ISSN 2616-5902 Vol. 7, Issue 1: 22-29, DOI: 10.25236/AJBM.2025.070103

Research on the Coupling and Coordination of Higher Education and Regional Economic Development—Taking Five Northwestern Provinces as an Example

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Abstract: *Based on the panel data of five northwestern provinces from 2014 to 2023, the article explores the degree of coupling coordination and spatial agglomeration of the two systems of higher education and regional economy using the coupling coordination degree model and the global Moran index. From the time dimension, the coupling and coordination degree of higher education and regional economy in the five northwestern provinces shows an increasing trend year by year, but there is a significant difference in the growth rate of each province; from the spatial dimension, there is an insignificant spatial clustering effect between the coupling and coordination degree of the five northwestern provinces, and the Moran index shows a fluctuating upward trend, which suggests that although there is a spatial heterogeneity between the five provinces, the spatial links between them are also gradually strengthened.*

Keywords: *Higher education, Regional economy, Coupling coordination,Moran index, Five provinces in Northwest China*

1. Introduction

In today's era of globalization and booming knowledge-based economy, the relationship between higher education and the regional economy has become more and more closely linked, and together they constitute a powerful engine for sustained social progress and development.

The five northwestern provinces - Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang - occupy a pivotal position in China's economic and geographical map. Since the 18th CPC National Congress, the state has implemented a series of major strategic initiatives such as the Central and Western Higher Education Revitalization Plan and the "Provincial-Ministerial Co-construction of Colleges and Universities". These have provided strong talent and scientific and technological support for accelerating the connotation construction of higher education in central and western China and promoting the high-quality development of the regional economy and society. However, against the goal of accelerating the formation of a new pattern of western development, there are still some gaps in higher education in the five northwestern provinces to promote high-quality economic and social development[1]. With the in-depth promotion of the "Belt and Road" construction, the economic strength of the five northwestern provinces has grown significantly, and the industrial structure has been continuously optimized and upgraded, but the five provinces have a vast area, varying levels of economic development, and a relative lack of investment in higher education, which makes it challenging for the coordination and symbiosis of higher education and the regional economy in the five provinces. Therefore, in-depth analysis and precise grasp of the interaction mechanism between higher education and regional economy in the five northwestern provinces, and comprehensive and objective assessment of the level of coordinated development between the two, not only has significant theoretical value, but also shows urgent practical significance in practice.

2. Research design

2.1. Indicator selection and data sources

Higher education and economic high-quality development are both comprehensive concepts, so this

ISSN 2616-5902 Vol. 7, Issue 1: 22-29, DOI: 10.25236/AJBM.2025.070103

paper divides higher education and economic high-quality development into two sub-systems, namely, higher education system and regional economic high-quality development system, and sets up breakdown indicators. According to the general system theory, the system has wholeness, openness, dynamic relevance, hierarchy and orderliness, so this paper measures the two systems of the five northwestern provinces comprehensively, and selects 15 secondary indexes from four dimensions, namely, higher education scale, higher education funding, infrastructure construction, and level of scientific and technological innovation, to measure higher education development; and the status of high-quality development of the regional economy is measured from three dimensions, namely, economic scale, economic structure, and economic quality, and 10 secondary indexes. The high-quality development of regional economy is measured by 10 secondary indicators in 3 dimensions: economic scale, economic structure, and economic quality. In view of the authority and availability of data, the data for the empirical analysis of this paper were obtained from the National Bureau of Statistics, the National Economic and Social Development Statistics Bulletin (Northwest Five Provinces), China Education Statistics Yearbook, China Science and Technology Statistics Yearbook, and National Science and Technology Investment Statistics Bulletin.

2.2. Data processing

2.2.1. Normalization

Firstly, in order to ensure the timeliness of the data, this study selects the panel data of the economic high-quality development system and the higher education system of the five northwestern provinces from 2014 to 2023 for integration; secondly, some of the missing years are interpolated to obtain the complete dataset; finally, in order to transform the quantitative data in the index system into the expression of the data without the quantitative scale, this paper carries out the normalization of the panel data to eliminate the effect of the quantitative scale.

