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Higher Education and Regional Economic Coordination: Measurement and Evaluation, Influencing Factors, and Development Decisions

Shuxi Yan[1,2*], Lifeng Guo[2], Liwei Sun[2]

1 Faculty of Education, Shaanxi Normal University, Xi'an 710062, China
2 School of Mathematics and Statistics, Yulin University, Yulin 719000, China

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ABSTRACT

Higher education relies on the support of the regional economy, while the demand for human capital to drive regional economic growth largely originates from higher education. Thus, their coordinated advancement is essential in the contemporary knowledge-based economy. This study establishes an indicator system and evaluates the current state of higher education and regional economic development. Utilising statistical data from Shaanxi Province spanning 2008 to 2022, the entropy method is applied to determine indicator weights. Decision analysis on the coordination level and influencing factors of higher education and regional economic development is conducted through statistical methods, including multiple linear regression, the coupling coordination model, and the obstacle degree model. Findings indicate a gradual strengthening in the coupling coordination degree, progressing from an initial phase of moderate imbalance to primary coordination. However, the overall coordination level remains low, highlighting the need for further integration. The limited developmental progress of both sectors acts as an internal constraint on their coordination. The three primary indicators impeding higher education advancement are the per-student public financial budget allocation for regular universities, the proportion of senior academics within full-time faculty, and the enrolment ratio of postgraduate students in regular universities. Additionally, enrolment figures frequently emerge as limiting factors. Regarding regional economic constraints, factors such as social retail sales, GDP index, and the proportion of employees in the tertiary sector hinder progress. Meanwhile, urbanisation functions as a significant catalyst, primarily enhancing coordination through its positive effect on developmental levels. Based on these findings, the study puts forward policy recommendations to foster deeper integration and coordination between higher education and regional economic development.

1. Introduction

Education, science, and technology serve as fundamental and strategic pillars of national development, playing a pivotal role in advancing Chinese-style modernisation. In line with China's

* *Corresponding author.*
E-mail address: yanshuxi008@126.com

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objective of comprehensively establishing a socialist modern nation, the dynamic interaction between higher education and the regional economy has garnered increasing attention from scholars and policymakers. As a critical component of the education system, higher education holds a central position in cultivating exceptional talent, driving technological innovation, fostering economic growth, and enhancing national competitiveness. A thriving regional economy not only provides a solid material foundation for higher education but also creates vast opportunities for its expansion. Therefore, examining the coupling and coordination between higher education and the regional economy is essential for ensuring their sustained and integrated development.

In recent years, foreign scholars have concentrated on empirically analysing the relationship between these two subsystems. The authors in [1] combined traditional econometric techniques with random forests to examine data from 649 tertiary administrative regions across 29 European countries between 2014 and 2016, identifying a nonlinear relationship between regional income per capita and indicators of post-secondary education structures. The authors in [2] contended that workforce skills in education are fundamental to regional development and serve as a key determinant of national competitiveness, asserting that higher education fosters human capital accumulation by increasing gross enrolment rates, thereby accelerating economic growth.

The authors in [3] employed a two-step semi-parametric data envelopment analysis to investigate the link between regional universities and economic development in Russia, revealing a significant positive impact of higher education institutions' efficiency on regional economic expansion. The authors in [4] analysed panel data from various Spanish regions spanning 1985 to 2016 through a macroeconomic regression approach, concluding that an increase in the gross enrolment ratio of regional higher education positively correlates with GDP per capita. The authors in [5] applied the Solow growth model to examine this relationship in Nigeria, arguing that resolving economic challenges hinges on education quality and its alignment with market demands. The authors in [6], utilized panel data from selected Balkan countries from 2000 to 2020 and employing the Hausman-Taylor IV model, found a negative correlation between enrolment rates, the proportion of government spending on students relative to GDP, and local GDP. This was attributed to deficiencies within the education system. Overall, foreign scholars generally acknowledge a significant relationship between higher education and economic development. However, research findings exhibit some inconsistencies due to varying methodological approaches and perspectives. Despite these differences, a broad consensus exists that economic growth is positively influenced by the efficiency and quality of tertiary education.

In the 21st century, Chinese higher education has expanded rapidly and entered a phase of widespread accessibility, attracting significant attention from domestic scholars. The authors in [7] examined nine provinces in the Yellow River Basin, establishing an evaluation framework for tertiary education, technological progress, and economic growth. By measuring the coupling coordination degree among these three factors, the study identified a transition through three phases: formation, calibration, and coordination. The authors in [8] applied canonical correlation analysis and coordination models to assess the coordination degree between higher education and the regional economy in the Beijing-Tianjin-Hebei area, revealing a continuous increase from 1994 to 2017. The findings indicated that Beijing leads Tianjin and Hebei in development. The authors in [9] analysed their interaction in Quanzhou by considering development speed, scale, and structure, concluding that they were not well-coordinated. In response, the authors in [9] proposed a series of recommendations to enhance synchronised development. The authors in [10] constructed a modified Cobb-Douglas production function using time-series data from 31 Chinese regions and conducted a comparative analysis, finding that the influence of higher education on regional

economic growth strengthens as both sectors advance. The authors in [11] examined the economic conditions and higher education levels across China's three major regions, performing correlation tests that indicated a direct relationship between economic development and the quantity and quality of universities in each area.

The authors in [12] conducted an empirical study using provincial panel data from China, concluding that higher education positively contributes to improving coordination levels. The authors in [13] used sample data from China between 1997 and 2015, a Vector Autoregression (VAR) model was employed to examine that higher education investment is a significant factor influencing economic growth. Simultaneously, higher education investment serves as a crucial source and driver of technological innovation, which in turn further promotes economic growth. The authors in [14] investigated the role of higher education resource allocation in high-quality economic development across 30 Chinese provinces from 2001 to 2020, determining that improving resource allocation efficiency supports industrial structure optimisation. The authors in [15] have constructed a comprehensive evaluation system that incorporates the interactive mechanism of coupling coordination and two subsystems to measure their coordinated interactions. Subsequently, we conducted a spatiotemporal analysis of the current development status and the Coupling Coordination Degree (CCD) in China. It was discovered that there are significant spatial disparities in higher education. The authors in [16] constructed separate evaluation index systems for university scientific and technological innovation and sustainable economic development, assessing these indicators across 30 provincial regions in China from 2011 to 2020. On this basis, a coupling coordination degree model is established to evaluate the coupling coordination degree between university scientific and technological innovation and sustainable economic development.

Current domestic research suggests a strong connection between higher education and economic development, though the degree of correlation varies across regions. This insight provides valuable theoretical support for the present study. However, many scholars, both domestically and internationally, have yet to conduct in-depth analyses of the factors influencing the integrated and coordinated development of tertiary education and regional economies. Building upon previous research, this study establishes an assessment framework for tertiary education and regional economic growth. It applies an integrated interaction model to evaluate the synergy between the two systems, utilises a barrier model, and employs linear regression analysis to examine the internal and external factors affecting their coordinated development. Finally, the study proposes strategies and policy recommendations to enhance their synergistic evolution.

