

Research on the Relationship between Population Urbanization and Higher Education Development in China

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Abstract: In the paper, firstly, the population urbanization index and the comprehensive development index of higher education in China in the past years were obtained by the population ratio of different residential areas and PCA-AHP method respectively. Then, considering that in the traditional coupling degree model, when the value of the coupling degree is very close to 1, the value of the coupling coordination degree is almost determined by the comprehensive index of each system, and the coupling degree loses its utility. Based on this, the thesis amends the coupling degree model and improves the coupling coordination degree model using game theory ideas. Finally, using the improved model, the development relationship between urbanization and higher education in China from 2010 to 2020 is discussed. The results show that the coordination relationship between urbanization and higher education development in China has risen from the primary level to the intermediate level, and the overall trend is positive, but the coupling relationship between the two has shown a downward trend. Analyzing the reasons for the formation, some development suggestions are given from the perspectives of accelerating the development of population urbanization and strengthening higher education services.

1. Introduction

Urbanization is the only path to modernization, an important way to solve the problems of agriculture, rural areas, and farmers, and a strong support for rural revitalization and regional coordinated development ^[1]. With the gradual advancement of urbanization, its impact on higher education has also surfaced. On the one hand, the advancement of urbanization and the development of technology have gradually made people realize the importance of higher education, providing a continuous stream of human, material, and financial support for higher education, and promoting the development of higher education. On the other hand, the development of higher education has provided strong high-level labor support for the urbanization process, promoting the development of urbanization level. That is to say, in theory, there is a mutually reinforcing relationship between the two, but in reality, is this the case? In 2003, Jian Kun and Gu Peiliang conducted an isomorphic analysis of the education development of cities and the education development of the entire country, inferring that the development of higher education, urbanization, and urban modernization are mutually prerequisite and promoting each other ^[2]. In 2012, Weng Jinghua and Han Yuqi used Person correlation and combined effective indicators to analyze the positive correlation between the urbanization process and the development of higher education in Zhejiang Province ^[3]. In the same year, taking Heilongjiang Province as an example, Lv Ziyang analyzed the development of higher education through the current situation of urbanization development and found that there is a certain degree of positive correlation between the urbanization process and the development of higher education ^[4]. In 2015, Zhang Shuhui and He Juanjuan analyzed data from China from 2005 to 2011 and concluded that the level of urbanization promotes the development of higher education, with a trend of high in the east and low in the west in China ^[5]. In 2019, Zhou Qiliang and Fan Hongzhong based their research on data from 1999 to 2015 and concluded that there is a certain positive correlation between higher education and urbanization, but it is not a simple linear conclusion ^[6]. In

2021, Dong Lingbo took 29 provinces as samples and found that the development of higher education has a positive correlation with the urbanization process, but the overall level is weakening [7].

Although the above conclusions express different details, overall, there is a positive correlation between urbanization and higher education. Chinese Mainland has entered a new era of development. What is the state of this relationship? During the 14th Five Year Plan period in China, this is a practical issue related to how to implement policies related to urbanization and higher education. Based on the macro data of Chinese Mainland from 2010 to 2020, this study will establish an indicator system, and analyze the relationship between urbanization and the development level of higher education by using the improved coupling and coupling coordination model, with a view to contributing a little to promoting the coordinated development between them.

2. Improvement and Application of Coupling Degree and Coupling Coordination Model

2.1 Selection of evaluation indicators and data processing

The level of population urbanization can be characterized by the ratio of urban population to total population [3]. Higher education is a multidimensional concept that cannot be measured solely by a single quantity. In order to characterize the composite system of higher education development level, some literature has been referenced [2-10]. The evaluation indicators for the development of higher education come from three aspects: higher education development, fertility strength, and research level, including: Number of ordinary higher education institutions (institutions) X_1 , number of enrollment of ordinary higher education institutions (10000 people) X_2 , average number of students in higher education institutions per 100000 population (people) X_3 , number of graduates of ordinary higher education institutions (10000 people) X_4 , total number of teaching and administrative staff of ordinary higher education institutions (10000 people) X_5 , education funds of higher education institutions (10000 yuan) X_6 , publication of scientific and technological works by ordinary higher education institutions (types) X_7 , The number of invention patent applications authorized by ordinary higher education institutions X_8 .

