An Empirical Study on the Conjugate Relationship Between Industrial Economy and Vocational Education

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Abstract

On the basis of summarizing the existing literature, this paper analyzes the relationship between industrial economy and the development of vocational education from the perspective of "conjugate", and establishes the conjugate model of industrial economy and vocational education. Based on the conjugate theory, this paper show that the conjugation between vocational education and industrial economy is generally good, but structurally speaking, its conjugation state is not enough. Finally put forward policy suggestions.

Keywords: Industrial economy, vocational education, Conjugate relation, empirical study, policy suggestion

I. Introduction

Action plan for improving the quality of Vocational Education (2020-2023) points out that we should adhere to the strategic positioning of different types and equal importance of vocational education and general education, greatly improve the modernization level and service capacity of Vocational Education in the new era, and provide multi-level and high-quality technical and skilled talents support for promoting the sustainable economic and social development and improving the national competitiveness. Vocational education is the most closely related part of education with economic development and industrial transformation. It is the main channel to cultivate innovative technical and skilled talents. On the one hand, traditional industries are facing transformation and upgrading, as well as the implementation of "made in China 2025" and "Internet plus", new types of jobs and new positions are constantly emerging, resulting in sharp increase of skilled and technical talents. The purpose of vocational education is to train various types of technical personnel to provide strong intellectual support for the development of industrial economy. Therefore, promoting industrial upgrading through vocational education, promoting the dialogue between vocational education and industry, and promoting the organic connection of education chain, talent chain and industrial chain are the main melody of deepening the integration of vocational education and industry. On the other hand, the development of industrial economy determines the demand and supply of vocational education, which provides necessary material guarantee and financial support for vocational education and promotes the development of vocational education. It can be said that the relationship between vocational education and industrial economy is one of the key factors affecting regional decision-making and long-term development.

Industrial economy takes industry as the research object, mainly including industrial structure, industrial layout, industrial organization, industrial development and industrial policy. Industrial economy is a meso-economy between macro-economy and micro-economy, and it is the link between macro-economy and micro-economy. Vocational education refers to the education that enables the educated to obtain the professional knowledge, skills and professional ethics required by a certain occupation or productive labor. The vocational education in this study mainly refers to vocational school education, and the main research objects are secondary and higher vocational school education, excluding technical schools. The research on the coordinated development of industrial economy and vocational education has always been concerned by the academic circles, and the relevant research results are relatively fruitful. In terms of theoretical research, including the modern human capital theory established by Schultz

and Becker [1] and the endogenous growth theory represented by Romer and Lucas [2], the in-depth research on this problem is limited due to different research perspectives and changes in environmental conditions. In terms of empirical analysis, Tam Bang Vu [3], based on the worldwide data from 1998 to 2008, proposed that vocational education has a greater impact on economic growth than university education, and the reaction of economic growth to vocational education is also stronger than university education. Zhang Jia [4] calculated the contribution rate of higher vocational education to regional economic development in China, provinces and cities from 2001 to 2012. The conclusion is that the contribution rate of national higher vocational education to regional economy is greater than that of ordinary undergraduate education, and the contribution of higher vocational education to economic growth in the Eastern and central regions is greater than that in the western region. Wang Wei et al. [5] studied the coordination between secondary vocational education and industrial structure from the perspective of teachers and students through the indicators of coincidence and deviation, and believed that there was still obvious disharmony between secondary vocational education and industrial structure. Li Defang et al.[6], Deng Zuoming [7], Li Wen [8] and Liang Dan [9] respectively used empirical methods to study the coincidence between professional structure and industrial structure of Vocational Education in C City, Zhuhai, Beijing, Liaoning and other provinces, and put forward corresponding policy suggestions. Gao Yaoming [10] believes that economic development promotes the expansion of the scale of vocational education, the adjustment of professional structure and the promotion of hierarchical structure. Luo Zhe et al.[11][12] successively analyzed the relationship between industrial economy and vocational education in Chengdu-Chongqing Economic Zone from the perspective of balance and supply and demand, and believed that vocational education plays an increasingly important role in promoting regional development. However, the current development of Vocational Education in Chengdu-Chongqing Economic Zone can not meet the needs of industrial economic development.The contradiction between talent transportation, structural level, resource integration, specialty setting and planning implementation is prominent.

