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A Study on the Adaptability between the Specialty Structure of Higher Vocational Education and Regional Industrial Structure: An Empirical Analysis Based on Provincial Panel Data

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Abstract: Based on panel data from 31 Chinese provinces (autonomous regions, municipalities) from 2012 to 2023, this study constructs an adaptability index between the specialty structure and industrial structure encompassing three dimensions: scale, structure, and quality. It employs a two-way fixed effects model and a panel threshold model for empirical testing. The findings are as follows: (1) The depth of industry-education integration, the mechanism for dynamic specialty adjustment, and the degree of industry-enterprise participation all have significant positive effects on adaptability, with the dynamic specialty adjustment mechanism having the largest effect size (β=0.287). (2) The impact of industry-education integration exhibits a single threshold effect (threshold value of 0.624). After crossing this threshold, its marginal effect increases from 0.142 to 0.305, effectively doubling.This research provides important empirical evidence and policy implications for deepening industry-education integration and establishing a precise and flexible dynamic specialty adjustment mechanism.

Keywords: Higher Vocational Education; Specialty Structure; Industrial Structure; Adaptability; Panel Model; Threshold Effect

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1. Introduction

As the main channel for supplying high-quality technical and skilled talent in China, whether the specialty structure of Higher Vocational Education (HVE) can dynamically adapt to the regional industrial structure is directly related to the enhancement of national competitiveness and sustainable economic development. According to the “2023 China Vocational Education Quality Annual Report”, vocational colleges have cultivated over 40 million graduates in the past decade. Their employment quality and fit in the labor market are key indicators for measuring the effectiveness of vocational education. However, against the backdrop of accelerated industrial upgrading and technological transformation, the structural contradiction between talent supply and demand has become increasingly prominent. This contradiction highlights the urgency of systematically evaluating and optimizing the adaptability between the specialty structure of HVE and the regional industrial structure.

Existing literature provides a solid foundation for this study, but there is room for expansion: Firstly, most research focuses on macro-theoretical exposition or case studies, with relatively insufficient empirical testing based on long-term, large-sample data. Secondly, the analysis of influencing factors is mostly limited to linear assumptions, failing to fully reveal potential complex nonlinear relationships among variables. Therefore, utilizing provincial panel data from 2012-2023, this paper aims to explore the following questions: (1) What are the key factors influencing the adaptability between the two, and what is their magnitude of effect? (2) Does the impact of core variables (e.g., industry-education integration) exhibit nonlinear characteristics? What are the policy implications?

The marginal contributions of this paper are: First, it identifies the core drivers of adaptability through rigorous econometric models. Second, it innovatively applies a threshold regression model to reveal the "critical effect" of the depth of industry-education integration, providing a theoretical basis for targeted policies.

2. Literature Review and Research Hypotheses

2.1. Literature Review

Scholars domestically and internationally have extensively explored the relationship between educational structure and economic structure. International research, from the perspective of the "Skill Formation System," emphasizes the institutional role of deep industry-enterprise participation in ensuring the match between skill supply and job requirements (D.Soskice, 2004; Saviotti, et al., 2016)[1,2]. Domestic research focuses more on the measurement and problem diagnosis of adaptability, such as the homogenization of specialty setup and lagged response (Pan Haiyan & Yang Xuan, 2023; Song Yafeng & Zhao Kangjian Xuan, 2025)[3,4]. These studies provide valuable theoretical perspectives and practical references for this topic, but most lack in-depth empirical testing of the mechanisms and boundary conditions of influencing factors.

2.2. Theoretical Analysis and Research Hypotheses

Based on systems theory and human capital theory, the adaptation between specialty structure and industrial structure is essentially a process of achieving dynamic balance between talent supply and industrial demand in terms of quantity, structure, and quality[5]. This process is jointly influenced by the internal governance mechanisms of the education system and the synergistic effects of the external environment[6]. Accordingly, this paper proposes the following hypotheses:

H1: The depth of industry-education integration has a significant positive impact on the adaptability between the specialty structure and industrial structure.

H2: The dynamic specialty adjustment mechanism has a significant positive impact on the adaptability between the specialty structure and industrial structure.

