On the Coupling Relationship between Economic Development and University Discipline Construction during the COVID-19 Pandemic

Bin Zhao[1*] and Xia Jiang[2]

[1]*School of Science, Hubei University of Technology, Wuhan, Hubei, China*

[2]*Department of Economics, Hubei University of Technology, Wuhan, Hubei, China*

Abstract

With the continuous development of economy and the acceleration of social transformation, the contradiction between regional economic development and discipline construction in universities is becoming more and more prominent. It is urgent to explore the coupling and coordination relationship between the two to achieve higher-quality development. At the same time, Hubei Province is a big education province in China and it is also one of the important areas of the rise strategy of central China. Taking Hubei Province as an example to study has certain representativeness and demonstration significance. Therefore, this paper builds the economic development and subject construction of colleges and universities in two comprehensive evaluation index system, selection of Hubei province in 2010-2019 and the 13 regional administrative region economic development and subject construction of colleges and universities in two system index data, using poor method and principal component analysis to data standardization and index weight calculation, two comprehensive evaluation index system, The results show that both of them increase steadily, the comprehensive evaluation index of economic development subsystem increases from 0.0962 to 0.9519, and the comprehensive evaluation index of university discipline construction subsystem increases from 0.1303 to 0.8438. Then the coupling coordination degree model was adopted, and the ArcGIS software was used to measure the coupling coordination relationship between the two systems and analyse the spatial pattern evolution. Finally, the Granger causality test method was used to test the coupling relationship between the two systems. The results show that the coupling coordination degree of the two systems in Hubei Province has changed from mild misalignment to high quality coordination, and has been developing continuously. The spatial distribution of administrative regions at different levels is not consistent, there is false coupling, and most of them are low level coordinated development. Economic development is insufficient in supporting the discipline construction in colleges and universities. Suggestions are given: the government should plan the two systems synchronously to make them develop harmoniously; Colleges and universities should actively respond to the policy call of "Double First-class" and improve the discipline construction system; Normal financial support system for discipline construction should be established between government and university, so as to give full play to the "Economic Education Power" of regional economy during the COVID-19 pandemic.

Keywords: Regional economy • Discipline construction • Principal component analysis • Granger causality test

Introduction

Introduce the problem

In the new era, China's economic development is moving from a stage of high-speed growth to a stage of high-quality development. With the continuous improvement of the level of economic and social development, people have a deeper understanding of education, especially the innovation-driven development strategy put forward by the state has promoted the development of knowledge economy to a great extent and economic development and higher education present an increasingly close relationship [1]. As the core of university construction, discipline is the basis for the survival and development of higher education [2]. The discipline construction of local colleges and universities aims at serving local economy. Local colleges and universities provide talents and technical support for the development of local economy. Therefore, the discipline construction of colleges and universities has established a close relationship with the development of regional economy [3]. However, with the deepening of China's economic system reform and the acceleration of social transformation, the contradiction between regional economic development and university discipline construction is becoming increasingly

prominent [4]. The discipline construction of colleges and universities has been improving its ability to serve regional economic development, but its development cannot fully meet the needs of regional economic development. At the same time, General Secretary Xi Jinping has clearly expressed the importance of coordinated development at the symposium on deepening the development of Yangtze River Economic Belt held in Wuhan. Therefore, how to effectively recognize the objective law of their development and find out the existing problems to promote the coordinated development of regional economy and university discipline construction has become an urgent problem to be solved. So it is necessary to study the coupling relationship between regional economy and university discipline construction.

By the end of 2019, Hubei had 13 prefecture-level administrative regions, including 12 prefecture-level cities and one autonomous prefecture. At present, there are 129 colleges and universities in the province, including 68 undergraduate colleges and 61 junior colleges. In recent years, the Government of Hubei Province has implemented the implementation measures for promoting the construction of first-class universities and first-class disciplines in Hubei Province, adhering to the principle of "supporting the excellent, supporting the needs, supporting the special and supporting the new". Layout construction "building world-class university college", "world first-class discipline construction in colleges and universities" and "domestic first-class university construction in colleges and universities", "domestic first-class discipline construction in colleges and universities", guide and support strength strong, reasonable positioning, connotation and development in colleges and universities have the characteristics, first-class, for subject construction of colleges and universities in Hubei province and talent training provides a good environment for development [5]. Hubei province, as one of the strategic important regions in the rise of central China, is not only an important part of economic and social development,

but also a large province with higher education in China, with a large number of universities and strong scientific and technological strength. Therefore, taking Hubei Province as an example, it is necessary to conduct an in-depth study on the coupling relationship between regional economic development and university discipline construction.

Importance of the problem

In order to solve the problem of disharmony between regional economy and discipline construction in colleges and universities, this paper takes Hubei Province as an example to quantitatively analyze the coupling coordination between economic development in Hubei Province and discipline construction in colleges and universities. This not only has a good representative and exemplary significance, but also provides a scientific basis for rational regulation of economic development in Hubei Province and discipline construction in colleges and universities. In addition, the dynamic relationship and reality of interdependence, coordination and mutual promotion between economic development in Hubei Province and discipline construction in colleges and universities are analysed. It is of great significance to promote the formation of a virtuous cycle of Hubei province's university discipline construction helping regional economic development and regional economic development promoting university discipline construction.