2. The Interaction Mechanism

2.1 The Mechanism of Higher Education's Impact on Regional Economy

The impact of higher education on regional economic systems is primarily reflected in two critical dimensions: driving force and structural transformation. As the global economy transitions into the cognitive era, regional economic growth increasingly depends on skilled labour and innovation capacity, with higher education playing a central role in both areas [17]. In the knowledge-based economy, human capital and technological innovation serve as the principal drivers of economic growth [18]. As a hub for talent cultivation and scientific advancement, higher education provides a sustained impetus for regional economic development. A highly skilled workforce can optimise resource utilisation, particularly in resource-constrained settings, by enhancing production efficiency, minimising costs, and maximising economic returns. Furthermore, such talent can address structural limitations in traditional industries by fostering technological innovation, thereby facilitating the

emergence of new industries, advancing productivity, increasing product-added value, and ultimately improving regional economic performance.

For regional economies to transition from resource-dependent models to innovation-driven frameworks, it is essential to rely on higher education for the cultivation of technologically proficient and practically skilled individuals. Continuous advancements in technology and production processes are crucial for enhancing resource efficiency and reducing operational costs. Through scientific research and technological innovation, higher education facilitates the adoption of advanced production technologies, minimises resource consumption, improves efficiency, and strengthens regional economic competitiveness. Consequently, the sustained development of higher education enables regional economies to leverage their limited natural and social resources more effectively, fostering long-term economic growth. Beyond serving as a catalyst for economic growth, higher education plays a crucial role in optimising regional economic frameworks [19]. As regional economies increasingly demand industrial transformation and upgrading, higher education supports this process by supplying specialised talent to meet evolving market needs [20]. In the context of globalisation and rapid technological advancement, traditional industrial structures and production models have become increasingly outdated and inefficient. Labour-intensive industries, in particular, face mounting cost pressures and intensified market competition, necessitating technological innovation and managerial optimisation to sustain competitiveness. In response, higher education not only provides technological support for traditional industries but also nurtures innovative capabilities aligned with emerging industries.

By aligning academic programmes with local economic development needs, higher education institutions contribute to the rationalisation of industrial structures. Through market research and technology transfer, universities design specialised courses and research projects tailored to regional economic demands, thereby producing a workforce equipped with relevant skills. These professionals directly contribute to regional economic growth while also driving the practical application of new technologies through innovation and managerial improvements. This process facilitates the modernisation of established industries and fosters the emergence of new ones. Furthermore, collaboration between higher education institutions and enterprises accelerates the transformation and industrialisation of scientific and technological advancements. Such partnerships support industrial upgrading and innovation-driven economic progress, strengthening regional economies and ensuring their sustainable development in a competitive global environment.

2.2 Mechanism of Regional Economy's Impact on Higher Education

The connection between local economic growth and tertiary education is mutually beneficial and deeply intertwined. The stage of advancement in regional economies not only provides the foundation for expanding the scale of higher education but also serves as a prerequisite for investment and further development in this sector [7]. As regional economies continue to progress, the allocation of educational resources, along with adjustments in teaching content and structure, will be correspondingly influenced. Firstly, the development of regional economies directly determines the scale and pace of tertiary education growth. With rapid economic expansion, increased government financial investment allows for the expansion of higher education institutions. Economic growth provides substantial funding support, facilitating the modernisation of teaching methods and tools. In today's rapidly evolving educational technology landscape, governments can gradually introduce advanced teaching facilities through financial investments, such as electronic whiteboards, computer-aided instructional tools, and state-of-the-art laboratory equipment. The modernisation of these resources significantly enhances the quality and efficiency of education.

Furthermore, as regional economies develop, funding for education is no longer confined to infrastructure improvements but also extends to teacher training and research support, creating favourable conditions for the comprehensive advancement of tertiary education systems.

Secondly, shifts in economic structures drive adjustments in curriculum content and programme offerings in higher education. Teaching content is closely linked to production practices, making it directly influenced by changes in economic structures and technological advancements. As productivity increases, traditional curricula often fail to meet the evolving demands of industries, necessitating continuous adaptation in academic programmes. With new technologies and industrial models constantly emerging, higher education institutions must revise their courses to align with the real needs of social and economic development, ensuring that graduates possess the skills required to keep pace with contemporary advancements. Many countries are reforming their higher education systems by updating textbooks, streamlining course content, and broadening knowledge areas. These reforms aim not only to enhance educational quality but also to address the specific demands of economic development on the education sector. For instance, with the rise of emerging industries such as big data, numerous universities have introduced specialised programmes to train professionals in these fields, ensuring that education remains responsive to economic transformation.

Thirdly, structural changes in regional economies have a profound impact on the hierarchical framework of higher education. The expansion of regional economies and the increasing demand for vocational skills contribute to the continuous advancement of higher education. As regional industrial structures evolve, particularly with the growth of the service sector and high-tech industries, the demand for talent from higher education institutions rises accordingly. These emerging industries require a highly skilled workforce equipped with innovation capabilities, professional expertise, and managerial competencies, whereas traditional industries focus more on craftsmanship and technological advancements. Such transformations necessitate that higher education institutions align their academic offerings with local industrial demands through curriculum reforms and specialised programme development. Additionally, as traditional manufacturing shifts towards smart manufacturing and environmentally sustainable industries, higher education must place greater emphasis on training technical specialists and skilled professionals. This alignment between education and industry fosters the enhancement and optimisation of the regional economic framework, ensuring that the labour market remains responsive to ongoing economic transformations.

3. Research Design

3.1 Construction of Evaluation Index System

Higher education is an advanced, specialised system with academic and vocational traits, focusing on knowledge transmission, theoretical education, innovation, and research. It cultivates talents to serve society. In China, tertiary education includes conventional higher education (traditional undergraduate universities and higher vocational colleges) and adult higher education (via specialised institutions). This study evaluates traditional academic institutions using a framework based on scale, quality, and investment. Educational scale reflects institutional resources, capabilities, influence, and social responsibility, measured by four sub-indicators: number of regular higher education institutions, students enrolled per 10,000 population, total students, and admissions. Educational quality, impacting learning outcomes and national competitiveness, ensures students are better prepared for professional and life challenges, aiding continuous improvement of the education system.

To measure higher education quality, this study selects secondary indicators: number of full-time faculty, proportion of faculty with associate professorships or higher, student-to-faculty ratio, number of enrolled graduate students, proportion of graduate students to total enrolment, and number of graduates. Educational investment, encompassing human, material, and financial resources, supports the education system's operation. Appropriate investment enhances quality, meeting labour market demands. Indicators include per capita public and educational expenditure in regular higher education institutions. By evaluating scale, quality, and investment, this study provides a comprehensive assessment of China's regular higher education progress, offering insights for policymakers and administrators to drive improvements.

Regional economy refers to economic activities within a specific area, representing tangible regional development. It can broadly refer to a country's economy or narrowly focus on smaller regions. This study assesses economic development through scale, structure, and quality. Economic scale reflects total production activities, linked to investment attractiveness and competitiveness, measured by retail sales of consumer goods, local government revenue, employment, and total imports. Economic efficiency evaluates resource utilization, aiming for maximum output with minimal input, using indicators like GDP index, per capita disposable income, per capita consumption, industrial profits, and per capita GDP. Economic structure examines the composition of agriculture, manufacturing, and services. Increasing the service sector's share optimises structure, enhancing stability and growth potential. Indicators include the primary industry's GDP share, tertiary industry employment, and tertiary industry GDP share. Comprehensive data is provided in Table 1.