According to the index, find the relevant data, eliminate the dimensional influence in the index, and get Table 1. The dimensionality elimination formula is as follows:

$$x_{ij} = \frac{X_{ij}}{\max\{X_j\}}$$

Where x_{ij} refers to the data after dimension elimination, X_{ij} refers to the original data of index j in year i , $i=1 \cdots n$, $j=1 \cdots m$, n refers to the total number of samples, and m refers to the total number of evaluation indicators.

Table 1 Standardized data of various indicators of population urbanization and higher education over the years

<i>Nears</i>	<i>y</i>	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
2010	0.4995	0.8612	0.6841	0.7003	0.7218	0.8090	0.3689	0.8357	0.1548
2011	0.5183	0.8798	0.7044	0.7207	0.7629	0.8240	0.4501	0.8219	0.2149
2012	0.5310	0.8919	0.7120	0.7470	0.7836	0.8427	0.5403	0.8502	0.2953
2013	0.5449	0.9098	0.7233	0.7735	0.8012	0.8614	0.5726	0.8306	0.3076
2014	0.5575	0.9237	0.7457	0.7959	0.8271	0.8764	0.6186	0.8626	0.3384
2015	0.5733	0.9350	0.7626	0.8074	0.8541	0.8876	0.6812	0.9462	0.4717
2016	0.5884	0.9481	0.7738	0.8093	0.8833	0.8989	0.7333	0.9765	0.5695
2017	0.6024	0.9609	0.7871	0.8241	0.9230	0.9139	0.8025	1.0000	0.6709
2018	0.6150	0.9726	0.8176	0.8503	0.9449	0.9326	0.8701	0.9825	0.6840
2019	0.6271	0.9817	0.9457	0.9139	0.9515	0.9625	0.9461	0.9504	0.7922
2020	0.6389	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9425	1.0000

2.2 The comprehensive index calculation of the development level of Higher Education

Before using the coupling degree and coupling coordination degree model to calculate, the comprehensive index of the development level of higher education should be obtained. Considering that the principal component analysis can eliminate the linear correlation between indicators, but the results are too dependent on the data itself and can not reflect the actual significance of the indicators themselves. Therefore, the principal component hierarchical analysis method is adopted here (PCA-AHP) [7-8], that is, a combination of subjective and objective methods to determine the index weight.

Through analysis, The KMO test value of the standardized data matrix is 0.821, greater than 0.6, and the chi square test value in Bartlett sphericity test is 201.356, with the corresponding significance of 0.000, far less than 0.05, which shows that it is necessary to use the principal component analysis method in the calculation of higher education. From the cumulative variance contribution rate, it can be seen that 92.399% of the original information can be extracted by one principal component. So a principal component is extracted here.

Set the weight of each indicator as a_j based on the component matrix, as shown in Table 2. The weights of each indicator calculated by Analytic Hierarchy Process (AHP) are set as b_j , and the comprehensive weight is w_j . The formula relationship is:

$$w_j = \frac{a_j b_j}{\sum_{j=1}^8 a_j b_j}$$

Table 2 Weights of higher education indicators based on PCA-AHP method

indicators	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
a_j (PCA)	0.129	0.122	0.126	0.129	0.130	0.130	0.105	0.129
b_j (AHP)	0.1047	0.1644	0.2437	0.1573	0.1823	0.0359	0.0582	0.0534
w_j	0.1073	0.1593	0.2438	0.1611	0.1882	0.0371	0.0485	0.0547

According to this, the comprehensive index model of the development level of higher education can be obtained as follows:

$$f(x) = 0.107x_{i1} + 0.159x_{i2} + 0.244x_{i3} + 0.161x_{i4} + 0.188x_{i5} + 0.037x_{i6} + 0.049x_{i7} + 0.055x_{i8}$$

The calculation results of the composite index are shown in Figure 1.