Relevant scholarship

There is a dynamic relationship between higher education and regional economic development which influences, promotes, depends on and restricts each other [6]. Ogurtsova, et al. [7] found that the balance of regional higher education system is closely related to the development of regional economic system after studying the relationship between economy and education in various regions of the Russian Federation. Bian, et al. [8] believe that only by coordinating the development of the discipline structure and the change of the industrial structure can we better promote the optimization of the regional industrial structure. Wenjun, et al. [9] point out that the interaction between higher education and regional economic development is not high in China, and we should promote the formation of a benign interaction mechanism between higher education and regional economic development. Zhao, et al. [10] used the coupling theory to construct a coupling relationship model among the three systems, and conducted an empirical analysis on the coordinated development of higher education, innovation capacity and economic growth of 18 prefecture-level cities in Henan Province from 2006 to 2016 by using multidimensional indicators. Jinpeng, et al. [11] Innovatively introduced DPSIR theory to analyze the coupling coordination mechanism among three systems, and further constructed an evaluation model of coupling coordination degree optimized by information entropy on this basis. Liyin, et al. [12] Introduced an improved coupling coordination degree model to effectively evaluate the coupling coordination relationship between social economy and carbon emissions in China from 1995 to 2015. Wang, et al. [13] used the grey relational system model to analyze the coordination between higher education and economic development in China. Zhanyong, et al. [14] studied the coupling relationship between China's economic development and vocational education by using time series data and Granger causality test.

To sum up, there are many research achievements on regional economy and university education, but there are few researches on regional economy and university discipline construction, and most of them are analyzed by coupling coordination degree model. This paper studies the coupling coordination relationship between regional economy in Hubei province and discipline construction in colleges and universities by combining the coupling coordination degree model and Granger causality test method, providing scientific theoretical basis for reasonably regulating the coordinated development of economic development and discipline construction in Hubei province and even all regions.

Research content and framework

The research content of this paper is mainly divided into two core parts:

Research content one: Analysis of the coupling relationship between Hubei province's economic development and university discipline construction. In this paper, the principal component analysis method is used to calculate the index weight, and the coupling coordination degree model is established to calculate and analyze the coupling relationship between the economic development of Hubei province and the discipline construction of colleges and universities. In addition to analyzing the overall situation of the province, this paper also analyzes the spatial distribution and spatial pattern evolution of the coupling and coordination relationship between the two systems in 13 prefecture-level administrative regions of Hubei Province by using ArcGIS10.7 software, so as to explore the differences between the coupling relationship between the two systems of the prefecture-level administrative regions and seek corresponding countermeasures accordingly.

Research content two, Hubei province economic development and university discipline construction coupling relationship test. Based on the analysis results of research content 1, relevant variables are selected and the unit root test and Granger causality test are used to test the coupling and coordination relationship of data to verify whether the two systems are bidirectional coupling or one-way coupling, providing theoretical basis for subsequent conclusions and suggestions.

Methodology

Data sources and pre-processing

This paper takes Hubei Province as the research unit and Hubei province's economic development level and university discipline construction as the research object. The research period is from 2010 to 2019. All data are derived from 2010-2019 Education Statistics of the Ministry of Education of the People's Republic of China, Statistical Yearbook of Hubei Province, Statistical Yearbook of Various Administrative Regions of Hubei Province and Statistical Bulletin of National Economic and Social Development. Some missing data are deduced and supplemented according to the average growth rate.

All the data of the research object matrix X=(xii)m × n with m rows × n columns were dimensionless to eliminate the influence of different dimensions on the index values and control the range of variation of each index between 0 and 1. In order to avoid the continuous negative value in the calculation process of index weight, which may affect the final result, this paper adopts range method to standardize the data. Before processing, the positive and negative attributes of the index should be clarified. Generally, the larger the positive index value is, the better the result will be, while the negative index has the opposite effect. Assume that the value of each indicator data after processing is Z1, Z 2,----Zi, the processing formula of the forward indicator is (Equations 1 and 2).

$$Z_{ij} = \frac{X_{ij} - \min(X_i)}{\max(X_i) - \min(X_i)}, X_i = x_1, x_2, ---, x_i \qquad (1)$$

The processing formula of negative indicators is as follows:

$$Z_{ij} = \frac{\max(X_i) - X_{ij}}{\max(X_i) - \min(X_i)}, X_i = x_1, x_2, ---, x_i \qquad (2)$$

In the above formula, Xij represents the j index value in the i region, min (Xi) represents the minimum value of the j index in the i region, and max (Xi) represents the maximum value of the j index in the i region. The final calculation result may have a value of 0. In order to make the value meaningful when calculating the weight, the data need to be treated with non-zero.

Construction of index system

Following the principles of comparability, hierarchy, comprehensiveness and representativeness of data, this paper selects indexes that can objectively reflect the regional economic development and the discipline construction of colleges and universities, so as to construct a two-system comprehensive index system. The system takes the discipline construction and regional economic development as the target layer and then constructs the criterion layer and index layer respectively. In terms of the construction of index system of regional economic development, this paper refers to the existing research results [15,16], and combines the actual situation of Hubei Province to construct a comprehensive index system of regional economic development from 11 indicators at three levels of economic development quality, economic development efficiency and economic development structure, as shown in Table 1.