Generally speaking, the existing research covers the overall situation at the international, national and regional levels, selects some cases for analysis, and makes full use of the combination of qualitative and quantitative methods. The research content involves the relationship between the scale of vocational education and industrial economic development, and the relationship between vocational education structure and industrial structure, the research conclusion also has important reference value. In the existing research, it mainly involves the relationship between vocational education and economic growth in developed areas, while there are few studies involving Chengdu and Chongqing. The latest research has been seven years ago. In addition, the existing literature mostly adopts econometric analysis methods such as correlation analysis and regression analysis, which inevitably leads to the lack of factual and logical rationality and scientificity of the research itself. In recent years, many scholars such as Guo Li [13], Liu Lin [14] and Tu Baojun [15] have expounded the application of conjugate theory in philosophy and Social Sciences, especially in the field of educational economics, discussed the internal laws between the two interrelated from a new perspective of conjugate, constructed a conjugate model, conducted empirical research, and obtained rich research results. Based on this, under the background of Chengdu-Chongqing twin city economic circle as a new national strategy in 2020, how to realize the conjugate development of industrial economy and vocational education in the twin city economic circle is worthy of in-depth research.

II. Model Construction

2.1 Conjugate meaning

Conjugation is a phenomenon widely existing in the universe. As an important basic concept in the field of natural science, it involves many disciplines such as chemistry, physics and mathematics. It is mainly used to represent the attribute characteristics of balance, stability and symmetry."Conjugation" provides a new perspective, which not only has some characteristics of "coordination", "coupling", "equilibrium" and other perspectives, but also has its unique special properties."Conjugate" emphasizes the symmetry between paired elements, the directional consistency acting on the system, and the stability of the whole system. Today, conjugate theory has broken through the field of natural science, gradually evolved into a methodology with unique vision and rigorous logic to describe

the relationship between things or phenomena, and gradually has been more and more used in the field of philosophy and social sciences. The so-called conjugate relationship refers to the relationship between two things that go hand in hand, stick to each other and interact with each other.

2.2 Conjugate model construction

Based on the practices of Liu Lin (2014) and Tu Baojun (2019), this paper constructs a conjugate model of vocational education and economic development. Taking the focus of vocational education and economic development as the conjugate point, the quasi Mahalanobis distance and Mahalanobis distance of vocational education and economy in different regions are measured and compared to judge whether the vocational education and economic development in each region are conjugate. The conjugate model is constructed as follows:

Suppose that X and y are the development level of vocational education and economic development respectively, and a and B are the two regions studied. There are n periods of observation data for the development of vocational education and economic development, marked as X_{ij} and Y_{ij}.

$$X_{ij} = (X_{i,1}, \quad X_{i,2}, ..., \quad X_{i,n})^T \quad (1)$$
$$Y_{ij} = (Y_{i,1}, \quad Y_{i,2}, ..., \quad Y_{i,n}) \quad (2)$$

Where i = 1,2, 1 represents region a and 2 represents region B. j represents the development level in period j, j = 1,2,..., n.

The general focus of vocational education and economic development is:

$$\mu_1 = \frac{\sum_{j=1}^{n} X_{1,j} + \sum_{j=1}^{n} X_{2,j}}{2n} \quad (3)$$

$$\mu_2 = \frac{\sum_{j=1}^{n} Y_{1,j} + \sum_{j=1}^{n} Y_{2,j}}{2n} \quad (4)$$

The overall variance of vocational education and economic development is:

$$\sigma_1^2 = \frac{\sum_{j=1}^{n} (X_{1,j} - \mu_1)^2 + \sum_{j=1}^{n} (X_{2,j} - \mu_1)^2}{2n} \quad (5)$$

$$\sigma_2^2 = \frac{\sum_{j=1}^{n} (Y_{1,j} - \mu_2)^2 + \sum_{j=1}^{n} (Y_{2,j} - \mu_2)^2}{2n} \quad (6)$$