The steps of the normalization formula are as follows, where $X_{ij}^{'}$ denotes the data of the normalized economic high-quality development system indicators and higher education system indicators.

$$X_{ij}^{'} = \frac{X_{ij} - X_{\min}}{X_{\max} - X_{\min}} \tag{1}$$

Some of the indicators of the two systems appeared to have zero or negative values after normalization, so they were leveled in this paper.

$$X_{ij}^{''} = H + X_{ij}^{'} \tag{2}$$

Where H is the magnitude of the indicator shift, so that $H = 0.01$. $X_{ij}^{''}$ denotes the data of the j th evaluated object (year) under the i th evaluated indicator in the data after the shift.

2.2.2. Entropy weighting method to determine weights

This paper adopts the entropy weight method to determine the weight of the indicator by judging the degree of dispersion of the indicator of high-quality economic development and higher education, the smaller the information entropy it contains, the greater the degree of dispersion of the indicator, and the greater the impact of the indicator on the system.

Calculate the weights of the two system indicators, where Y_{ij} denotes the weight of the j th evaluation indicator in year i in the leveled data, n =2023.

$$Y_{ij} = \frac{X_{ij}^{''}}{\sum_{i=1}^{n} X_{ij}^{''}} \tag{3}$$

Calculate the entropy weight of the j th evaluation indicator in year i :

$$e_j = -\frac{1}{\ln n} \sum_{i=1}^{n} Y_{ij} \ln Y_{ij} \tag{4}$$

Calculate the coefficient of variation for the i th evaluation indicator. The higher the value of the

ISSN 2616-5902 Vol. 7, Issue 1: 22-29, DOI: 10.25236/AJBM.2025.070103

calculated coefficient of variation E_j, the greater the range of variation of the data of the indicator, the greater the degree of imbalance, the greater the impact of the indicator on the comprehensive evaluation, and the higher the weight of the indicator, where $p \in \{1,...,25\}$.

$$E_j = 1 - e_j \tag{5}$$

In order to ensure the accuracy and reliability of the data, this paper adopts entropy weighting method to calculate the weights of each indicator based on the characteristics of the panel data itself, which avoids the error of human subjective judgment. Among them, the attributes of all indicators are positive, the coefficient of variation is abbreviated as COV, and the measurement weights are abbreviated as weights. The analysis results are shown in Table 1:

$$\omega_j = \frac{E_j}{\sum_{j=1}^{p} E_j} \tag{6}$$

Table 1: Results of entropy weighting for calculating indicators of higher education and economic development.

Primary indicators	Weights	Indicator measure	Units	Entropy	COV	Weights
Scale of higher education	0.24334	Number of higher education institutions	Size	0.8924	0.1076	0.0482
		Number of students in general higher education institutions	Person	0.8923	0.1077	0.0482
		Number of full-time teachers	Person	0.9017	0.0983	0.0440
		Number of graduates this year	Person	0.8783	0.1217	0.0545
		Enrollment in general colleges and universities	Person	0.8919	0.1081	0.0484
Funding for higher education	0.11019	State financial funding for education	Million yuan	0.9168	0.0832	0.0373
		Funding for education social donations	Million yuan	0.9078	0.0922	0.0413
		Other education funds	Million yuan	0.9293	0.0707	0.0317
Infrastructure construction	0.07322	Number of books	Million books	0.9363	0.0637	0.0285
		Capital expenditures of colleges and universities	Billions of yuan	0.9002	0.0998	0.0447
Level of science and technology innovation	0.57326	R&D personnel full-time equivalent	Personyears	0.7497	0.2503	0.1121
		Internal expenditures of R&D funds	Million yuan	0.7706	0.2294	0.1027
		Number of R&D projects	Item	0.7964	0.2036	0.0911
		R&D project funds	Million yuan	0.7533	0.2467	0.1105
		Number of patents granted (pieces)	Item	0.6496	0.3504	0.1569
Economic scale	0.42256	Gross domestic product (GDP)	Billions of Yuan	0.8840	0.1160	0.1643
		Regional fiscal revenue	Billions of Yuan	0.8913	0.1087	0.1539
		Regional fiscal expenditure	Billions of Yuan	0.9263	0.0737	0.1044
Economic structure	0.34203	Value added of secondary industry	Billions of Yuan	0.8567	0.1433	0.2029
		Value added of tertiary industry	Billions of Yuan	0.9017	0.0983	0.1391
Economic quality	0.23542	Regional GDP per capita	Yuan	0.9569	0.0431	0.0610
		Urban disposable income	Yuan	0.9548	0.0452	0.0640
		Disposable income of rural residents	Yuan	0.9572	0.0428	0.0606
		Consumption level	Yuan	0.9648	0.0352	0.0498