Table 1
Evaluation Index System for Higher Education and Regional Economy in Shaanxi Province

Subsystem	Primary Indicator	Tertiary Indicator	Unit	Indicator Attributes
Higher Education U1	Scale of Higher Education	Number of regular higher education institutions	Item	+
		Number of students enrolled per 10,000 population	Person	+
		Total number of students in regular higher education institutions	Ten Thousand People	+
		Number of admissions in regular higher education institutions	Ten Thousand People	+
	Educational Quality	Number of full-time faculty members at regular higher education institutions	Ten Thousand People	+
		Proportion of faculty with associate professorships or higher among full-time faculty	%	+
		Student-to-faculty ratio at regular higher education institutions	%	-
		Number of graduate students enrolled at regular higher education institutions	Ten Thousand People	+
		Proportion of graduate students compared to total enrolment at regular higher education institutions	%	+
		Number of graduates from regular higher education institutions	Ten Thousand People	+
	Educational Investment	Per capital public expenditure in regular higher education institutions	Yuan	+
		Per capital educational expenditure in regular higher education institutions	Yuan	+
Regional Economy U2	Economic Scale	Retail sales of consumer goods	100 Million Yuan	+
		Local government general budget revenue	100 Million Yuan	+
		Number of employed persons	Ten Thousand People	+
		Total imports	100 Million Yuan	+
	Economic Efficiency	GDP index	%	+
		Per capital disposable income of residents	Yuan	+
		Per capital consumption expenditure of residents	Yuan	+
		Total profit of industrial enterprises above designated size	100 Million Yuan	+
		Per capital GDP	Yuan	+
		Proportion of the primary industry in GDP	%	-

Economic Structure	Proportion of employment in the tertiary industry	%	+
	Proportion of the tertiary industry in GDP	%	+

Note: "+" implies a supportive aspect of the metric, and "-" implies a limiting aspect.

3.2 The Measurement of the Coupling and Coordinated Development Level between Higher Education and Regional Economy

3.2.1 Coupling Coordination Degree Model

This study is grounded in the framework of system interdependence and employs statistical analysis to examine the collaborative dynamics between higher education and regional economic growth. The objective is to quantitatively assess the integration status and interaction intensity of both systems. For an n-system model, the mathematical expression used to compute the synergy degree (C) is as follows:

$$C = n \times \left[\frac{U_1 U_2 \cdots U_n}{(U_1 + U_2 + \cdots U_n)^n} \right]^{\frac{1}{n}} \tag{1}$$

This study examines the interaction between higher education and the regional economy in Shaanxi Province. When n = 1, the synergy degree can be derived, resulting in the following formula (2):

$$C = \frac{2\sqrt{U_1 U_2}}{U_1 + U_2} \tag{2}$$

In formula (2), U1 and U2 represent the overall assessment metrics of the two systems. Due to the strong interconnection between these systems, the coupling degree is expected to fall within the range of 0 to 1. The classification criteria for different levels of coupling degrees are outlined in Table 2.

Table 2
Classification Standards for Coupling Degree Range

Range of Coupling Degree	Coupling Degree Classification Criteria
0.0～0.3	Low-Level Coupling Stage
0.3～0.5	Antagonistic Coupling Stage
0.5～0.8	Benign Coupling Stage
0.8～1.0	High-Level Coupling Stage

In complex coupled systems, subsystems may promote or hinder each other. While the coordination index reflects their linkage, it doesn't clarify if the impact is favourable or unfavourable. To better assess interactions, we use the Coupled Coordination Degree Model. Synergistic coordination reflects both interaction intensity and overall development status. Uneven development leads to a non-coordinated state; similar but low development results in low coordination; mutual promotion of high-level development achieves high coordination, the ideal state. This tool measures interaction intensity and mutual adaptation, reducing imbalances, enhancing overall levels, and fostering positive interactions. Synergistic coordination indicates healthy coupling and engagement levels, classified as non-coordinated or coordinated coupling. Since the interaction level model only indicates the intensity of interaction and influence between the two systems without fully reflecting their development status, there may be cases where a high coupling degree does not necessarily correspond to optimal harmonious growth. To address this limitation, this study establishes a Coupled Coordination Degree Model (D) to more accurately assess the extent

of balanced advancement between the two systems.

$$D = \sqrt{C \times T} \tag{3}$$

$$T = \alpha U_1 + \beta U_2 \tag{4}$$

In this formula, C represents the coordination index, while T signifies the advancement level of the combined system of higher education and regional economic development, reflecting the overall system progression. The coefficients α and β are to be determined, and as higher education and the regional economy are of equal importance, this study sets (α = β = 0.5). The degree of integrated harmonisation ranges from 0 to 1, with values approaching 1 indicating stronger cohesive interaction and harmonization between the two systems. Drawing on the work of relevant scholars, this study establishes the determination criteria for the cohesive interaction degree, as outlined in Table 3.

Table 3
Criteria for Determining Coupling Coordination Degree

No.	Coupled Coordination Degree	Type	No.	Coupled Coordination Degree	Type
1	0.00~0.09	Severe Imbalance	6	0.50~0.59	Strained Coordination
2	0.10~0.19	Serious Imbalance	7	0.60~0.69	Primary Coordination
3	0.20~0.29	Moderate Imbalance	8	0.70~0.79	Intermediate Coordination
4	0.30~0.39	Slight Imbalance	9	0.80~0.89	Good Coordination
5	0.40~0.49	Near Imbalance	10	0.90~1.00	High-Quality Coordination

3.2.2 Indicator Weight Calculation Method - Entropy Method

When addressing the heterogeneity in magnitude and dimension inherent in raw data, pre-processing is essential to eliminate these discrepancies, ensuring the accuracy and consistency of data analysis. This study employs the range normalization method to standardize the raw data. Given the presence of both positive and negative indicators within the indicator system, corresponding calculation formulas are applied to ensure data comparability and analytical precision.

(1) Data Normalization: Select m indicators, with a total of n samples, $x_{ij}{}'$ is the value of the i-th indicator for the j-th sample, $i = 1,2,3,\cdots,n, j = 1,2,3,\cdots m$. The normalization calculation formula is as follows:

$$x_{ij}{}' = \frac{x_{ij} - x_{\min}}{x_{\max} - x_{\min}} \text{ (Positive Indicator)} \tag{5}$$

$$x_{ij}{}' = \frac{x_{\max} - x_{ij}}{x_{\max} - x_{\min}} \text{ (Negative Indicator)} \tag{6}$$

Where, $x_{ij}^{'}$ $\left(0 \le x_{ij}{}' \le 1\right)$ is the indicator data after range normalization processing. x_{max} and x_{min} represent the maximum and minimum observed values of the j-th indicator among all samples.

(2) To derive the fraction of the j-th sample under the i-th indicator, the formula is outlined below:

$$P_{ij} = \frac{x_{ij}{}'}{\sum_{i=1}^{n} x_{ij}{}'} \tag{7}$$

(3) Quantify the information entropy(M_j) for the i-th measure.

$$M_j = -\frac{\sum_{i=1}^{n} P_{ij} \ln P_{ij}}{\ln n} \tag{8}$$

In the formula, $M_j \in [0,1]$, $ln\, P_{ij}$is the natural logarithm. It is assumed that $P_{ij}.ln\ P_{ij} = 0$. When P_{ij} equals 0.