In terms of the construction of discipline construction index system in colleges and universities, this paper draws on relevant researches [17,18] to construct a comprehensive discipline construction index system in colleges and universities from 12 indicators at three levels of resource conditions, achievement output and environmental coordination, as shown in Table 2.

Principal Component Analysis (PCA)

Principal Component Analysis (PCA) is a multivariate statistical analysis method which selects a small number of important variables by linear transformation of multiple variables. That is, a group of related variables are transformed into another group of unrelated variables by linear transformation, and the new variables obtained are arranged in order according to the magnitude of variance. To avoid calculating the index weight of subjective factors, this paper use SPSS25.0 software principal component analysis was carried out on the standardization of data calculating weight, according to the characteristic value is greater than 1 and the cumulative contribution rate of not less than 80% of the principle of extracting reflect the economic development of Hubei province and the comprehensive index of subject construction in university, the results as shown in Tables 3 and 4.

The eigenvalues of the two principal components in Table 3 are both greater than 1 and can reflect 97.691% of data information. Therefore, the corresponding eigenvalues and variance contribution rates of the two principal components can be used in the calculation process of index weight. The eigenvalues of the three principal components in Table 4 are all greater than 1 and can reflect 97.953% of data information. Therefore, the corresponding eigenvalues and variance contribution rates of the three principal components can be used in the calculation process of index weight.

Table 1. Comprehensive index system of economic development level.

Target layer	Rule layer	Index layer	Unit	Attribute
Level of economic development	Quality of economic development	GDP per capita	Yuan	+
		Per capita local fiscal revenue	Yuan	+
		Per capita investment in fixed assets	Yuan	+
		Total retail sales of consumer goods per capita	Yuan	+
	Efficiency economic development	Energy consumption per ten thousand yuan GDP	Tons of standard coal/ten thousand yuan	-
	Structure of economic development	Total labor productivity	Yuan/person	+
		Land yield	Yuan/square meter	+
		Contribution rate of non-agricultural industries	%	+
		Contribution rate of tertiary industry	%	+
		Per capita disposable income of urban residents	Yuan	+
		Per capita disposable income of rural residents	Yuan	+

Table 2. Comprehensive index system of discipline construction in universities.

Target layer	Rule layer	Index layer	Unit	Attribute
Discipline construction In Universities	Resource Conditions	Proportion of teachers with master's degree or above	%	+
		Professor number	Position	+
		Total Input Of Discipline Funds	Ten thousand yuan	+
		Total Fixed Assets Of Universities	Ten thousand yuan	+
		Scientific research achievements at provincial and ministerial level or above	Item	+
	Results output	Number of university graduates	Number	+
		Number of patents granted	Item	+
		Average number of students per teacher	Number	-
	Yuan	Average student occupies the school floor space	Square meters	+
		Books and materials	Ten thousand copies	+
		Educational computer	Number	+
		Number of multimedia classrooms	Number	+

Table 3. Principal component results of economic development index system.

Principal component	Eigenvalue	Variance contribution rate (%)	Cumulative contribution rate (%)
1	9.68	87.999	87.999
2	1.066	9.692	97.691

Table 4. Principal component results of the discipline construction index system in colleges and universities.

Principal component	Eigenvalue	Variance contribution rate (%)	Cumulative contribution rate (%)
1	9.279	77.327	77.327
2	1.374	11.452	88.779
3	1.101	9.174	97.953

Comprehensive evaluation index

The idea of comprehensive evaluation index is to transform multiple indexes into one index that can reflect the comprehensive situation, and its core is to calculate the weight of indexes. Referring to the research results of system coupling [19], this paper defines the comprehensive evaluation indexes of Hubei province's economic development system and university discipline construction system as follows (Equations 3 and 4).

$$f(x) = \sum_{i=1}^{m} a_i x_i \qquad (3)$$

$$g(y) = \sum_{i=1}^{m} b_i y_i \qquad (4)$$

In the above formula, i represents the number of indicators of each system, a_i and b_i represent the weight of each system indicator, x_i and y_i represent the index value of each system indicator feature, f x and g y represent the comprehensive benefit of each system, namely the comprehensive evaluation index, and they are all dimensionless values.

Coupling coordination degree model

Coupling coordination degree is refers to the system or system elements between the coordinated degree of each other, the coupling interaction between the relationship of the size of the benign coupling, used to measure whether match between two or more subsystems appropriate relationship, forming a virtuous cycle, it can reflect the trend of the system from disorderly to orderly, embody the coordination situation of good or bad, The coordination state is divided into several grades according to the interval of coordination degree [20].

The coupling degree function of Hubei province's economic development and university discipline construction can be expressed as (Equations 5).

$$C = \sqrt{\frac{f(x) \times g(y)}{\left[\frac{f(x) + g(y)}{2}\right]^2}} \qquad (5)$$

Where, C is coupling degree and its value range is 0-1, f (x) represents the comprehensive evaluation index of the economic development system,

and g (y) represents the comprehensive evaluation index of the discipline construction system of colleges and universities. C reflects the degree of quantization between the economic development system and the discipline construction system of universities. The closer the value of C is to 1, the greater the degree of coupling between economic development and discipline construction of universities. The closer it is to 0, the smaller the coupling degree between the two systems is, and the data of each indicator is irrelevant and does not need to be developed.