The weights of the indicators are multiplied with the standard, leveled processed indicator data to

ISSN 2616-5902 Vol. 7, Issue 1: 22-29, DOI: 10.25236/AJBM.2025.070103

obtain the composite scores of the two systems. The provinces are abbreviated as prov, and the education and economic scores are abbreviated as EdS and EoS, respectively, and the results of the analysis are shown in Table 2:

Table 2:Composite scores for the two systems in the five northwestern provinces, 2014-2023.

prov	year	EdS	EoS	prov	EdS	EoS	prov	EdS	EoS
Shaanxi	2014	0.4749	0.4253	Gansu	0.1327	0.1148	Qinghai	0.0132	0.0353
	2015	0.4588	0.4546		0.2960	0.1338		0.0109	0.0558
	2016	0.4878	0.4814		0.1397	0.1576		0.0195	0.0733
	2017	0.4903	0.5614		0.1475	0.1794		0.0150	0.0888
	2018	0.4886	0.6449		0.1544	0.2176		0.0172	0.1160
	2019	0.5466	0.6943		0.1670	0.2423		0.0330	0.1401
	2020	0.6200	0.7055		0.1742	0.2590		0.0324	0.1501
	2021	0.6948	0.8284		0.1889	0.3037		0.0425	0.1791
	2022	0.7220	0.9419		0.1899	0.3318		0.0417	0.2007
	2023	0.7916	0.9896		0.2044	0.3669		0.0394	0.2279
Ningxia	2014	0.0299	0.0561	Xinjiang	0.1262	0.2266			
	2015	0.0412	0.0785		0.1577	0.2507			
	2016	0.0414	0.1015		0.1246	0.2733			
	2017	0.0479	0.1304		0.1424	0.3306			
	2018	0.0450	0.1547		0.1661	0.3770			
	2019	0.0602	0.1696		0.1998	0.4223			
	2020	0.0581	0.1771		0.2184	0.4231			
	2021	0.0710	0.2155		0.2255	0.4862			
	2022	0.0749	0.2509		0.2509	0.5708			
	2023	0.0838	0.2788		0.2796	0.6376			

According to Table 2, it can be concluded that the economy and education of the five northwestern provinces all show a gradual upward trend, with individual provinces showing a slight decline in some years. Among them, the education and economic scores of Shaanxi Province are significantly higher than those of the other four provinces during the period (2014-2023) and reach 0.7916 and 0.9896 respectively in 2023, which indicates that Shaanxi Province has always been the center of education and economic development in the western region, and plays a leading role in economic aggregate, financial strength and industrial development. During the “13th Five-Year Plan” period, Shaanxi Province's total economic output exceeded 2 trillion yuan, the per capita GDP jumped from 50,000 yuan to 60,000 yuan, and the modernized industrial system with Shaanxi characteristics accelerated the construction of Shaanxi Province, and after achieving the success of the stage of economic development, it continues to implement the “14th Five-Year Plan and 2035 Plan of Shaanxi Province” and to implement the “14th Five-Year Plan and 2035 Plan of Shaanxi Province”. After achieving success in the stage of economic development, it continues to implement the “Shaanxi Province's 14th Five-Year Plan and 2035 Vision Proposals”, continuously optimizes and adjusts the structure of economic development, and realizes the enhancement of the quality and efficiency of industries, so that the economic scores show a continuous upward trend. At the same time, Shaanxi has a large number of higher education institutions and a rich level of higher education resources, prompting its education score to continue to maintain its leading position. Gansu, Xinjiang and Qinghai have the next highest scores, with Xinjiang's education and economy scores slightly higher than those of the other three provinces. Due to its rich natural resources and its role as a golden corridor of the “Belt and Road”, Xinjiang is an inland and border opening highland, and has experienced strong economic growth in recent years, with nominal and real GDP growth rates exceeding the national average. Since 2014, with the “counterpart” aid to Xinjiang and the regularization of the mechanism for sharing quality education resources between Xinjiang and the mainland, the education level in Xinjiang has been significantly improved, and the education score has shown a gradual increase. Qinghai is slightly lower than the other two provinces, with a population of 5.94 million as of 2023, the lowest among the five northwestern provinces, so the direct demand for higher education is weak, and the willingness to run schools is low, which also leads to more expensive labor costs and a slump in local consumer demand, which to some extent hinders the development of Qinghai's economy and education system.