(4) Next, quantify the informational utility (D_j)of the j-th dimension, which is the variation coefficient. The higher the value, the greater its influence on the weight, making the dimension more significant. The formula is expressed as follows:

$$D_j = 1 - M_j \tag{9}$$

(5) Analyse the weight (W_j) of the j-th measure, which is the share of the variation coefficient of the j-th measure. The higher the variation coefficient, the greater its impact on the assessment result. The formula is as follows.

$$W_j = \frac{D_j}{\sum_{j=1}^{m} D_j} \tag{10}$$

3.2.3 Evaluation Index Function

The evaluation measure effectively represents each system's progression level, with higher values indicating more optimal development. Before measuring the aligned coordination degree, indicator weights for each system are determined using the linear weighting method. For higher education and regional economy systems, evaluation index functions are constructed to calculate their respective comprehensive evaluation indices. Let indicator system for the higher education subsystem is$\{x_{1,}x_2, \cdots, x_m\}$, and the indicator system for the regional economy subsystem is$\{y_1, y_2, \cdots, y_n\}$. The functions $f(x)$ and $g(y)$ characterize the integrated evaluation criterion function of academic education level and area economic development, the mathematical expressions are outlined below:

$$f(x) = \sum_{j=1}^{m} a_j x_j' \tag{11}$$

$$g(y) = \sum_{j=1}^{n} b_j y_j' \tag{12}$$

In (11) and (12), a_j, $b_j$represent the weights for the two subsystems, x_j' and y_j' represent the standardized data obtained from the original observed values of the indicators for the two subsystems in year t.

3.2.4 Factors Influencing the Coupling Coordination Development Model of Higher Education and Regional Economy

(1) Obstacle Degree Model

To explore internal barriers affecting the aligned coordination development of the two subsystems, an obstacle degree model is developed to identify restrictive factors. The mathematical expression is as follows:

$$C_j = \frac{1 - x_j \times W_j}{\sum_{j=1}^{n} 1 - x_j \times W_j} \times 100\% \tag{13}$$

C_j is obstacle degree of j-th indicator, and a larger value indicates a greater obstacle degree. x_j represents the normalized value of the j-th parameter.$W_j$denotes the weighting factor of the j-th metric.

(2) Multiple Linear Regression Model

To assess the impact of external factors on the coupling coordination level of the two subsystems,

this study establishes a multi-variable regression framework. Before proceeding with this, the grey relational analysis method is employed to evaluate the influence of external factors on the coupling coordination level, determining whether a correlation exists between these factors and the coordinated development of the two subsystems. Following this, a multiple linear regression model is constructed. The grey association level is calculated using SPSSAU software, where a higher grey relational value indicates a stronger correlation between the factors. Once the grey relational degrees between variables are obtained, the study formulates the following multiple linear regression model.

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon \tag{14}$$

In this formula, Y represents the dependent variable—the degree of synergistic coordination development between the two subsystems. X_1, X_2, X_3, X_4 represent the independent variables, including urbanization, environmental governance, transportation level, and government intervention. $\beta_1, \beta_2, \beta_3, \beta_4$ represent the regression coefficients. α represents the intercept. ε is the error term.

3.3 Data Sources and Processing

This study uses statistical data from Shaanxi Province (2008–2022) sourced from the Shaanxi Statistical Yearbook, China Statistical Yearbook, and China Educational Expenditure Statistical Yearbook. Most indicators are directly queried, except for proportions like graduate students, senior faculty, and tertiary industry employment, which require simple calculations. To analyse factors influencing coupling coordination development, four variables are used: urbanisation (urbanisation rate), environmental governance (industrial pollution control investment/GDP), transportation level (railway mileage), and government intervention (general budget expenditure/GDP). Descriptive statistics for these variables are provided in Table 4.

Table 4
Descriptive Statistics of Variables

Variable Name	Symbol	Mean	Standard Error	Min	Max	Observed Value
Coupling Coordination Degree	D	0.4666	0.1351	0.2362	0.6604	15
Coupling Degree	C	0.9968	0.0054	0.9798	1.0000	15
Level of Coordinated Development	T	0.2353	0.1248	0.0559	0.4364	15
Urbanization	$urben$	53.6147	7.3395	42.1000	64.0200	15
Government Intervention	gov	0.2246	0.0131	0.1994	0.2445	15
Traffic Level	jt	4141.7200	1770.6230	1033.0000	6439.0000	15
Environmental Governance	gz	0.0015	0.0009	0.0001	0.0034	15

4. Empirical Analysis

4.1 Analysis of the Evaluation Index of Higher Education and Regional Economy

The evaluation indices of the higher education and regional economic subsystems in Shaanxi Province are presented in Table 5, with the changing trends illustrated in Figure 1.

The evaluation index results in Table 5 and the trend of evaluation index changes in Figure 1 indicate that both the higher education and regional economic subsystems, along with their overall evaluations, exhibit an upward trajectory. During the analysis period, the higher education index in Shaanxi Province fluctuated but increased from 0.0535 to 0.4498, representing a 7.4-fold rise, with an average annual growth rate of 17.4%. The regional economic index increased from 0.0582 to 0.4229, growing 6.3 times, with an average annual growth rate of 16%. The comprehensive index of

the two systems rose from 0.0559 to 0.4364, marking a 6.8-fold increase, with an average annual growth rate of 16.3%. A closer examination of the development trends of these three indices reveals notable disparities between the two systems in Shaanxi Province. The evaluation index of the regional economic system exceeded that of the higher education system, primarily due to the provincial government's focus on economic development during this period. This emphasis was driven by the "Build a Strong Western Economic Province" initiative proposed at the 11th Party Congress of Shaanxi Province. With clear development objectives and strategic planning, the provincial government led Shaanxi towards sustained economic growth.

Table 5
Evaluation Index of Higher Education and Regional Economy in Shaanxi Province

Year	Higher Education Index	Regional Economic Index	Comprehensive Evaluation Index(T)
2008	0.0535	0.0582	0.0559
2009	0.0648	0.0857	0.0752
2010	0.1024	0.1044	0.1034
2011	0.1385	0.1223	0.1304
2012	0.1912	0.1274	0.1593
2013	0.1895	0.1533	0.1714
2014	0.1891	0.1844	0.1867
2015	0.2148	0.2211	0.2180
2016	0.2405	0.2428	0.2417
2017	0.2535	0.2928	0.2731
2018	0.2923	0.3440	0.3181
2019	0.3658	0.3769	0.3713
2020	0.3962	0.3375	0.3668
2021	0.4177	0.4262	0.4219
2022	0.4498	0.4229	0.4364

Fig. 1. Changes in the Evaluation Index of Higher Education and Regional Economy in Shaanxi Province from 2008 to 2022

From 2011 to 2014, the measurement indicator of the higher education system exceeded that of

the regional economic system, reflecting a lag in regional economic development. This suggests that the rapid expansion of higher education in Shaanxi did not effectively translate into a corresponding enhancement of the regional economy through the talent cultivated. Additionally, the line graph trend reveals a significant rise in the higher education index from 2009, likely driven by initiatives under the "Shaanxi Higher Education Teaching Quality and Educational Reform Project" launched by the Provincial Department of Education. Since then, the Shaanxi Provincial Party Committee and government have prioritized higher education. In 2010, following the "four strengths and four focuses" strategy, Shaanxi's higher education sector achieved notable advancements in technological contributions, core competitiveness, and social influence, strengthening the development of various university disciplines and improving overall teaching quality, thereby reinforcing its status as a key educational hub. Between 2014 and 2016, the evaluation indices of both systems were nearly equal, marking a brief phase of balanced development. From 2015 to 2019, the evaluation index of the regional economic system surpassed that of the higher education system. Under the Party's "Five Solid" guidelines, the Shaanxi provincial government introduced a series of economic stabilization and growth policies in 2015, triggering a new phase of economic expansion. However, this economic progress did not fully support the concurrent advancement of higher education in the province. After 2019, the impact of the pandemic led to instability in the evaluation indices of both systems, resulting in alternating fluctuations.