2.3 Description and application of improved coupling degree and coupling coordination degree model

The explanation of the concept of ‘coupling’ in physics refers to the phenomenon that two or more systems or motion forms affect each other through various interactions between system elements. The traditional coupling and coupling coordination model of two systems is [11-12]:

$$C = \left\{ \frac{f(x) \times g(y)}{\left[\frac{f(x) + g(y)}{2} \right]^2} \right\}^{\frac{1}{2}} \quad (1)$$

$$D = \sqrt{C \times T} \quad (2)$$

$$T = \alpha f(x) + \beta g(y) \quad (3)$$

Where $f(x)$ represents the comprehensive index of higher education development level, $g(y)$ represents the comprehensive index of population urbanization level, C represents the coupling degree, $0 \leq C \leq 1$, D is the coupling co scheduling between systems, α and β are undetermined coefficients, and T is the composite index of the two systems.

According to formula (1), the value of coupling degree between urbanization and higher education is mainly between $[0.97, 0.99]$. If we continue to use formula (2), D will be mainly determined by T , that is, the coupling coordination degree is mainly determined by the development degree of the system itself, and is almost independent of the coupling degree between systems, which greatly reduces the validity of coupling degree^[12]. Based on this, the treatment method of reference^[12] is quoted here, that is, the model (1) is modified as follows:

$$C = \sqrt{\left[1 - \sqrt{(g(y) - f(x))^2}\right]} \times \frac{f(x)}{g(x)} \quad (4)$$

This model makes the coupling degree distributed between $[0, 1]$ as much as possible, thus increasing the degree of dispersion of C .

As the value of α and β , the idea of game theory is used to assign the value. The basic idea of the Game theory aggregation model is to find consistency or compromise between different weights, that is, to minimize the deviation between the possible weights and the original weights^[13]. The discussion here is about the consistent and coordinated development level between population urbanization and higher education development. It is reasonable to use this method to obtain weights.. Consider $f(x)$ and $g(y)$ as both parties in a mutual game, and T as the result of reaching a balance between the two parties in the game, that is, the sum of deviations between $f(x)$ and $g(y)$ is minimized. The model is:

$$\begin{aligned} & \min \left(\|T - f(x)\|_2 + \|T - g(y)\|_2 \right) \\ & = \min \left(\|\alpha f(x) + \beta g(y) - f(x)\|_2 + \|\alpha f(x) + \beta g(y) - g(y)\|_2 \right) \\ & \text{s.t. } \alpha + \beta = 1, \alpha, \beta \geq 0 \end{aligned}$$

According to the differential principle, the first-order differential condition for the above model to obtain the optimal value is:

$$\begin{cases} \alpha f^T(x)f(x) + \beta f^T(x)g(y) = f^T(x)f(x) \\ \alpha g^T(y)f(x) + \beta g^T(y)g(y) = g^T(y)g(y) \end{cases}$$

Bring the data into the above equation to get

$$\begin{cases} 3.6253\alpha + 5.2475\beta = 3.6253 \\ 5.2475\alpha + 7.6037\beta = 7.6037 \end{cases}$$

Under the condition of $\alpha + \beta = 1$, the approximate solution obtained by the least square method is:

$$\begin{cases} \alpha^* = 0.3216 \\ \beta^* = 0.6784 \end{cases}$$

Bring it into equation (3) to obtain the specific value of coupling coordination degree. Refer to the criteria for coupling degree and coupling coordination degree^[13], the specific results are shown in Table 3, and the broken line diagram is shown in Figure 2.

Table 3 Coupling degree, coupling coordination degree value and grade between population urbanization and higher education

year	Coupling degree	grade	coupling coordination degree	grade
2010	0.7519	intermediate	0.6925	primary
2011	0.7495	intermediate	0.7038	intermediate
2012	0.7402	intermediate	0.7105	intermediate
2013	0.7396	intermediate	0.7186	intermediate
2014	0.7327	intermediate	0.7251	intermediate
2015	0.7255	intermediate	0.7331	intermediate
2016	0.7245	intermediate	0.7414	intermediate
2017	0.7166	intermediate	0.7479	intermediate
2018	0.7105	intermediate	0.7537	intermediate
2019	0.6790	primary	0.7542	intermediate
2020	0.6412	primary	0.7520	intermediate

2.4 Result analysis and suggestions

According to the above data, the line chart is drawn as follows:

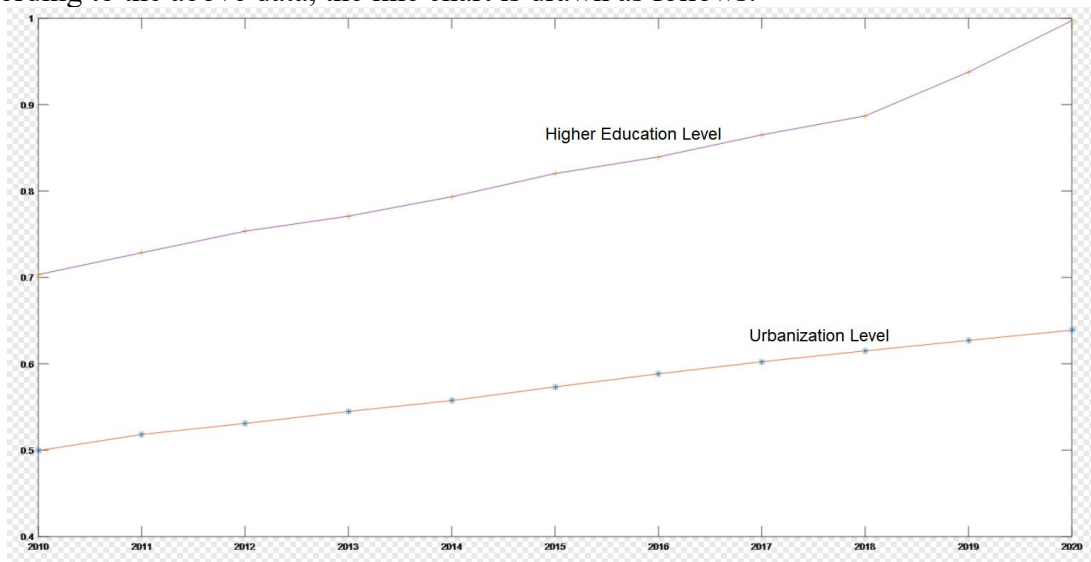


Figure 1. The line chart of comprehensive index of two systems

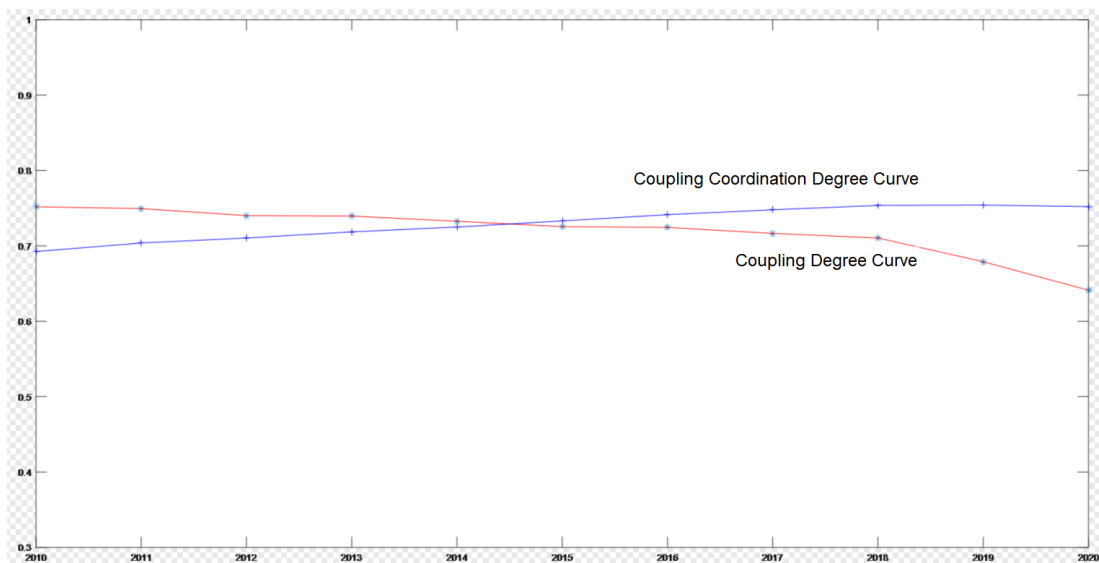


Figure 2 Line chart of coupling degree and coupling coordination degree

From the development of the composite index of the two systems, with the passage of time, the level of population urbanization and the development level of higher education in China have shown a gradual upward trend. Among them, the development level of higher education has increased faster from 0.7 to 0.99, with an average growth rate of 4.0%. The level of population urbanization increased from 0.50 to 0.63, with an average growth rate of 2.8. It shows The level of higher education and urbanization has rapidly improved.