The Mahalanobis distance between vocational education, economic development and conjugate point is:

$$d^2(X_{i,j}, \quad \mu_1) = \frac{(X_{i,j} - \mu_1)^2}{\sigma_1^2} \quad (7)$$

$$d^2(Y_{i,j}, \quad \mu_2) = \frac{(Y_{i,j} - \mu_2)^2}{\sigma_2^2} \quad (8)$$

The quasi Mahalanobis distances of vocational education, economic development and conjugate point are respectively:

$$d\ (X_{i,j},\ \mu_1) = \frac{X_{i,j} - \mu_1}{\sigma_1} \qquad (9)$$

$$d(Y_{i,j},\ \mu_2) = \frac{Y_{i,j} - \mu_2}{\sigma_2} \qquad (10)$$

Then the conjugate discrimination model between vocational education and economic development level is as follows (see Table 1)

Table 1 conjugate discriminant model between vocational education and economic development level

	vocational education	economic development	The quasi Mahalanobis distances and Mahalanobis distances between the development of vocational education and conjugate point	The quasi Mahalanobis distances and Mahalanobis distances between the economic development and conjugate point	Criterion
Area A	μ11	μ12	d(μ11,μ1), d2(μ11,μ1)	d(μ12,μ2), d2(μ12,μ2)	If the quasi Mahalanobis distance of the region is both positive (negative), the region tends to the conjugate state in the positive (negative) direction, otherwise it deviates from the conjugate state; The smaller the Mahalanobis distance gap, the more the system tends to conjugate state
Area B	μ21	μ22	d(μ21,μ1), d2(μ21,μ1)	d(μ22,μ2), d2(μ22,μ2)	
Overall center of gravity and standard deviation	μ1,σ1	μ2,σ2			

$$\mu_{11} = \frac{\sum_{j=1}^{n} X_{1,j}}{n} \qquad (11)$$

$$\mu_{12} = \frac{\sum_{j=1}^{n} Y_{1,j}}{n} \qquad (12)$$

$$\mu_{21} = \frac{\sum_{j=1}^{n} X_{2,j}}{n} \qquad (13)$$

$$\mu_{22} = \frac{\sum_{j=1}^{n} Y_{2,j}}{n}$$

(14)

Where μ_{11} and μ_{12} represents the focus of area A and area B on vocational education respectively,Where μ_{21} and μ_{22} represents the focus of area A and area B on economic development respectively.

III. Empirical Results and Analysis

3.1 Whole conjugate analysis

In order to empirically study the conjugate relationship between vocational education and economic development, this paper first takes Sichuan Province and Chongqing as the research object, and selects the relevant data from 2010 to 2019 for overall analysis. In order to simplify the calculation, the development of vocational education is measured by the number of students in the region every year, and the economic growth is measured by the regional GDP (gross domestic product). The number of students in school includes the number of students in Higher Vocational Education (junior college) and secondary vocational education.The data comes from Chongqing statistical yearbook, Sichuan statistical yearbook and the statistical data of the competent department of education.Considering the large difference between the number of students in school and GDP, in order to prevent the actual effect of the model from being affected by the large value, the number of students in school and GDP are corrected and processed, that is, the number of students in school and GDP are processed by taking the natural logarithm.According to the constructed conjugate model, the corrected data are calculated, and the operation results are shown in Table 2

Table 2 Analysis results of conjugate state between the number of students in Sichuan and Chongqing Vocational Education and GDP from 2010 to 2019

	vocational education	economic development	The quasi Mahalanobis distances and Mahalanobis distances between the development of vocational education and conjugate point	The quasi Mahalanobis distances and Mahalanobis distances between the economic development and conjugate point
Sichuan	5.0840	10.2931	0.9689,0.9387	0.7189,0.5168
Chongqing	4.1021	9.6084	-0.9689,0.9387	-0.7189,0.5168
Overall center of gravity and standard deviation	4.5931, 0.5067	9.9507, 0.4762		

On the whole, the Mahalanobis distance between vocational education development, economic development and conjugate point in Sichuan Province is positive, and the Mahalanobis distance gap is small, indicating that vocational education and economic development in Sichuan Province tend to be conjugate; the negative trend of vocational education and economic development in Chongqing is conjugate.