4.2 Coordinated Development Status of Higher Education and Regional Economy

The study applies relevant computational formulas to assess the intensity of integration and the degree of collaborative interaction between higher education and regional economic development in Shaanxi Province. By utilizing classification criteria for these interaction levels, the nature and extent of coordination between the two systems over different years can be determined. The specific findings are outlined in Table 6, with the corresponding trends illustrated in Figure 2.

Table 6
Coupling Degree and Coupling Coordination Degree of Higher Education and Regional Economy in Shaanxi Province

Year	Coupling Degree	Level	Coupling Coordination Degree	Level
2008	0.9991	High-Level Coupling Stage	0.2362	Moderate Imbalance
2009	0.9903	High-Level Coupling Stage	0.2730	Moderate Imbalance
2010	0.9999	High-Level Coupling Stage	0.3216	Moderate Imbalance
2011	0.9981	High-Level Coupling Stage	0.3607	Moderate Imbalance
2012	0.9798	High-Level Coupling Stage	0.3950	Slight Imbalance
2013	0.9944	High-Level Coupling Stage	0.4128	Slight Imbalance
2014	0.9999	High-Level Coupling Stage	0.4321	Slight Imbalance
2015	0.9999	High-Level Coupling Stage	0.4669	Slight Imbalance
2016	0.9999	High-Level Coupling Stage	0.4916	Near Imbalance
2017	0.9974	High-Level Coupling Stage	0.5219	Near Imbalance
2018	0.9967	High-Level Coupling Stage	0.5631	Strained Coordination
2019	0.9999	High-Level Coupling Stage	0.6093	Primary Coordination
2020	0.9968	High-Level Coupling Stage	0.6047	Primary Coordination
2021	0.9999	High-Level Coupling Stage	0.6496	Primary Coordination
2022	0.9995	High-Level Coupling Stage	0.6604	Primary Coordination

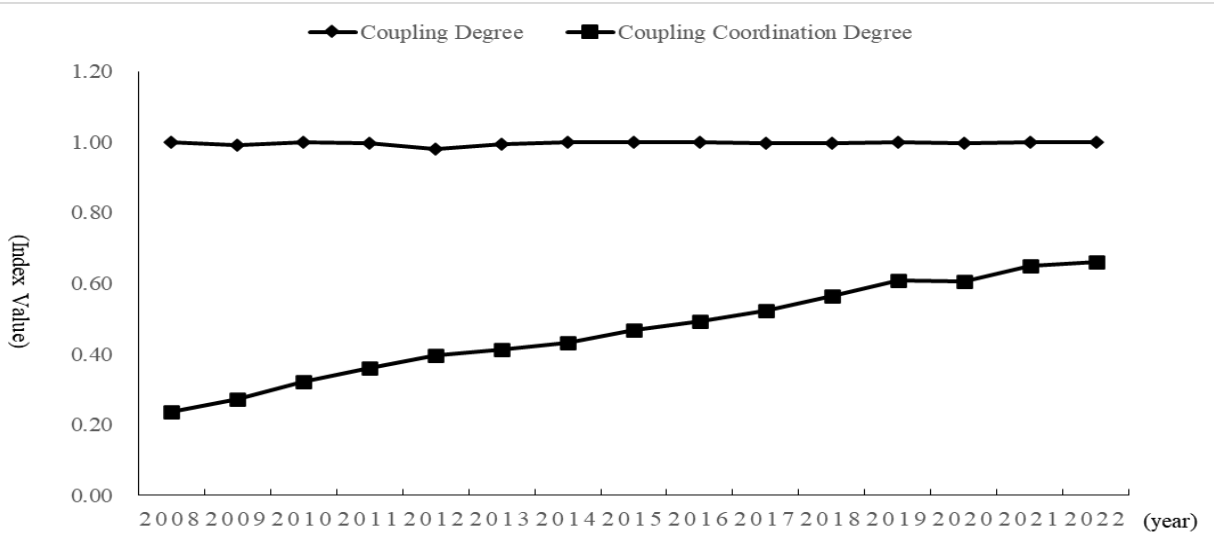

Fig. 2. Coupling Degree and Coupling Coordination Degree of Higher Education and Regional Economy in Shaanxi Province from 2008 to 2022

Referring to Table 6 and Figure 2, the coupling degree between the two subsystems in Shaanxi Province remained relatively stable from 2008 to 2022, consistently ranging between 0.9 and 1. Based on the classification criteria for coupling degree outlined in Chapter 3, this indicates that the interdependence between the two subsystems has persistently been at a high level. Such a strong interaction reflects the Shaanxi provincial government's continued emphasis on the integrated development of both subsystems, alongside substantial policy investments that have maintained their close relationship over time. Analyzing the coordination degree results and the trends depicted in the figure, it is evident that the level of mutual coordination between the two subsystems has shown a steady improvement from 2008 to 2022. According to the classification of coupling coordination degrees presented in Chapter 3, the development trajectory of these subsystems has progressed through three distinct stages.

First Stage (2008–2012): During this period, the interconnected development of the two systems remained unbalanced. Higher education resources were unevenly distributed, with limited availability outside Xi'an and Xianyang. This resource disparity hindered technological innovation and industrial upgrading in these regions, restricting the full potential of regional economic growth. Post-2010, the degree of imbalance between the two systems showed some improvement, yet they remained largely disconnected. The skills and expertise of university graduates did not effectively align with the needs of local industries, and investments in higher education failed to translate into significant economic growth. Additionally, government policies, strategic planning, and incentive measures for the coordinated development of both subsystems lacked sufficient integration, further impeding their synchronized advancement.

Second Stage (2013–2016): This period represented a transitional phase in the collaborative advancement of the two subsystems in Shaanxi Province. The level of integration between them improved, with their synergistic coordination approaching a more balanced state. The province progressively prioritized enhancing the coordination between the two subsystems, accelerating the development of a technology innovation system that integrated industry, academia, and research. The distribution of higher education resources across different regions was optimised, and the academic structure gradually adapted to align with regional demands, thereby fostering economic growth. Shaanxi’s economic progress increasingly depended on improving the skills and capabilities of the local workforce, alongside the investment in and application of technological advancements.

Third Stage (2017–2022): During this stage, the integration between the two systems progressed into a phase of balanced development, shifting from minimal coordination to initial coordination by 2018. The level of synchronization steadily improved, indicating a positive developmental trajectory. It is evident that during this period, Shaanxi Province effectively aligned with the strategic objectives of the national "13th Five-Year Plan," resulting in a growing level of coordinated expansion between the two subsystems. Collaboration between universities, enterprises, and research institutions deepened, further strengthening the interconnection between higher education and economic growth. Overall, the coupling coordination degree advanced from moderate imbalance to near imbalance and ultimately to initial coordination. This progression highlights the gradual enhancement of the relationship between the two subsystems, reflecting a continuous pattern of mutual reinforcement and the emergence of a sustainable and synergistic cycle.