Because the coupling degree is only to judge the degree of correlation between systems, and cannot measure the level of coordination between systems, this paper further introduces the coupling coordination degree function on the basis of coupling degree and its calculation formula is as follows (Equations 6).

$$D = \sqrt{C \times T}, T = \alpha f(x) + \beta g(y) \qquad (6)$$

Where, C is coupling degree, D is coupling coordination degree. The higher the D value is, the higher the benign correlation degree is between the economic development of Hubei Province and the discipline construction of colleges and universities. T is the comprehensive evaluation index of the coupling relationship between economic development and discipline construction in colleges and universities, representing the overall level of the two systems. α and β are the undetermined coefficients respectively, namely the weight of each system. According to the existing research data [21], α and β are set as 0.5 and 0.5 respectively.

As for the evaluation criteria of coupling degree and coupling coordination degree, the academic circle has not provided a unified standard for the division of their values. Therefore, based on the research results of Jie Duan, et al. [22], this paper divides the classification criteria of coupling degree and coupling coordination degree into 6 levels and 10 levels respectively, as shown in Table 5.

Within each level, further types can be divided according to the size of f(x) and g(y). If f(x)=g(y), it is called synchronous development type; If f(x)<g(y), it is relatively backward in discipline construction in colleges and universities.

Table 5. Evaluation criteria of coupling degree and coupling coordination degree.

	Value range	In phase
Coupling coordination degree	0<C<0.1	Minimum coupling
	0.1 ≤ C<0.3	Low level coupling
	0.3 ≤ C<0.5	Coupling of antagonism
	0.5 ≤ C<0.8	Running-in coupling
	0.8 ≤ C<0.9	High level coupling
	0.9 ≤ C<1.0	Maximum coupling
	0<D<0.1	Extreme imbalance
	0.1 ≤ D<0.2	Serious imbalance
	0.2 ≤ D<0.3	Moderate disorder
	0.3 ≤ D<0.4	Mild disorder
	0.4 ≤ D<0.5	Verge disorder
	0.5 ≤ D<0.6	Barely coordination
	0.6 ≤ D<0.7	Primary coordination
	0.7 ≤ D<0.8	Intermediate coordinate
	0.8 ≤ D<0.9	Good coordination
	0.9 ≤ D<1.0	Quality coordination

Relationship between inspections

Model assumes: In order to establish the ideal coupling state between economic development and discipline construction in universities, this paper proposes a hypothesis model as shown in Figure 1. Through empirical analysis, the paper verifies whether the two curves representing "discipline construction in universities" (line A) and "economic development" (line B) in the model can move upward at the same time and tend to the coupling line and the high coupling point, indicating that economic development and discipline construction in universities have a positive interaction. Or whether only line A or line B has A large upward movement, indicating that only the discipline construction of colleges and universities has A positive effect on economic development, or that only the economic development has a positive effect on the discipline construction of colleges and universities. In a word, it is to test whether there is a two-way coupling or some one-way coupling between economic development and university discipline construction.

Variable selection

In order to facilitate the statistical analysis, according to the statistical convention, this paper selected the total investment of discipline funds (unit: Ten thousand yuan) to represent the development index of discipline construction in colleges and universities, which was recorded as JFZTR (pinyin initials of "total investment of funds"). The per capita GDP (unit: Yuan) is chosen to represent the economic development index and is recorded as RJGDP. The variable data is shown in Table 6.

Unit root test

For non-stationary series, due to the long-term influence of exogenous shocks on the series, it is impossible to predict the future trend through the historical data information of the series, but stationary series can [23,24]. In order to avoid the pseudo regression phenomenon caused by non-stationary sequence, the unit root test for the stationarity of data should be carried out first. The more common test methods include the Augmented Dico-Fuller test (ADF test) and Phillips-Perron test (PP test). According to the model, ADF test is selected in this paper for the stationarity test and the model form is as follows (Equations 7).

$$\Delta y_t = a_0 + \theta y_{t-1} + \gamma_1 \Delta y_{t-1} + \gamma_2 \Delta y_{t-2} + --- + \gamma_p \Delta y_{t-p} + u_t \quad (7)$$

In the above formula, Xij represents first-order difference, a0 represents intercept term, Δ represents time trend term, t=1,2,----;θ represents coefficient, and ut represents the minimum P value of white noise sequence.

Granger causality test

The granger causality test model is as follows

The test model is as follows (Equations 8):

$$M: y_t = \alpha_0 + \alpha_1 y_{t-1} + --- + \alpha_p y_{t-p} + \beta_1 x_{t-1} + --- + \beta_p x_{t-P} + u_t \quad (8)$$

The model with constraints is (Equations 9):

$$MR: y_t = \alpha_0 + \alpha_1 y_{t-1} + --- + \alpha_p y_{t-p} + u_t \quad (9)$$

Where, the constraint conditions are (Equations 10):

$$\beta_1 = \beta_2 = --- \beta_p = 0 \quad (10)$$

The original hypothesis and alternative hypothesis of the above test model are (Equations 11):

$$H_0 = \beta_1 = \beta_2 = --- \beta_p = 0 \quad (11)$$

Indicating granger non-causality between variable xt and variable yt (Equations 12).