3.2 Structural conjugate analysis

In order to better analyze the conjugate relationship between vocational education and industrial economy in Chengdu Chongqing economic circle, this paper also selects the branch data of Vocational Education in Sichuan and Chongqing and the data of three industries for discussion. Due to the lack of branch data of Higher Vocational Education in Sichuan Province, this paper makes an empirical analysis based on the branch data of secondary vocational education in two provinces and cities.

According to the research purpose of this paper, the main index system of national economic accounting is selected in the measurement index of industrial economic development level, which are the GDP of the primary industry, the GDP of the secondary industry and the GDP of the tertiary industry. On the demand index of vocational education, the number of students corresponding to secondary vocational talents in the three industries is selected as the research variable. Specifically, according to the corresponding relationship between the major categories of secondary vocational schools and industrial categories, agriculture, forestry, animal husbandry and fishery should be corresponding to the primary industry; Resources and environment, energy and new energy, civil engineering and water conservancy, processing and manufacturing, petrochemical industry and light textile Food correspond to the secondary industry; Transportation, information technology, medicine and health, leisure and health care, finance and trade, tourism services, culture and art, sports, education, social and public utilities and other corresponding tertiary industries. The statistical data are from Chongqing statistical yearbook, Sichuan statistical yearbook and the statistical data of the competent department of education. Markov distance and quasi Markov distance are used for conjugate analysis. According to the constructed conjugate model, the operation results are shown in Table 3.

Table 3 Analysis results of the conjugate state of the number of students in Sichuan and Chongqing Vocational Education and the GDP of the three industries from 2010 to 2019

	vocational education	economic development	The quasi Mahalanobis distances and Mahalanobis distances between the development of vocational education and conjugate point	The quasi Mahalanobis distances and Mahalanobis distances between the economic development and conjugate point
First industry in Sichuan	10.7939	8.1748	-0.6076,0.3691	-0.4832,0.2334
Secondary industry in Sichuan	12.3205	9.4483	0.5381,0.2896	0.8917,0.7951
Tertiary industry in Sichuan	13.5166	9.4821	1.4358,2.0615	0.9281,0.8614
First industry in Chongqing	9.5468	6.9500	-1.5435,2.3823	-1.8055,3.2597
Secondary industry in Chongqing	11.1907	8.7836	-0.3097,0.0959	0.1741,0.0303
Tertiary industry in Chongqing	12.2521	8.8953	0.4868,0.2370	0.2947,0.0869
Overall	11.6034,	8.6224,		

center of gravity and standard deviation	1.3324	0.9263		

The negative trend of vocational education and economic development in the primary industry of Sichuan Province is conjugate; the secondary industry, the tertiary industry, vocational education and economic development are all in a conjugate state. The negative trend of vocational education and economic development in Chongqing's primary industry is conjugate; the tertiary industry tends to be conjugate; however, the quasi Mahalanobis distance of secondary industry vocational education is negative, while its economic quasi Mahalanobis distance is positive, indicating that the secondary industry vocational education and industrial economic development in Chongqing deviate from the conjugate state.