4.3 Analysis of the Influencing Factors of Coupling Coordination between Higher Education and Regional Economy

4.3.1 Analysis of the Barrier Factors Affecting Coupling Coordination between Higher Education and Regional Economy

In analysing internal factors, it is crucial to determine whether the low coupling coordination development level is hindered by the coupling degree or the development degree. The obstacle degree model is then used to calculate specific indicators' obstacle degrees, and their frequency is examined to identify negative impacts. During the observation period, Shaanxi Province's coupling degree remained above 0.9, indicating strong interactions. However, the development degree, though increasing 7.8114 times, peaked at only 0.4364, suggesting the unified system's progress needs improvement, particularly in the two subsystems. The underdevelopment of higher education and the regional economy has hindered collaborative interaction. To identify specific reasons, the obstacle degree model explores internal factors. Figure 3 shows the frequencies and proportions of indicators hindering higher education. The top three were: per capita public financial budget for universities (7 occurrences), proportion of senior faculty (6 occurrences), proportion of graduate students (6 occurrences), and number of university admissions (6 occurrences). Addressing these four aspects is urgent for enhancing higher education in Shaanxi Province.

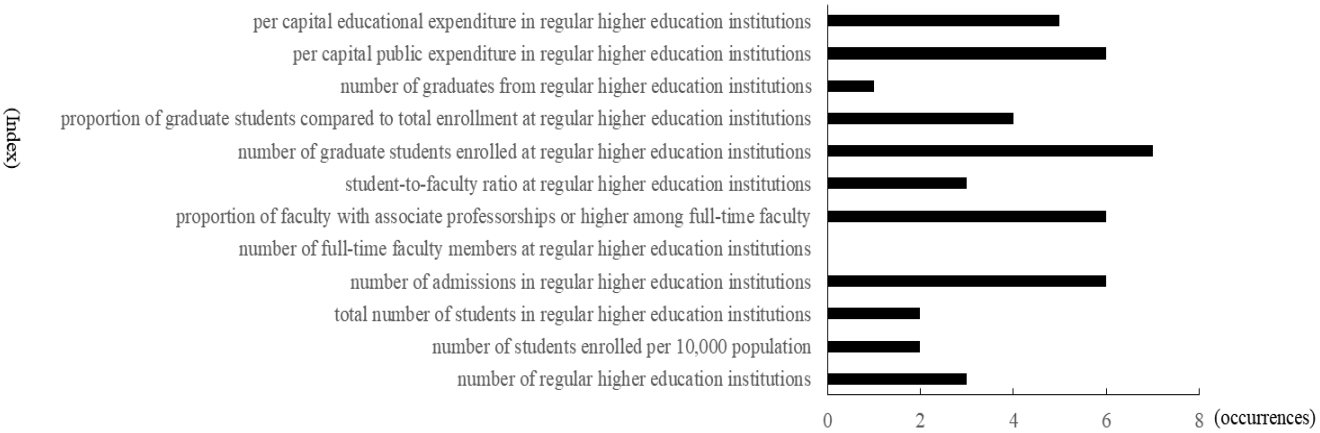

Fig. 3. Frequency of Barrier Factors in Subsystems of Higher Education

The emergence of these challenges can be attributed to several factors. Regarding the per capita public financial budget allocated to ordinary universities, the constrained financial support from national and local governments has resulted in funding shortages for higher education. In terms of the proportion of faculty at the associate senior level or above among full-time academic staff, not

only is financial support for talent acquisition necessary, but there is also a need to ensure professional development and training opportunities for junior faculty members to enhance teaching quality and qualifications. Additionally, the proportion of postgraduate students and undergraduate admissions to universities represents a significant barrier, as the concentration of educational resources in specific areas, particularly Xi'an, limits access elsewhere. Variations in national policy support, discipline structures, and institutional standards contribute to students' preference for universities in Xi'an, leading to lower enrolment numbers in other cities and subsequently hindering the overall development of higher education. As illustrated in Figure 4, the three most significant barriers to regional economic development during the observation period were retail sales of consumer goods, the GDP index, and the proportion of employment in the tertiary sector. Several factors explain this phenomenon. In response to the 2008 global financial crisis, the government introduced a 4 trillion-yuan stimulus package, temporarily driving economic growth and mitigating economic decline. However, in the long run, the investment structure was imbalanced—excessive focus on industries such as real estate and finance exacerbated supply-side structural issues, causing China to shift from a phase of rapid economic expansion to a new normal characterized by lower growth rates.

In 2015, the Central Economic Work Conference introduced supply-side structural reforms aimed at revitalizing economic growth by addressing inefficiencies in production and investment. These reforms focused on reducing excess production capacity, managing inventories, deleveraging, lowering costs, and addressing structural weaknesses, which further contributed to the slowdown in economic growth rates. The report from the 19th National Congress of the Communist Party in 2017 provided a scientific assessment of China's development stage, highlighting the transition to a high-quality growth phase where innovation is the primary driving force. Innovation fosters economic progress through the introduction of new technologies, processes, and resource reallocation. However, innovation is a gradual process and does not yield immediate economic returns. Moreover, it demands substantial financial investment, which, while reducing production costs for enterprises in the long run, can also temporarily constrain output. Conversely, Shaanxi Province, endowed with abundant natural resources such as coal and recognize as the birthplace of red culture, has experienced rapid growth in its tourism industry in recent years. However, ongoing supply-side structural adjustments have hindered the rise in residents' income levels, leading to a slowdown in the growth rate of the tertiary sector. As a result, the sector's capacity to absorb labour has diminished, further constraining regional economic development.

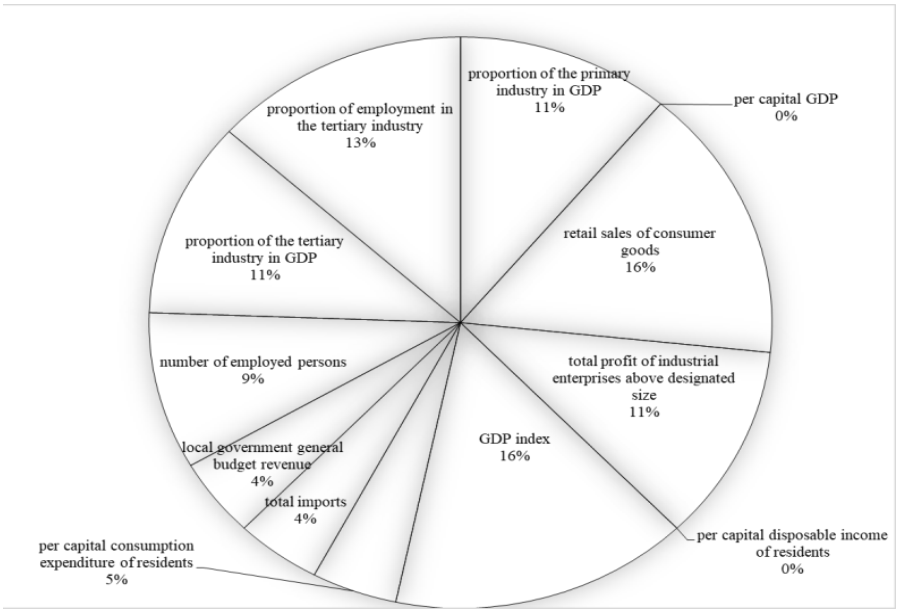

Fig. 4. Proportion of Barrier Factors in Subsystems of Regional Economy

4.3.2 Analysis of External Influencing Factors on Coupling Coordination between Higher Education and Regional Economy

In this study, internal barrier factors affecting the two subsystems are first analysed. Next, external factors influencing the coupling coordination development level are examined. The grey relational analysis model is used to assess the correlation between selected external factors and the coupling coordination level, while a multiple linear regression model determines the direction of their impact. According to Table 7, urbanization, government intervention, environmental governance, and transportation level have a correlation degree with the cohesive interaction metric exceeding 0.5, indicating a relatively high correlation. Notably, the correlation degree level of the two subsystems is greater than 0.8, showing an extremely strong correlation.