$$H_1: \beta_1, \beta_2, ---, \beta_p \quad \text{are not all zero} \quad (12)$$

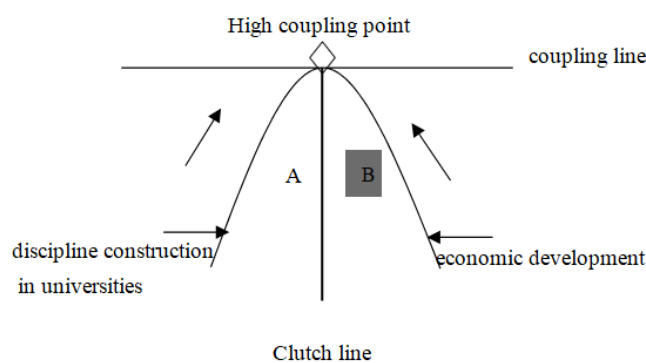It indicates that there is granger causality between variable xt and variable yt.

Figure 1. Coupling hypothesis model.

Table 6. Variable data results.

Year	JFZTR	RJGDP
2010	460254	28359
2011	480311	34738
2012	369694	39163
2013	389182	43838
2014	394202	48630
2015	443381	52015
2016	701098	56836
2017	774652	63180
2018	862796	71109
2019	1005805	77387

The test model and the model with constraints are analyzed respectively and the sum of the squares of two residuals is obtained, which is used to construct the F statistic. At the same time, the significance level α was defined, and the critical value Fα was obtained. If F<Fα, the null hypothesis was accepted, indicating that there was a Granger non-causality relationship between variable xt and variable yt. If F>Fα, the null hypothesis is rejected, indicating that there is granger causality between variable xt and variable yt.

Results and Discussion

Analysis of coupling relationship between two systems in the whole province

The comprehensive evaluation index, coupling degree and coupling coordination degree between economic development of Hubei Province and discipline construction of colleges and universities from 2010 to 2019 are calculated by the calculation formula provided above. The results are shown in Table 7 and Figure 2.

As can be seen from Table 7 and Figure 2, the economic development of Hubei Province improved steadily from 2010 to 2019, with the comprehensive evaluation index rising from 0.0962 in 2010 to 0.9519 in 2019. After experiencing slow adjustment and growth in the early stage, the economic development level achieved large-scale growth in the later stage. From 2010 to 2019, the discipline construction level of colleges and universities in Hubei Province improved year by year, and the comprehensive evaluation index increased from 0.1303 in 2010 to 0.8438 in 2019. Its growth rate slowed down significantly since 2016, and the gap with the comprehensive evaluation index of economic development gradually widened. The value of coupling degree is always close to 1, with a small fluctuation range and always in the maximum coupling stage, reflecting the strong interaction between the two systems of economic development and discipline construction in universities. In addition, the coordination degree coefficient between the two systems increased year by year, from 0.3346 in 2010 to 0.9467 in 2019, and the coordination stage changed from mild disorder to high-quality coordination. This shows that the coordination between economic development and discipline construction in Hubei province has been improved year by year in the past ten years and the imbalance has been greatly changed.

Table 7. Results of coupling relationship between the two systems in Hubei Province.

| Year	f (x)	g(y)	Coupling	Coupling	Determine Type	Coupling level	Coordination level
2010	0.0962	0.1303	0.9886	0.3346	Economic development is relatively backward type	Maximum coupling	Mild disorder
2011	0.1879	0.2124	0.9981	0.447	Economic development is relatively backward type	Maximum coupling	Verge disorder
2012	0.2364	0.239	1	0.4875	Economic development is relatively backward type	Maximum coupling	Verge disorder
2013	0.3065	0.3042	1	0.5526	Discipline construction of universities is relatively backward type	Maximum coupling	Barely coordination
2014	0.4307	0.3726	0.9974	0.6329	Discipline construction of universities is relatively backward type	Maximum coupling	Primary coordination
2015	0.512	0.542	0.9996	0.7258	Economic development is relatively backward type	Maximum coupling	Intermediate coordinate
2016	0.6224	0.6866	0.9988	0.8085	Economic development is relatively backward type	Maximum coupling	Good coordination
2017	0.7404	0.7118	0.9998	0.852	Discipline construction of universities is relatively backward type	Maximum coupling	Good coordination
2018	0.9051	0.7822	0.9973	0.9173	Backward type discipline construction of universities is relatively backward type	Maximum coupling	Quality
2019	0.9519	0.8438	0.9982	0.9467	Backward type discipline construction of universities is relatively backward type	Maximum coupling	Quality
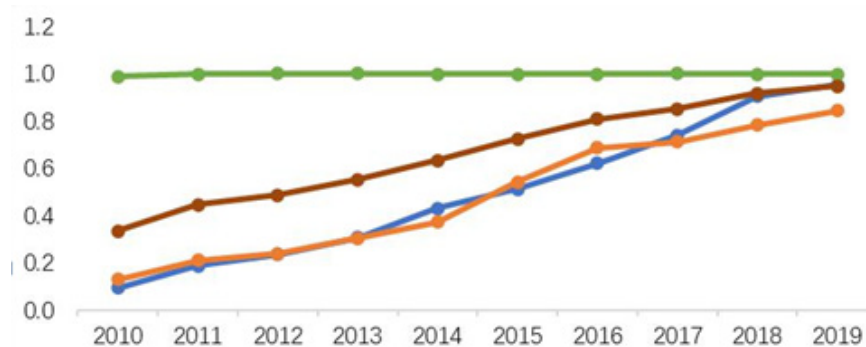
Figure 2. Coupling coordination trend of the two systems in Hubei Province from 2010 to 2019. Note: (——) Comprehensive evaluation index of economic development f(x); (——) Comprehensive evaluation index of university disapline construction g(y); (——) Coupling C; (——) Coupling co-ordination D