IV. Conclusions and Policy Implications

Based on the data of Sichuan and Chongqing from 2010 to 2019, this paper calculates the quasi Mahalanobis distance and Mahalanobis distance between vocational education, industrial economy and the center of gravity from the perspective of constructing a conjugate model, reveals the conjugate relationship between industrial economy and vocational education, and draws the following main conclusions: first, on the whole, the development of vocational education and economy in Sichuan Province tends to be conjugate; The negative trend of vocational education and economic development in Chongqing is conjugate. Second, from the perspective of structure, vocational education and economic development of the primary industry in Sichuan Province and Chongqing Municipality tend to be conjugate in a negative direction; Vocational education and economic development of the secondary and tertiary industries in Sichuan Province and the tertiary industry in Chongqing Municipality tend to be conjugate; However, Chongqing's secondary industry vocational education and industrial economic development deviate from the conjugate state. The reasons for the deviation between the secondary industry and industrial economic development in Chongqing may be as follows: First, industrial transformation or upgrading, and the students' knowledge does not match the industrial development, such as the knowledge they have learned is old or the knowledge they have learned cannot be well converted and implemented. Second, national or local governments have issued corresponding laws and regulations, so that some industries have more restrictions in a short period of time, which can not reflect the real situation of their development, such as the relevant requirements of environment and new energy. Third, the development stage of the industry Part of the secondary industry is in the late stage of industry maturity or recession. The more vocational education students there are, the more serious the vocational involution is. There is a state of oversupply of talents in the industry, which does not necessarily promote the development of industrial economy. Sichuan did not have this situation, probably because its industrial layout is more reasonable; the number of students enrolled in Vocational Education matches the development of the industry; better government policy support and services; the cooperation between schools and enterprises is more in-depth, so that students' knowledge and industrial development match each other.

Based on the research conclusions, the following policy implications are drawn:

First, accelerate coordinated development and build a sharing mechanism for Vocational Education in two cities. The new mechanism and model of vocational education development, which meet the needs of economic and social development in Chengdu and Chongqing and meet the requirements of educational modernization in both places, will provide strong technical and skilled talent support for the upgrading of industries, the acceleration of economic shift and the improvement of people's livelihood in Chengdu-Chongqing twin city economic circle. In September 2020, the Alliance for coordinated development of Vocational Education in Chengdu Chongqing dual city economic circle jointly launched by Sichuan and Chongqing was established. In order to promote the integration of industry and education, school enterprise cooperation, strengthen skill innovation services, and jointly cultivate compound technical and skilled talents, Chengdu and Chongqing government, vocational colleges and enterprises have jointly

established a large number of financial vocational education alliances, including Chengdu-Chongqing twin city economic circle, Chengdu-Chongqing twin city economic circle business circulation vocational education group Alliances or communities such as the collaborative development alliance of chemical industry and education in Chengdu-Chongqing twin city economic circle, the development alliance of preschool education of Vocational Colleges in Chengdu-Chongqing twin city economic circle, and the Vocational Education Alliance in the middle (regional) of Chengdu-Chongqing twin city economic circle. These measures show that the governments, enterprises and colleges of Sichuan and Chongqing are trying to accelerate the coordinated development of vocational education in Chengdu-Chongqing economic circle. However, to realize the talent training sharing mechanism of comprehensive market sharing, inter school sharing and school enterprise sharing, we still need the joint efforts of many parties.

Second, strengthen professional construction and enhance the service capacity of vocational education in twin city. Under the leadership of provincial and municipal departments and industry associations in Sichuan and Chongqing, a professional construction Steering Committee is established according to the classification of professional categories to coordinate the professional setting and construction of vocational education, regularly publish professional setting guidelines, guide colleges and universities to add majors urgently needed by the society according to the needs of economic and social development, and shut down majors with poor market prospects and low employment rate for many years, Gradually form a professional dynamic adjustment mechanism of vocational education, and enhance the scientificity and flexibility of professional adjustment. Guide vocational colleges to expand the enrollment scale of vocational education at all levels and enhance the social service capacity of vocational education in professional fields urgently needed by the people, such as preschool education, nursing, elderly care services and health services. At the same time, actively adapt to the development strategy of twin city economic circle in Chengdu and Chongqing, meet the talent needs of "twin city", adjust and optimize the professional talent training structure, cultivate and build the main and characteristic majors with high matching degree with the economic structure adjustment and industrial upgrading in twin city area, form a characteristic professional group, and improve the supply capacity of intelligent technical talents.