Table 7
Grey Relational Analysis Results

Evaluation Items	Correlation Degree	Ranking
jt	0.7682	3
$urben$	0.8767	1
gov	0.7773	2
gz	0.5636	4

The grey relational degree serves as the foundation for the multiple regression analysis in this study. However, while it identifies correlations between factors and outcome variables, it does not establish the direction of influence for each independent variable. To address this limitation, a multiple regression model is developed to assess the impact of external factors, with the specific results outlined in Table 8. In column (1), the R^2 value of 0.9852 indicates that four external influencing factors, including government intervention, collectively account for 98.52% of the variation in D (the coupling coordination between the two subsystems). The model successfully passes the F-test, confirming that at least one of these external factors significantly influences D.

Table 8
Regression Results of External Influencing Factors on the Coupling Coordination of Higher Education and Regional Economy

Variable	D	C	T
	(1)	(2)	(3)
Constant	-0.5214** (-4.6287)	1.01723** (30.7167)	-0.4205** (-3.2713)
gov	-0.3828 (-0.7934)	-0.1378 (-0.9717)	-1.3051* (-2.3702)
jt	-0.0403 (-1.1797)	-0.0948 (-0.9426)	-0.0300 (-0.0767)
gz	13.5847 (1.1635)	0.2089 0.0609	11.7334 (0.8807)
$urban$	0.0200** (14.5297)	0.0003 (0.6523)	0.0174** (11.0942)
R^2	0.9852	0.2064	0.9774
F	166.5635**	0.6504	108.3535**
D-W value	2.0667	1.9206	1.4053

Note: * and ** respectively indicate significance levels of 5% and 1%, the values in parentheses are t-statistics.

Examining the specific external influencing factors, the coefficient of urbanisation's effect on the coupling coordination development is 0.0200, passing the 1% significance level test. This suggests

that higher urbanization levels enhance the coupling coordination development. As population concentration increases in urban areas, a readily available labour force reduces recruitment costs for enterprises, boosts production investment, and expands innovation funding. These factors collectively contribute to improving the quality and efficiency of the regional economic system. Additionally, urbanization drives investment in higher education, fostering the establishment of academic disciplines aligned with labour market demands, thereby supporting regional economic growth.

However, government intervention, transportation infrastructure, and environmental regulations did not pass the significance test regarding their impact on coupling coordination development. This suggests that their influence remains relatively minor and is currently insufficient to significantly affect the metric of cohesive interaction between the two subsystems. A key question arises: does urbanization influence the cohesive interaction metric through the development level or the coupling degree? A comparison of columns (2) and (3) reveals that urbanization's impact on the coupling degree is statistically significant at the 1% level. Moreover, column (3) shows an R^2 value of 0.9774, indicating that the four external factors, including government intervention, account for 97.74% of the variation in development level. Notably, government intervention appears to negatively affect the improvement of development level.

5. Research Conclusions and Policy Recommendations

5.1 Research Conclusions

The advancement of higher education is intrinsically linked to regional economic support, while the human capital essential for economic growth is primarily derived from higher education. In the contemporary knowledge economy, achieving synchronised development between higher education and regional economies is particularly crucial. This study examines Shaanxi Province as a case study, conducting a comprehensive analysis of the current state of higher education and regional economic performance. It establishes an evaluation system and, using data from 2008 to 2022, applies the entropy method to determine variable weights. Additionally, balanced coordination degree models, obstacle degree frameworks, and regression analysis are employed to empirically assess the level of coordinated development and its influencing factors.

The key findings are as follows:

(1) Throughout the study period, the level of balanced coordination between the two subsystems has progressively improved, transitioning from moderate imbalance to initial coordination. However, the overall coupling coordination level remains relatively low.

(2) Development levels have constrained the degree of coupling coordination. The primary factors impeding higher education improvement, ranked by frequency, include public financial budget expenditure per student in ordinary universities (7 occurrences), the proportion of full-time teachers at or above the associate senior level (6 occurrences), the ratio of graduate students in ordinary universities (6 occurrences), and enrolment figures in ordinary higher education institutions (6 occurrences). Inhibiting factors for regional economic growth include retail sales of consumer goods, the GDP index, and the proportion of employees in the tertiary sector.

(3) Urbanization positively influences coupling coordination development, primarily exerting its effect through the development degree pathway.

5.2 Policy Recommendations

Firstly, strengthening mutual reinforcement is essential to improving the coupling coordination level between higher education and regional economic development. On one hand, enhancing the

capacity of higher education to support regional economic sustainability is crucial. Universities should align academic programmes with local economic demands by conducting comprehensive market analyses to ensure that graduate training meets workforce requirements. The proportion of students at different academic levels should be adjusted accordingly, along with modifications to talent development plans. Faculty members should be encouraged to realign their research focus towards regional economic priorities, with increased incentives for research contributions that support local industries. Additionally, higher education planning should incorporate industrial trend analyses to anticipate future economic shifts and adapt the educational structure accordingly. Establishing collaborative platforms between universities and businesses can facilitate student participation in real-world projects, accelerate the commercialisation of research outputs, and enhance higher education's role in advancing the regional economy.

On the other hand, strengthening regional economic support for higher education is equally vital. The evolution of the local economic structure provides fundamental backing for the advancement of higher education. Increasing financial investment in universities, accelerating the development of experimental facilities, modernising teaching infrastructure, and expanding research funding for academic staff can significantly enhance the quality of higher education. Furthermore, the ongoing transformation of regional industries creates new skill requirements, compelling universities to revise curricula, refine teaching methodologies, and improve overall educational standards. Implementing these measures can foster a more integrated development model between higher education and the regional economy, ensuring a mutually beneficial relationship that drives sustained progress in both domains.

Secondly, eliminating obstacles and enhancing the development of both systems is crucial. The government should increase financial investment and policy support for higher education by establishing dedicated education development funds to improve university infrastructure. Additionally, a well-structured "Talent Attraction Plan" should be implemented to strengthen the academic and research capabilities of higher education institutions. Social capital investments in universities should be incentivised through tax reductions and financial subsidies. Each university should align its academic programmes with the province's economic development needs and industrial restructuring by increasing enrolment quotas for key disciplines and emerging fields. Scholarships should be expanded in both amount and coverage to attract high-calibre students. Furthermore, professional development for young and mid-career faculty members should be prioritised, providing opportunities for domestic and international study, training programmes, and academic exchanges. Encouraging inter-university collaboration and faculty training partnerships with prestigious national and international institutions will enhance teaching and research quality. Standards and procedures for academic title evaluations should be optimised to improve faculty composition, while comprehensive talent recruitment plans should offer competitive benefits and research support to attract top scholars.