Analysis of coupling relationship between two systems in prefecture-level administrative region

Spatial distribution of coupling coordination between two systems: According to the above calculation method of comprehensive evaluation index and coupling coordination degree model, the comprehensive evaluation index, coupling degree and coupling coordination degree of economic development and university discipline construction in 13 prefecture-level administrative regions of Hubei Province from 2010 to 2019 are calculated. Limited by space, the results of 2019 are shown in Table 8.

In 2019, the mean coupling degree between the two systems of prefecture-level administrative regions in Hubei Province was 0.9825, and the standard deviation was 0.0145, indicating that the economic development of prefecture-level administrative regions in Hubei Province and the discipline construction system of universities have reached the maximum coupling stage, and there is little difference between them. In terms of the distribution of coupling coordination degree, the coupling coordination degree of each administrative region in Hubei province in 2019 was between 0.8426 and 0.9891, including two grades of good coordination and excellent coordination. Among them, the good coordination level accounted for 38.46% and the good coordination level accounted for 61.54%, indicating that the coupling coordination relationship between the two systems in most prefecture-level administrative regions of Hubei province was in the stage of good coordination in 2019, which was basically consistent with the above analysis of coupling degree.

From the spatial distribution of coupling coordination relations, there are regional differences in the coupling relations between the economic development of administrative regions and the discipline construction of universities. Then according to the classification of coupling relationship grade and type, we can divide Hubei provincial administrative regions into three types in 2019:

(1) High-quality coordinated prefecture-level administrative regions, only Wuhan, the capital city, belongs to the relatively backward type of economic development;

(2) High quality and coordinated prefecture-level administrative regions, including Huangshi city, Jingzhou City, Shiyan City, Xiaogan City, Jingmen City, Ezhou City and Enshi Tujia and Miao Autonomous Prefecture, belong to the relatively backward type of university discipline construction;

(3) Good coordination of prefectural administrative regions, including Xiangyang city, Yichang City, Huanggang city, Xianning City and Suizhou City, belongs to the relatively backward discipline construction of colleges and universities. It can be seen that the coupling and coordinated development between the economic development of various administrative regions and the discipline construction of universities in Hubei province roughly forms a gradient coordination hierarchy centered on Wuhan, the provincial capital. In addition, it should be pointed out that the coupling coordination type of Wuhan city is relatively backward in economic development, and the other prefecture-level administrative regions are relatively backward in university discipline construction.

Spatial pattern evolution of coupling coordination relationship

Based on the classification of the level and type of the coupling relationship between the two systems, this paper uses ArcGIS 10.7 software to draw the spatial pattern evolution map of the coupling coordination relationship between the economic development and the discipline construction of colleges and universities in 13 prefecture-level administrative regions of Hubei Province in 2010, 2015 and 2019. The result is shown in Figure 3.

From the analysis of spatial pattern evolution in 2010, 2015 and 2019, it can be seen that the coupling coordination relationship between economic development and university discipline construction of 13 prefecture-level administrative regions in Hubei province has gradually evolved from a three-level pattern of severe imbalance, moderate imbalance and mild imbalance to a bipolar pattern of good coordination and high quality coordination. The coupling coordination level of most prefecture-level administrative regions is relatively backward in the discipline construction of universities. Therefore, to further examine the coupling relationship between economic development and discipline construction in Hubei province, in order to find out the internal reasons that lead to the high coupling of the two systems but the relatively backward discipline construction in colleges and universities, and to provide suggestions for the higher level of coordinated development between the two systems in Hubei Province.

Analysis of relationship test results

In this paper, Eviews10.0 software is used to test the stationarity of the data, and the test results are shown in Tables 9 and 10 below. Where, Δ RJGDP and Δ JFZTR represent first-order difference processing for variables, Δlog (RJGDP) represents first-order difference processing after taking logarithms of variables, and Δ^2 JFZTR represents second-order difference processing for variables.

As can be seen from the test results in Table 9, the ADF test value of economic development variable of Hubei Province is -1.458982, and the critical values of 1%, 5% and 10% are -5.835186, -4.246503 and -3.590496, so RJGDP series are non-stationary series at the significance level of 1%, 5% and 10%. When the logarithm of economic development variable is taken first and then the first-order difference is made, its test value is -4.653664, while the critical values of 1%, 5% and 10% are -4.582648, -3.320969 and -2.801384. Therefore, Δlog (RJGDP) sequences are stable at 1%, 5%, and 10% significance levels.