From the change of coupling degree and coupling coordination degree, the coupling degree between the two decreased from 0.75 to 0.64, which belongs to the correlation between intermediate and primary levels. However, the level of coupling coordination between the two has developed from primary coordination to intermediate coordination, and the overall trend is gradually improving. This indicates that the mutual influence between population urbanization and higher education in China has decreased over time, but their mutual promotion has increased. That is to say, a large part of the relationship is mutual inhibition. In the original coupling relationship, this inhibitory relationship began to weaken, and the mutual promotion relationship between them began to strengthen with the coordinated development of various industries in society. This is a very positive development state.

According to China's current development characteristics and some literatures, the author believes that in order to maintain the good development trend of China's population urbanization and higher education, efforts can be made in the following two aspects:

First, continue to improve the value of population urbanization. China is a traditional large agricultural country with a large rural population. Although in recent years, with the economic development and the progress of agricultural science and technology, a lot of agricultural labor productivity has been liberated, a large number of labor force has poured into the city, and the number of urban population has been increased, there is still a long way to go compared with the urbanization level of more than 80% of the developing countries. It can be improved in the following aspects: (1) strengthen urban planning and construction: improve the quality and efficiency of urban construction through scientific planning and rational layout, create a livable and business friendly urban environment, and attract more people into the city. (2) Strengthen modern infrastructure: increase investment in infrastructure construction, including roads, transportation, energy, water and other fields, to provide efficient and convenient public services, enrich and meet the living needs of urban residents. (3) Further improve the speed of urban economic development: by optimizing the industrial structure, promoting innovation and entrepreneurship, attracting foreign investment and other measures, enhance the competitiveness and vitality of the urban economy, provide more choices for employment opportunities, and further attract population into the city. (4) Further improve the social security system: strengthen the construction of the social security system, provide comprehensive social welfare security, including medical treatment, education, housing, etc., improve the quality of life and sense of security of residents, and increase the attractiveness of the city. (5) Further improve the development of rural economy and science and technology, so that the agriculture, forestry, animal husbandry, sideline, fishery and other industries in rural areas can achieve a high degree of industrialization, science and technology, low-carbon green, and increase the competitiveness of these industries, but also can liberate more labor force and accelerate the development of urbanization.

Second, strengthen the social service function of higher education. Higher education represents the scientific and technological level of a country or region. In order to make the coordinated development of higher education and urbanization, we must give full play to the ability of higher education to serve the society, which can be improved in the following aspects: (1) improve the assumption of vocational colleges. With the development of society, there is an increasing demand for craftsman talents. At present, most of China's secondary vocational colleges can't meet the needs of the society for relevant talents. Therefore, the state can rectify and improve these colleges and universities to make them enter the ranks of higher vocational colleges, or transform some colleges and universities with strong application into higher vocational colleges to meet the needs of the society for these talents, Better serve social development, and then help promote the process of urbanization. (2) Strengthen exchanges and cooperation between different types of universities and

disciplines in the same university. Colleges and universities can encourage cooperation in different disciplines, carry out interdisciplinary research projects, education and training, set up interdisciplinary laboratories, employ teachers from different disciplines to give lectures, etc. to carry out interdisciplinary cooperation, promote the innovation, intersection and transformation of scientific research achievements, and expand the transformation fields and application scope of scientific research achievements, so as to enhance social scientific and technological strength and promote the process of urbanization

3. Summary

The coupling degree and coupling coordination degree model are common models to judge the mutual development relationship between systems, but when the coupling degree is above 0.9, its utility will be reduced in the calculation of coupling coordination. In view of this, this paper improves the traditional coupling degree and coupling coordination degree, and obtains that the coupling degree and coupling coordination degree between China's population urbanization and the development of higher education are about 0.7, which is similar to China's situation in a developing country, All walks of life are still improving and consistent with the current situation of development, which is a more acceptable result with high credibility. In order to maintain this good momentum of development, this paper puts forward some suggestions in the two directions of improving the level of population urbanization and accelerating the development of higher education, hoping to provide a theoretical reference for the overall progress of Chinese society.

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