The government should also adapt to the evolving economic landscape by supporting the growth of emerging industries and fostering technological innovation in key areas such as big data, cloud computing, and AI. This will drive advancements in the technology services sector. Additionally, leveraging the province's historical and cultural assets, efforts should be made to promote major tourism sites, including the Tomb of Emperor Qin Shihuang, the Yan'an Revolutionary Memorial Hall, and the Tang Paradise. Strengthening regional cooperation among cities such as Xi'an, Xianyang, and Baoji within the service sector will further contribute to economic development. Moreover, the government should enhance employment support, create additional income opportunities for residents, and raise overall income levels. Public services in healthcare, education, and other essential

sectors should be improved to reduce household expenditures and boost consumer spending, ultimately driving sustainable regional economic growth.

Third, the Chinese government should accelerate urbanisation to enhance coupling coordination.

(1) Reforming the household registration system to remove barriers to population mobility. Decou-pling household registration from employment, education, healthcare, and pensions will facilitate rural-urban migration, improving labour mobility and urban resource allocation. This will inject skilled workers into cities, strengthening ties between higher education and local economies.

(2) Improving the cost-sharing mechanism to reduce migration expenses. Governments should ease financial burdens on mobile populations by enhancing cost-sharing in housing, employment, education, healthcare, and social security. Strengthening regional transportation infrastructure will further lower migration costs and boost economic competitiveness.

(3) Promoting urban renewal to upgrade public services. Investing in infrastructure, healthcare, education, and environmental improvements will enhance urban living standards, increasing city attractiveness and economic vitality.

(4) Leveraging the agglomeration effect to foster innovation. The clustering of population, industries, and resources transforms cities into innovation hubs, strengthening higher education's role in advancing emerging industries and upgrading traditional sectors.

Data Availability Statement

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgement

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References

[1] Bertoletti, A., Berbegal-Mirabent, J., & Agasisti, T. (2022). Higher education systems and regional economic development in Europe: A combined approach using econometric and machine learning methods. *Socio-Economic Planning Sciences*, *82*, 101231-101231. https://doi.org/10.1016/j.seps.2022.101231

[2] Johansen, T., & Arano, K. (2016). The Long-Run Economic Impact of an Institution of Higher Education: Estimating the Human Capital Contribution. *Economic Development Quarterly*, *30*(3), 203-214. https://doi.org/10.1177/0891242416655204

[3] Agasisti, T., Egorov, A., Zinchenko, D., & Leshukov, O. (2021). Efficiency of regional higher education systems and regional economic short-run growth: empirical evidence from Russia. *Industry and Innovation*, *28*(4), 507-534. https://doi.org/10.1080/13662716.2020.1738914

[4] Canal Domínguez, J. F. (2021). Higher education, regional growth and cohesion: insights from the Spanish case. *Regional Studies*, *55*(8), 1403-1416. https://doi.org/10.1080/00343404.2021.1901870

[5] Machi, I. O., Okechukwu, N. M., Okafor, V. C., & Collins, N. K. (2023). Higher Education and Africa's Economic Development: Challenges for the Nigerian Economy. *Asian Journal of Economics, Business and Accounting*, *23*(20), 103-112. https://doi.org/10.9734/ajeba/2023/v23i201096

[6] Osmani, F., & Jusufi, G. (2022). The Contribution of Higher Education To Economic Growth of Western Balkans: Evidence From Kosovo, Albania, North Macedonia, and Montenegro. *InterEULawEast*, *9*(1), 85-106. https://doi.org/10.22598/iele.2022.9.1.4

[7] Yan, S. X., Yu, Z. L., Nan, S. J. & Wang, M. N. (2024). Coupling and Coordination Measurement of Higher Education, Scientific and Technological Innovation and Economic Growth: A Case Study of Nine Provinces in the Yellow River Basin. *Statistics & Decision*, *40*(22), 81-86. https://doi.org/10.13546/j.cnki.tjyjc.2024.22.014

[8] Han, W. Q., Sun, Z. R., & Zhao, B. (2020). A study on the coordination between higher education and regional economy in Beijing-Tianjin-Hebei region based on canonical correlation analysis. *Tianjin Science and Technology*, *47*(2), 5-8+11. https://doi.org/10.3969/j.issn.1006-8945.2020.02.002

[9] Yan, H. Q., & Wu. F. (2020). Research on the coordinated development of higher education and regional economy in Quanzhou under the "Maritime Silk Road" Strategy-Discussing the Training of Talent in Marine Economy. *Statistics and Management*, *35*(3), 57-61. https://d.wanfangdata.com.cn/periodical/tjygl202003011

[10] Zhao, W. X. (2022). A Comparative Study on the Contribution Rate of Higher Education to Regional Economic Growth. *Heilongjiang Researches on Higher Education*, *40*(11), 1-7. https://doi.org/10.3969/j.issn.1003-2614.2022.11.001

[11] Zhao, Z. (2021). Optimization Analysis of Higher Education Based on the Theory of Regional Economic Balanced Development. *Economic Research Guide*, *35*, 27-29. https://doi.org/10.3969/j.issn.1673-291X.2021.35.009

[12] Zhou, L. (2024). Higher education promoting regional coordinated development: influencing mechanisms and empirical evidence. *University Education Science*, *2*, 77-87. https://doi.org/10.3969/j.issn.1672-0717.2024.02.09

[13] Zhou G. Y., & Luo, S. M. (2018). Higher Education Input, Technological Innovation, and Economic Growth in China. *Sustainability, 10*(8), 2615. https://doi.org/10.3390/su10082615

[14] Liu, Z. Y., & Ma, J. F. (2023). The Impact of Regional Higher Education Resource Allocation on High-Quality Economic Development Under the Trend of Population Mobility. *Educational Research*, *44*(12), 106–120. https://d.wanfangdata.com.cn/periodical/Ch9QZXJpb2RpY2FsQ0hJTmV3UzIwMjUwMTE2MTYzNjE0Eg1qeXlqMjAyMzEyMDExGghrNnlrMmY2bA%3D%3D

[15] Geng, Y. Q., Chen, L. Y., Li, J. Y., & Iqbal, K. (2023). Higher education and digital Economy: Analysis of their coupling coordination with the Yangtze River economic Belt in China as the example. *Ecological Indicators, 154*, 110510. https://doi.org/10.1016/j.ecolind.2023.110510

[16] Yang, J, & Chen, H. D. (2023). Coupling Coordination between University Scientific & Technological Innovation and Sustainable Economic Development in China. *Sustainability, 15*(3), 2494. https://doi.org/10.3390/su15032494

[17] Tang, W. Z. (2015). Theoretical and Empirical Research on the Role of Higher Vocational Education in Promoting Economic Development in China. *Southeast Academic Research*, *4*, 226-231. https://d.wanfangdata.com.cn/periodical/dnxs201504031

[18] Jones, C. I., & Romer, P. M. (2010). The new Kaldor facts: ideas, institutions, population, and human capital. *American Economic Journal: Macroeconomics*, *2*(1), 224-245. https://doi.org/10.1257/mac.2.1.224

[19] Wu, N., & Liu, Z. K. (2021). Higher education development, technological innovation and industrial structure upgrade. *Technological Forecasting and Social Change, 162*, 120400. https://doi.org/10.1016/j.techfore.2020.120400

[20] Jiang, L., Li, Y. Q., & Dong, W. C. (2018). Research on the Interaction and Covariation Between

My Country's Higher Education Structure and Industrial Structure: Based on the Perspective of System Coupling Relationship. *Educational Science*, *34*(3), 59–66. https://doi.org/10.3969/j.issn.1002-8064.2018.03.009