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2.3. Coupling coordination degree modeling

In order to explore the coupled and coordinated relationship between higher education and economic development, this paper measures the panel data of the five processed Northwest provinces from 2014-2023 by establishing a coupled coordination degree model, and the results are shown in Table 3.Where C is the degree of coupling, T is the coordination index, D is the degree of coupled coordination, U denotes the composite score of the development of higher education, T denotes the composite score of the regional economic high-quality development, and α、β are the weights of the two sub-systems of higher education and α and β are the weights of the two subsystems of higher education and economic development respectively. Since the status of the two systems is equally important, $\alpha = \beta = 0.5$, and its calculation formula is as follows:

$$C = 2[\frac{U*G}{(U+G)^2}]^{\frac{1}{2}} \tag{7}$$

$$T = \alpha*U + \beta*G \tag{8}$$

$$D = \sqrt{C*T} \tag{9}$$

Table 3: Results of the coupled coordination of the two systems in the five northwestern provinces, 2014-2023.

Year	Prov	D	Prov	D	Prov	D	Prov	D	Prov	D
2014	Shaanxi	0.670	Gansu	0.351	Qinghai	0.147	Ningxia	0.202	Xinjiang	0.411
2015		0.676		0.446		0.157		0.238		0.446
2016		0.696		0.385		0.195		0.255		0.430
2017		0.724		0.403		0.191		0.281		0.466
2018		0.749		0.428		0.211		0.289		0.500
2019		0.785		0.449		0.261		0.318		0.539
2020		0.813		0.461		0.264		0.319		0.551
2021		0.871		0.489		0.295		0.352		0.575
2022		0.908		0.501		0.302		0.370		0.615
2023		0.941		0.523		0.308		0.391		0.650

Table 4: Classification of the degree of coordination of the coupling between the economy and the education system.

Coordination level	Level Classification	D
Extreme Dissonance	Sprouting stage	(0,0.1)
Severe Dissonance		(0.1001,0.2)
Moderate Dissonance		(0.2001,0.3)
Mildly dysfunctional		(0.3001,0.4)
Nearly dysfunctional	Starting Stage	(0.4001,0.5)
Barely coordinated		(0.5001,0.6)
Elementary coordination	Stabilization stage	(0.6001,0.7)
Intermediate coordination		(0.7001,0.8)
Good coordination	Mature stage	(0.8001,0.9)
Quality coordination		(0.9001,1)

According to the results of the coupling coordination degree, it can be seen that the overall coupling coordination degree of education and economy in the five northwestern provinces shows a steady increase. Drawing on the research of scholars Xie Yutong (2022)[3] and Tang Shunbiao (2024)[2] , this paper divides the degree of coupled coordination into 10 grades and 4 levels, and the classification results are shown in Table 4. Among them, Shaanxi Province has reached a mature stage from primary coordination in 2014 to quality coordination in 2023, indicating that the interaction between higher education and economic development in Shaanxi Province has obvious effects, the degree of adhesion has gradually become stronger, and the dependence, cooperation, and synergy between the economy and the higher education system maintains and develops the wholeness of the system. The high-quality development of the economy provides a better social environment for higher education, and plays a positive role in promoting faculty strength, education funding, and university infrastructure, prompting the improvement of the level of economic transformation results of higher education and the further high-