H3: The impact of the depth of industry-education integration on adaptability exhibits a nonlinear threshold effect, meaning that when its depth exceeds a certain critical value, the promoting effect increases significantly.

3. Research Design

3.1. Model Specification

To test the above hypotheses, this study constructs the following two econometric models.

3.1.1. Baseline Regression Model: Two-way Fixed Effects Panel Model

To control for time-invariant regional individual characteristics and individual-invariant time trends, we use a two-way fixed effects model for baseline regression:

$$Adaptation_{it} = \alpha + \beta X_{it} + \gamma Z_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Here, $Adaptation_{it}$ is the explained variable, representing the specialty-industrial structure adaptability of province i in year t; X_{it} is the vector of core explanatory variables; Z_{it} is the vector of control variables; μ_i and λ_t are individual fixed

effects and time fixed effects, respectively; ε_{it} is the random error term.

3.1.2. Nonlinear Relationship Test Model: Panel Threshold Model

To examine whether core variables have nonlinear effects, we use the panel threshold regression model developed by Hansen (1999)[7]. Using the depth of industry-education integration (*Int_Int*) as the threshold variable, the model is specified as follows:

$$Adaptation_{it} = \alpha + \beta_1 Int_{it} \cdot I(Int\_Int_{it} \le \theta) + \beta_2 Int_{it} \cdot I(Int\_Int_{it} > \theta) + \gamma Z_{it} + \mu_i + \varepsilon_{it}$$

Here, θ is the threshold value to be estimated, $I(\cdot)$ is the indicator function, and other variables are defined as in the baseline model.

3.2. Variable Definitions and Data Description

This study's data covers 31 Chinese provinces (autonomous regions, municipalities) from 2012 to 2023. All price variables are deflated to the 2012 base period.

Table 1. Variable Definitions and Descriptive Statistics

Variable Type	Variable Name	Symbol	Measurement Method
Explained Variable	Adaptability	Adaptation	Comprehensive index based on scale, structure, and quality dimensions, constructed using Entropy Weight-TOPSIS
Core Explanatory Variables	Industry-Education Integration Depth	Int_Int	Composite index of 6 indicators: School-enterprise co-construction base, co-developed courses, jointly trained students, etc.
	Dynamic Specialty Adjustment	Dyn_Adj	Composite of 4 indicators: specialty early warning/exit mechanism, evaluation frequency, adjustment response speed
	Industry-Enterprise Participation	Ind_Part	Principal component score of 3 indicators: industry steering committee coverage, enterprise expert teaching ratio, etc.
Control Variables	Economic Development Level	GDP_pc	Per capita Gross Regional Product (log)
	Government VET Investment	Gov_Inv	Per student public financial budget expenditure for HVE (log)
	Technological Innovation Level	Innovation	Number of invention patents per 10,000 people (log)
	Population Structure	Population	Proportion of population aged 18-22 in total population

4. Empirical Analysis

4.1. Baseline Regression: Two-way Fixed Effects Model Results

The regression results of the two-way fixed effects model are presented in **Table 2**. The impacts of each core variable are significant, and the specific analysis is as follows.

Industry-Education Integration Depth (*Int_Int*): Its coefficient is significantly positive at the 1% level across all model specifications, stable between 0.252 and 0.284. This indicates that a one-unit increase in industry-education integration depth leads to an approximately 0.25 to 0.28 unit increase in adaptability. This confirms the fundamental role of school-enterprise collaborative education in precisely meeting industrial demands.

Dynamic Specialty Adjustment (*Dyn_Adj*): This variable is the most influential factor, with coefficients between 0.287 and 0.327, highly significant. This means establishing a sensitive specialty early warning and adjustment mechanism is key to responding to rapid industrial changes and enhancing adaptability.

Industry-Enterprise Participation (*Ind_Part*): The coefficient is between 0.168 and 0.198, significant at the 5% level.

This indicates that the substantive participation of industries and enterprises in the specialty development process can effectively convey market demand signals and optimize talent training specifications.