As can be seen from the test results in Table 10, when the ADF test value of the discipline construction variable of colleges and universities in Hubei province is -1.188458, the critical values of 1%, 5% and 10% are -5.521860, -4.107833 and -3.515047, so JFZTR sequence is non-stationary at the significance level of 1%, 5% and 10%. However, after the second-order difference of the discipline construction variable in universities, its test value is -4.296141, while the critical values of 1%, 5% and 10% are -2.937216, -2.006292 and -1.598068. Therefore, Δ^2 JFZTR sequence is stable at the significance level of 1%, 5% and 10%. In order to further study the relationship between variables, it is necessary to conduct causality test on variables. In this study, Eviews10.0 software and Granger causality test are used to conduct causality test on variables. The results are shown in Table 11.

As can be seen from the test results in Table 11, in the first null hypothesis, its F statistic value is 3.48794 and P value is 0.1110, greater than the significance level of 0.1, indicating the acceptance of the null hypothesis and reflecting that the economic development level of Hubei Province is not the Granger cause affecting the discipline construction of colleges and universities. In the second null hypothesis, its F statistic value is 10.6975 and P value is 0.0170, which is less than the significance level of 0.05, indicating that the null hypothesis is rejected, reflecting that discipline construction of universities in Hubei province is the Granger cause affecting economic development.

It indicates that line A representing "discipline construction in colleges and universities" in the hypothesis model in Figure 1 has A fast upward movement, indicating that there is only A one-way coupling relationship between economic development in Hubei Province and discipline construction in colleges and universities, but there is no bidirectional coupling relationship. At the same time, it also shows that in recent ten years, the discipline construction of colleges and universities in Hubei province has helped to serve the regional economic development, made a great contribution to the economic development of Hubei Province, and played a positive "discipline service force"; However, the development of regional economy failed to meet the needs of discipline construction in colleges and universities, and did not consciously assume the responsibility of discipline construction in colleges and universities, that is, failed to give full play to "economic education".

Table 8. Coupling relationship between the two systems of prefecture-level administrative regions in 2019.

Administrative Region	f (x)	g(y)	Coupling	Coupling Coordination	Determine Type	Coupling leve	Coordination level
Wuhan	0.9768	0.98	1.0000	0.9891	Economic development is	0.9519	0.9519
relatively backward type	Maximum coupling	Quality coordination	0.9519	0.9519	0.9519	0.9519	0.9519
Huangshi	0.962	0.6889	0.9862	0.9023	Discipline Construction Of Universities Is Relatively Backward Type	Maximum Coupling	Quality Coordination
Xiangyang	0.9796	0.6005	0.9708	0.8758	Discipline construction of universities is relatively backward type	Maximum Coupling	Good coordination
Jingzhou	0.9879	0.6839	0.9833	0.9066	Discipline construction of universities is relatively backward type	Maximum Coupling	Quality Coordination
Yichang	0.9327	0.6617	0.9855	0.8863	Discipline construction of universities is relatively backward type	Maximum coupling	Good Coordination
Shiyan	0.9986	0.6775	0.9815	0.9069	Discipline construction of universities is relatively	0.9519	0.9519
backward type	Maximum coupling	Quality coordination	0.9519	0.9519	0.9519	0.9519	0.9519
Xiaogan	1.0000	0.8963	0.9985	0.973	Discipline construction of universities is relatively	0.9519	0.9519
backward type	Maximum coupling	Quality coordination	0.9519	0.9519	0.9519	0.9519	0.9519
Jingmen	1.0000	0.7536	0.9901	0.9317	Discipline construction of universities is relatively	0.9519	0.9519
backward type	Maximum coupling	Quality coordination	0.9519	0.9519	0.9519	0.9519	0.9519
Ezhou	0.9856	0.7603	0.9916	0.9304	Discipline construction of universities is relatively	0.9519	0.9519
backward type	Maximum coupling	Quality coordination	0.9519	0.9519	0.9519	0.9519	0.9519
Huanggang	0.9919	0.624	0.9737	0.887	Discipline Construction Of Universities Is Relatively	0.9519	0.9519
Backward Type	Maximum coupling	Good coordination	0.9519	0.9519	0.9519	0.9519	0.9519
Xianning	0.9888	0.5099	0.9476	0.8426	Discipline construction of universities is relatively	0.9519	0.9519
backward type	Maximum coupling	Good coordination	0.9519	0.9519	0.9519	0.9519	0.9519

Suizhou	0.993	0.5794	0.9648	0.8709	Discipline construction of universities is relatively	0.9519	0.9519
backward type	Maximum coupling	Good coordination	0.9519	0.9519	0.9519	0.9519	0.9519
Enshi	0.9967	0.9177	0.9991	0.978	Discipline construction of universities is relatively	0.9519	0.9519
backward type	Maximum coupling	Quality coordination	0.9519	0.9519	0.9519	0.9519	0.9519
Mean	0.9841	0.718	0.9825	0.9139	Discipline construction of universities is relatively	0.9519	0.9519
backward type	Maximum coupling		0.9519	0.9519	0.9519	0.9519	0.9519
Standard deviation	0.0181	0.1346	0.0145	0.0429	Discipline construction of universities is relatively	0.9519	0.9519
backward type	Maximum coupling		0.9519	0.9519	0.9519	0.9519	0.9519

Table 8. Coupling relationship between the two systems of prefecture-level administrative regions in 2019.

