higher-vocational-education-quality shocks (%)	Contribution from new-quality-productivity shocks (%)
Higher vocational-education quality	1	99.79	0.21
	3	97.29	2.71
	5	90.47	9.53
	7	78.93	21.07
	9	64.42	35.58
New-quality productivity	1	2.02	97.98
	3	1.23	98.77
	5	0.91	99.09
	7	0.75	99.25
	9	0.67	99.33

4 MAIN CONCLUSIONS AND POLICY IMPLICATIONS

4.1 Main Conclusions

Using 2018-2023 panel data for 30 Chinese provinces and multiple econometric tools, this paper investigates coupling-coordination levels, dynamic interactions and spatial patterns between higher vocational-education quality and new-quality productivity. Key conclusions are summarized below.

First, the national coupling-coordination between higher vocational-education quality and new-quality productivity lies at the moderate-coordination stage and is evolving toward higher coordination. Most provinces suffer from relatively lagging new-quality productivity, which acts as the primary bottleneck constraining joint advancement. Distinct regional gradients emerge: eastern provinces achieve superior synergy compared with central and western counterparts. Temporal trends reveal steady coordination growth in eastern China, whereas central-western regions lack sufficient momentum, and inter-regional gaps tend to expand.

Second, higher vocational-education quality positively contributes to new-quality productivity and system-wide coupling-coordination, yet pronounced regional heterogeneity exists. The empowering effects function effectively in eastern and western China. However, conversion barriers appear in central China, likely stemming from structural mismatches between talent provision and industrial needs. Multiple robustness-check specifications validate the positive role of higher vocational-education quality.

Third, asymmetric bidirectional dynamic interactions characterize the two systems. New-quality productivity generates feedback effects that push higher vocational-education quality upward as industrial upgrading imposes new talent requirements and compels educational reform. In contrast, higher vocational-education quality exerts delayed, limited short-run driving power over new-quality productivity, with frictions obstructing the transformation of educational resources into real-world productivity. In the long run, new-quality productivity increasingly explains fluctuations in higher vocational-education quality, while the explanatory power of vocational-education quality for new-quality-productivity evolution remains weak.

4.2 Policy Implications and Recommendations

Policy implications derived from the findings emphasize region-tailored interventions to mitigate regional gaps and smooth the transformation from educational outputs to real-world productivity. Governments, higher vocational colleges and industrial stakeholders should address local bottlenecks and unlock endogenous synergies. Specific policy recommendations are proposed as follows.

First, implement region-specific targeted strategies to narrow inter-regional synergy gaps. Leveraging industrial agglomeration and innovation advantages, eastern regions should deepen integration between higher vocational education and high-end manufacturing, digital industries and strategic emerging sectors, develop new majors for emerging occupations, and build industry-education platforms to consolidate existing high-level coordination. Central-western regions should avoid mechanically copying eastern development modes. Priority should be given to improving new-quality-productivity-related infrastructure, technological innovation and industrial systems. Policy instruments including paired assistance and cross-regional industrial linkages can introduce high-quality eastern industry-education resources and cultivate region-specific technical-skilled talent. For central provinces plagued by supply-demand mismatch, regular industrial-talent-gap surveys should inform dynamic adjustments to majors and curricula, phasing out obsolete programs disconnected from local industrial evolution.

Second, streamline channels for translating educational outputs to mitigate lagged empowering performance. Higher vocational colleges should highlight practical orientations, deepen college-enterprise collaborative education, and jointly build practical-training bases, R&D centers and industrial colleges. Enterprise technical standards and real-world innovation projects should be embedded throughout talent-training workflows to shorten the adaptation cycle for graduates entering the labor market. Application-oriented R&D, process improvement and technical services oriented toward local industrial transformation should be encouraged. Dedicated incubation platforms for vocational-college technical outputs can alleviate problems such as idle educational resources, market-detached research and under-realized talent value, enhancing both short-term and long-term contributions of higher vocational education to new-quality productivity.

Third, construct bidirectional dynamic adaptation mechanisms to foster virtuous interactive cycles. Industrial parks and leading enterprises should maintain active communication with higher vocational colleges, transmitting updated information about industrial upgrading, technological iteration and job-profile shifts to drive iterative improvements in vocational-education curricula and training schemes. Meanwhile, efforts should shift vocational education from passively adapting to industrial demands toward actively supporting industrial upgrading. Targeted cultivation of innovative, compound-type technical-skilled talent for key domains of new-quality-productivity development facilitates a self-reinforcing cycle: improvements in higher vocational education promote advances in new-quality productivity, and such advances subsequently stimulate further educational reform.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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