ISSN 2616-5902 Vol. 7, Issue 1: 22-29, DOI: 10.25236/AJBM.2025.070103

quality development of education. At the same time, higher education also improves the quality and quality of talents by cultivating extraordinary top-notch talents, realizes the transformation of innovative achievements, and provides a supporting role and endogenous power for the high-quality development of regional economy in Shaanxi Province. Gansu Province from mildly out of tune to barely coordinated, 2014-2015 shows that higher education pulls the economic development, but did not play a leading role and the effect is not obvious, but also reflects that the social service function of higher education is not perfect and colleges and universities to train talents of the cycle is long, the driving effect of the economy is often presented with lagging and cyclical characteristics. 2016-2023 to change to the economic driven Higher education development, coupling coordination improved, but the two systems have not yet reached a state of high-quality interaction. Xinjiang Province has changed from being on the verge of dislocation to primary coordination, with economic development slightly ahead of higher education, so it can be concluded that the coupling coordination of the two systems is weak and there is still much room for improvement in the development level of each system, especially the promotion of higher education to economic development should be fully emphasized, and the quality of higher education development should be improved and transformed into efficiency, so as to achieve a state of high-quality coordination between the two systems. The coupling coordination degree between Qinghai Province and Ningxia Province is still in the budding stage, and the coordination grade is mildly dysfunctional, indicating that the correlation between the two systems of economy and education is not strong and relatively independent. From the two higher education scores and economic scores, it can be seen that the scores of Qinghai Province and Ningxia Province are located in the back rank of the five northwestern provinces. In the indicator measurement weights established in this paper, the level of scientific and technological innovation and economic structure account for a relatively high proportion of the weights of the two systems. According to the “Evaluation Report of China's Regional Scientific and Technological Innovation”, Ningxia and Qinghai are at the bottom of the national list in terms of the regional innovation environment, innovation inputs and outputs, and the industrialization of high and new technologies. Meanwhile, the industrial structure is relatively backward, which is mainly manifested in the unreasonable structure of resource distribution and economic benefits obtained among the three major industries, with the secondary industry relying on energy, relying on the obvious, with a large proportion of primary raw material industry, mostly raw material processing, in the upstream of the industrial chain, and with a low risk-resisting ability and industrial added value. In the tertiary industry, the development of productive service industry and modern service industry is lagging behind, and the development quality is not high, so the coupling and coordination degree of the two systems in the two provinces is low.

2.4. Global Moran Index

This paper further explores the spatial aggregation characteristics of the coupling and coordination degree of higher education and regional economic development by calculating the global Moran index, and uses ArcMap 10.8 to determine the trend of Moran index changes in the five northwestern provinces, as shown in Table 5:

Table 5:Global Moran'I indices.

Year	Moran'I	Z-value	P-value
2014	-0.3366	-0.3354	0.7373
2015	-0.3697	-0.4467	0.6551
2016	-0.3179	-0.2678	0.7889
2017	-0.2844	-0.13405	0.893365
2018	-0.3100	-0.23086	0.817422
2019	-0.3209	-0.27329	0.784632
2020	-0.3293	-0.30582	0.759742
2021	-0.3215	-0.28065	0.778981
2022	-0.3061	-0.21812	0.827336
2023	-0.2946	-0.17227	0.863227

According to the research results from 2014 to 2023, the Moran's I index ranges between (-0.3697, -0.2844), while the P-values are all higher than 0.05, indicating a weak negative spatial correlation between higher education in the five northwestern provinces and the coupling and coordination of the regional economy. This relationship leads to the formation of spatial heterogeneity, but does not show

ISSN 2616-5902 Vol. 7, Issue 1: 22-29, DOI: 10.25236/AJBM.2025.070103

obvious spatial agglomeration, reflecting the relatively low interdependence among the five northwestern provinces and the need to further strengthen the regional development links among the provinces.

In terms of the overall trend, Moran's I index shows a fluctuating upward trend during this decade, indicating that although there are still large spatial differences among the five Northwestern provinces, the spatial links among them are gradually increasing. This change implies that the degree of interaction and coordination between the five northwestern provinces in terms of higher education and regional economic development is gradually improving, and that although the spatial linkages are not close enough at present, they are moving in the direction of greater coordination.