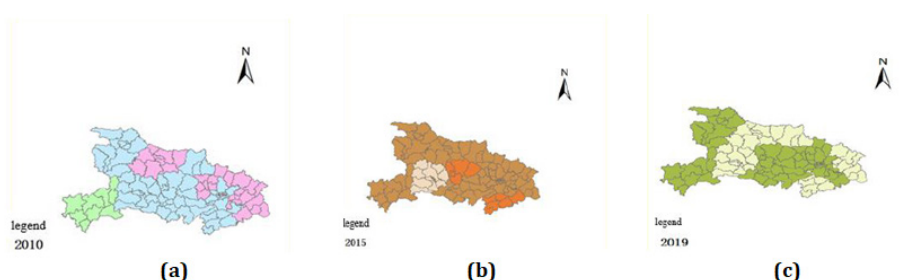**Figure 3.** Spatial pattern evolution of coupling coordination in 2010/2015/2019. Note: (　) Mild disorder;　(　) Serious imbalance;　(　) Modern disorder; (　) Intermediate coordination;　(　) Good coordination;　(　) Primary coordination;　(　) Quality coordination;　(　) Good coordination.

Table 9. ADF test of economic development variables in Hubei Province.

Variable	ADF test	1% critical value	5% critical value	10% critical value	Conclusion
RJGDP	-1.458982	-5.835186	-4.246503	-3.590496	Non-stationary
D RJGDP	-2.467727	-5.835186	-4.246503	-3.590496	Non-stationary
D log(RJGDP)	-4.653664	-4.582648	-3.320969	-2.801384	Stationary

Table 10. ADF test of discipline construction variables of universities in Hubei Province.

Variable	ADF test	1% critical value	5% critical value	10% critical value	Conclusion
JFZTR	-1.188458	-5.52186	-4.107833	-3.515047	Non-stationary
Δ JFZTR	-3.089027	-5.835186	-4.246503	-3.590496	Non-stationary
Δ^2 JFZTR	-4.296141	-2.937216	-2.006292	-1.598068	Stationary

Table 11. Granger causality test of two system variables.

Null hypothesis	n per	F statistic	P values
RJGDP is not the Granger cause of JFZTR	9	3.48794	0.1110
JFZTR is not the Granger cause of RJGDP	9	10.6975	0.0170

Conclusion

1) The coupling and coordination degree between economic development and discipline construction in Hubei province is developing well. Coupling coordination stage from mild maladjustment to high quality coordination, obviously in the gradual change to good. On the whole, the degree of coupling coordination between the two still needs to be constantly improved, which is also an important problem to be solved in the process of economic development and discipline construction in Hubei Province.

2) Most prefecture-level administrative regions are in the stage of low level coordinated development. The coupling coordination degree between the two systems of different administrative regions in Hubei province gradually evolved from a three-level pattern of mild, moderate and severe imbalance to a two-level pattern of high quality and good coordination, forming a differential pattern with Wuhan as the core and radiating to the surrounding areas. Most prefecture-level administrative regions belong to the relatively backward type of university discipline construction. Although the coupling coordination relationship has reached the stage of good coordination and even high-quality coordination, it actually belongs to the low level of coordinated development.

3) Economic development is not enough to support the discipline construction of colleges and universities. However, since 2017, the comprehensive evaluation index of economic development has been higher than the comprehensive evaluation index of university discipline construction, and the gap between the two has widened significantly. In addition, there is a unidirectional coupling relationship between economic development and discipline construction in colleges and universities, that is, discipline construction in colleges and universities has made its due contribution to economic development, but the strength of economic development to discipline construction in colleges and universities is slightly insufficient.

Suggestions

1) The provincial government should plan the coordinated development of the two systems synchronously. The ideal coupling relationship between the two systems should be high-quality coupling coordination. It is suggested that economic development and discipline construction in colleges and universities should be brought into the policy vision of Hubei Provincial government, and economic development and discipline construction should be planned simultaneously when formulating economic development planning scheme to coordinate the coupling relationship between the two.

2) Colleges and universities should actively respond to the call of "double first-class" policy. Most prefecture-level administrative regions in Hubei province are in a relatively backward stage of discipline construction in universities. However, the Hubei Provincial Government has issued the implementation measures for promoting the construction of first-class universities and first-class disciplines in Hubei province, calling on colleges and universities to sprint towards the world-class and domestic first-class two levels based on disciplines. Based on this, local colleges and universities should further promote the discipline construction, actively respond to the call of "double first-class" policy, build a more perfect discipline development system, dare to break the lag of education, and realize the coordinated development of regional economy and discipline construction in colleges and universities.

3) Establish a regular financial support system for discipline construction in colleges and universities. The long-term and effective development of discipline construction in colleges and universities depends on the establishment of the normal financial support system, which requires the long-term and definite guarantee of the object, subject, way, content and supervision of financial support. At present, the regional economic development of Hubei province has not been able to meet the needs of discipline construction in colleges and universities, and has not been able to give full play to "economic education". Therefore, it is necessary to establish a regular financial support system for discipline construction during the COVID-19 pandemic.

Conflict of interest

We have no conflict of interests to disclose and the manuscript has been read and approved by all named authors.

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