Third, improve the structural system and enhance the supporting capacity of vocational education in twin city. Actively undertake the important task of national vocational education reform, run well the existing application-oriented undergraduate universities in the two places, and strive to enable a number of higher vocational colleges or majors with good school running foundation and high talent training quality to participate in the "undergraduate level vocational education pilot" work of the Ministry of education. According to the establish system of the institution of higher learning, explore the inclusion of qualified technician colleges into the sequence of Institution of higher learning. Promote the transformation of qualified ordinary undergraduate colleges and universities to application-oriented or set up applied technology majors or courses; develop a professional degree postgraduate training model which is guided by professional needs, focuses on the cultivation of practical ability and the combination of industry, university, research and application; overall implementation of pilot work such as "3 + 3" for secondary and higher vocational education, "3 + 4" for secondary vocational and applied undergraduate education, and "3 + 2" for specialized and undergraduate education; Take the initiative to undertake the relevant tasks of the national higher vocational enrollment expansion policy of 1 million, expand the talent training scale of vocational education, and adjust and optimize the general vocational structure. Gradually integrate vocational education and all kinds of training, constantly enrich the connotation of vocational education level system, and broaden the ways of training technical talents; we will strengthen the construction of credit banks, accelerate the improvement of the recognition, accumulation and transformation of learning achievements, and build a talent training overpass to provide strong talent support and intellectual support for the economic and social development of the "two cities".

References

[1] T.W. Schultz, "Investment in Human Capital," Journal of The American Economic Review, vol. 51, no. 1, pp. 1-17, 1961.

[2] P.M. Romer, "The Origins of Endogenous Growth," Journal of Economic Perspectives, vol. 8, no. 1, pp. 3-22, 1994.

[3] T.B. Vu, D.L. Hammes, E.I. Im, "Vocational or University Education? A New Look at Their Effects on Economic Growth," Journal of Economics Letters, vol. 117, no. 2, pp. 426-428, 2012.

[4] J. Zhang, "Empirical analysis on the contribution of higher vocational education to regional economic development," Journal of Vocational and technical education, vol. 10, pp. 45-50, 2014.

[5] W. Wang, X.B. Chen, "Research on the adaptability of vocational education and industrial structure adjustment in China -- from the perspective of teachers and students," Journal of vocational and technical education, vol. 25, pp. 28-33, 2016.

[6] D.F. Li, H.F. Xu, et al., "An empirical study on the coincidence between professional structure and industrial structure of Vocational Education," Journal of Vocational Education Forum, vol. 30, pp. 4-8, 2010.

[7] Z.M. Deng, "Study on the consistency between the professional structure of Zhuhai vocational education and the adjustment of industrial structure," Journal of Vocational and technical education, vol. 2, pp. 17-20, 2013.

[8] W. Li, "Research on the coordinated development of specialty structure and industrial structure in Beijing Higher Vocational Colleges," Journal of Education and occupation, vol. 6, pp. 16-18, 2013.

[9] D. Liang, "Study on the coordination between professional structure and industrial structure of Vocational Education in Liaoning Province," dissertation of Shenyang Normal University, 2016.

[10] Y.M. Gao, "Research on the relationship between vocational education and economic development -- a case study of Jiaxing City, Zhejiang Province," Journal of Higher education research, vol. 3, pp. 89-93, 2000.

[11] Z. Luo, C.L. Wan, W.W. Liu, "Analysis on the balanced development of industrial economy and vocational education in Chengdu Chongqing Economic Zone," Journal of Vocational Education Forum, vol. 6, pp.20-22, 2014.

[12] Z. Luo, C.F. Wen, H.J. Wu, "Research on the contradiction between supply and demand of industrial economy and vocational education in Chengdu Chongqing Economic Zone," Journal of China Vocational and technical education, vol. 9, pp. 60-63, 2014.

[13] L. Guo, "Study on the conjugate mechanism of academic power and administrative power in Contemporary Chinese universities," dissertation of China University of mining and technology, 2013.

[14] L. Liu, "Study on the conjugate drive of higher education and talent agglomeration on regional economic growth," dissertation of China University of mining and technology, 2014.

[15] B.J. Tu, L. Guo, S.Q. Ding, Z.L. Yang, "Conjugate relationship between vocational education and urban development in Huaihai Economic Zone," Journal of Vocational and technical education, vol. 33, pp. 33-37, 2019.