3. Suggestion

Based on the status quo and challenges of the coordinated development of higher education and regional economy in the five provinces of Northwest China, this paper puts forward some reference suggestions, as follows:

First, strengthen the leading role of “double first-class” colleges and universities and their superior disciplines, and enhance the strategic effectiveness of higher education in serving regional development. The “double first-class” colleges and universities in the five northwestern provinces are the leaders of regional higher education development, and have a significant role in promoting the development of the local economy. It is necessary to deepen the exchanges and cooperation between these colleges and universities and their advantageous disciplines, and build a system of alliance between colleges and universities and their disciplines, so as to promote the improvement of the overall quality of education by taking advantage of the disciplines as a leader. At the same time, the construction of university disciplines should closely focus on the needs of regional development, deepen the reform of education and teaching, take the initiative to assume the responsibility of enhancing the regional economic power, focus on key core technologies to carry out scientific research, clarify the positioning of universities in the regional development pattern of talent cultivation, provide a higher quality, more relevant to the actual supply of education to improve the quality of labor force and skill level, and lay a solid foundation of scientific knowledge and excellent talents for the socio-economic development of the Northwest.

Secondly, build an interactive mode of deep integration of regional industries and higher education and regional connectivity and cooperation. Relying on the regional industrial clusters in the five northwestern provinces, we should build university science and technology parks, laboratories, engineering centers and other platforms for industry-university-research cooperation, so as to form an interactive mechanism of resource sharing and complementary advantages between industries and higher education, and to promote the in-depth integration and synergistic development of higher education and the regional economy. In addition, the five northwestern provinces should strengthen inter-regional connectivity and cooperation, expand the cooperation space between public universities and the regional economy by expanding the autonomy of universities, and cultivate a good order for synergistic development[4]. At the same time, the use of policy-driven means to guide colleges and universities to actively respond to the needs of regional synergistic development, and jointly promote the synergistic development of regional economy and higher education.

Third, optimize the layout of higher education to achieve differentiated development. According to the different conditions of the five northwestern provinces, take the road of reasonable division of labor and optimized development. Shaanxi should give full play to its comparative advantages to realize the high-quality development of higher education; Gansu, Qinghai and other provinces need external support and their own concentrated efforts to run a good head college; Xinjiang, and other provinces need the central government to provide greater support to promote the balanced development of higher education.

4. Conclusion

This paper constructs the index system of higher education and regional economic development, and explores the degree of coordination and spatial agglomeration between the two systems in the five northwestern provinces by using the coupling coordination degree model and the global Moran index. It is concluded that in the time dimension, the degree of coupling and coordination between the two systems in the five northwestern provinces increases with the year, among which, the interaction effect between the two systems in Shaanxi Province is obvious and shows a gradual convergence to the high-quality interaction pattern, while the coupling and coordination degree level of the other provinces still has a big difference, which is due to the lower level of development of a sub-system within the sub-system that

ISSN 2616-5902 Vol. 7, Issue 1: 22-29, DOI: 10.25236/AJBM.2025.070103

makes the degree of coupling and coordination weaker, and indicates that there is still much room for improvement in the level of development of the sub-systems. The reason for this is that a lower level of development of a subsystem makes the coupling coordination degree weaker, indicating that the subsystems still have more room for improvement. In the spatial dimension, although the Moran'I index fluctuates and rises in ten years, it is still negative, so it can be concluded that the coupling coordination degree of each province is relatively decentralized, and there are large spatial differences.

References

[1] Ningxia DAB. Boosting the high-quality development of the western region with high-quality higher education.[EB/OL].(2021-03-08)[2024-11-30].http://www.ningxiamj.gov.cn/info/1042/15777.htm

[2] Shunbiao Tang,Mingshan Zhang. Research on synergistic development of higher education and regional economy in western region [J]. Heilongjiang Science,2022,13(17):1-5.

[3] Yutong Xie, Hailong Shang. Study on the spatio-temporal pattern of coupling and coordination between higher education scale and regional economy in Guangdong, Hong Kong and Macao Greater Bay Area--Taking Guangdong area as an example[J]. Exploration of Higher Education,2024,(04):14-23.

[4] Shuolong Peng,Mingyang Wu.Research on the coupled and coordinated development of higher education scale and regional economy in China[J]. Statistics and Decision Making,2021,37(09):109-112.DOI:10.13546/j.cnki.tjyjc.2021.09.025.