Varying Effects of Control Variables:

Economic Development Level (*GDP_pc*) is significantly positive, suggesting that economically developed regions have more resources and motivation to optimize their vocational education structure; Government VET Investment (*Gov_Inv*) is significant at the 10% level, indicating that financial support is the foundation for ensuring the quality of specialty development; Technological Innovation Level (*Innovation*) and Population Structure (*Population*) have positive but insignificant coefficients, possibly because their influence is indirectly exerted through the core variables.

Table 2. Two-way Fixed Effects Model Regression Results

Variable	Model(1)	Model(2)	Model(3)	Model(4)	Model(5)
Int_Int	0.284***	0.271***	0.263***	0.258***	0.252***
Dyn_Adj	0.327***	0.312***	0.301***	0.294***	0.287***
Ind_Part	0.198**	0.185**	0.179**	0.174**	0.168**
GDP_pc		0.045**	0.041**	0.038*	0.035*
Gov_Inv			0.032*	0.030*	0.028*
Innovation				0.026	0.024
Population					0.019
Individual FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Observations	372	372	372	372	372
R^2 (Within)	0.536	0.552	0.561	0.567	0.569
F-statistic	47.85***	45.12***	43.27***	41.56***	39.88***

*Note: *, **, *** represent significance at the 10%, 5%, and 1% levels, respectively; t-values in parentheses.*

4.2. Nonlinear Relationship Test: Panel Threshold Model Results

The baseline regression assumes linear relationships, but real-world influences may be more complex. Therefore, we use the depth of industry-education integration (Int_Int) as the threshold variable to explore potential nonlinear effects.

Table 3. Threshold Effect Test

Model	Threshold Value	F-value	P-value	BS Reps	1% Critical Value
Single Threshold	0.624	28.73	0.012	500	22.45
Double Threshold	0.458	15.42	0.134	500	18.91

Table 3 shows that the single threshold effect is significant at the 5% level (P-value 0.012), while the double threshold effect is not significant (P-value 0.134). Therefore, the model has a single threshold at 0.624.

Table 4. Panel Threshold Model Regression Results

Variable	Coefficient	t-value
Int_Int (Low Integration Group: ≤0.624)	0.142*	(1.79)
Int_Int (High Integration Group: >0.624)	0.305***	(3.87)
Dyn_Adj	0.273***	(3.51)
Ind_Part	0.162**	(2.08)
Control Variables	Controlled	
Individual FE	Yes	
Observations	372	
R^2	0.581	

The threshold regression results reveal a crucial nonlinear pattern: When industry-education integration depth is below 0.624, its promoting effect on adaptability is relatively limited, with a coefficient of 0.142, significant only at the 10% level. When industry-education integration depth crosses the 0.624 threshold, its promoting effect doubles, with the coefficient increasing significantly to 0.305, highly significant at the 1% level.

This finding has profound policy implications: Industry-education integration must reach a certain depth and substantive stage to generate powerful synergistic effects. In the initial stage (e.g., simple internship cooperation), the effect is not obvious. Only when cooperation deepens to jointly formulate training standards, co-develop curricula and teaching materials, and share faculty and technical resources (i.e., integration degree > 0.624) can it significantly bridge the gap between talent training and industrial demand, leading to a qualitative improvement in adaptability.

5. Conclusion and Outlook

Based on provincial panel data from 2012-2023, this study systematically examines the adaptability between the specialty structure of HVE and the regional industrial structure and its driving factors using a two-way fixed effects model and a panel threshold model. The main conclusions are as follows: First, industry-education integration, dynamic specialty adjustment, and industry-enterprise participation are three key levers for improving adaptability, with dynamic specialty adjustment having the greatest effect. Second, the impact of industry-education integration exhibits significant nonlinear characteristics; its depth must cross the threshold value of 0.624 to produce a multiplier promoting effect. This finding provides a new quantitative benchmark for evaluating and guiding industry-education integration work.

Future research could further track the changing trends of future industrial job competency requirements against the backdrop of accelerated application of disruptive technologies like AI, and explore how HVE specialty clusters can respond to these changes more proactively and flexibly. Continuously deepening the supply-side structural reform of HVE and building a dynamic adaptation mechanism that resonates with regional industries will be the core issue in promoting the high-quality development of the modern vocational education system.

Disclosure statement

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