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Analysis of the Grey Correlation Between Higher Education and Economic Development

-- Take Guangxi as An Example

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Abstract: Regional higher education and economic development are inseparable, so it is of great significance to study the correlation degree between higher education and economic development. This paper integrates the relevant evaluation indexes, and uses the grey correlation analysis method to explore the degree of mutual influence between higher education and economic development in Guangxi. The results show that the gross product of primary industry, per capita disposable income of urban residents and urbanization rate are the key factors affecting the level of higher education; the Di-Clark theorem is not applicable to the industrialization development of Guangxi; the increase of institutions and full-time teachers and the investment of education funds are the main driving force for higher education to promote economic development. Finally, to provide policy suggestions for the high-quality development of higher education and economy in Guangxi.

Keywords: Higher Education, Economic Development, Grey Association Analysis, Guangxi.

1. Foreword

At the party's 20th Congress, Xi Jinping pointed out that education, science and technology, and talents are the basic and strategic support for building a modern socialist country in an all-round way [1]. As an important part of China's educational structure, higher education has trained many high-level knowledge-based, skilled and innovative talents for the socialist modernization construction. Higher education is an important means to realize the central task of the party, in the period of socialist revolution and construction, the establishment of the socialist higher education system has played an indelible role in the development of new China and the construction of the socialist system with Chinese characteristics [2]. Economic construction is the center of Chinese-style modernization, and higher education can promote economic development. Higher education affects the speed of economic growth through the accumulation of high-quality human capital and the improvement of social scientific and technological innovation ability. Therefore, it is still important to study the interactive relationship between higher education and economic development.

In recent years, many scholars have conducted a series of studies on the relevant relationship between higher education and economic development from different perspectives and viewpoints. Zhao Qingnian through threshold regression model test in 2005-2019 our country provincial local higher education scale, hierarchical structure, type structure and quality elements to promote the synergistic effect of local economic growth, found at the national level, higher education hierarchical structure, type structure and quality elements can promote scale elements achieve greater economic growth. At the same time, the scale expansion has a positive effect on the hierarchical structure and quality factors to better promote economic growth [3].Guo Liqiang measured the coordination model between the higher education system and the economic development level of 31 provinces in 2005 and 2015, and found that 2015 compared with 2005 China's higher education system, economic development level and the coordination and coupling relationship between the two has a certain improvement,the uneven distribution of higher education resources has been improved, but the national average coordination coupling degree value is still low, and the coordination relationship between higher education and economic development needs to be improved by [4]. Some scholars have also applied the grey correlation model to study the relationship between regional higher education and economic development, For example, Li Shuzhen used education funds, the number of students in colleges and universities, GDP and the development of the three major industries, study the relationship between higher education and economic development in Guangdong Province from 1999 to 2010 [5]; Hu Huoqun uses the use of GDP, the proportion of general public budget of students in the general public budget, the number of college students of ordinary institutions and the number of patents authorized by colleges and universities, study on the grey correlation between higher education and economic development in Anhui Province from 2008 to 2015 [6]; Chen Xia used grey correlation analysis to calculate the correlation coefficient[7] between primary education, secondary education, higher education and economic development indicators in Xinjiang from 2004 to 2013. Throughout the existing studies, it can be found that the selected evaluation indicators of higher education or economic development are too scattered, and the description of the evaluation system of higher education and economic development is not comprehensive enough, which may lead to the lack of scientific and certain accuracy of the research results. This paper integrated and perfect the higher education and economic development of primary indicators and secondary indicators, in the selection of indicators have certain innovation, using the grey correlation analysis, in Guangxi as the research object to discuss how higher education and economic development and mutual influence,

to promote the coordinated development of higher education and economy to provide reference.

2. The Selection of Indicators

The 18 evaluation indicators of higher education and economic development selected in this paper are shown in Table 1. Higher education level is measured by both scale and quality. In the scale of higher education, the number of regular higher education institutions (y_1), the number of graduates (y_2), the enrollment number (y_3) and the number of students in the school (y_4) are the observed objects; in terms of higher education quality, the full-time teachers (y_5) and education expenditure per student in ordinary institutions of higher learning (y_6) are the observed objects. Economic development is measured from three perspectives: economic development level, economic structure and residents' consumption ability of higher education. In terms of the level of economic development, with GDP (x_1), per capita GDP (x_2), local fiscal revenue (x_3), permanent resident population (x_4) and urbanization rate (x_5) as the observation objects; In terms of the state of the economic structure, the GDP of the primary industry (x_6), the GDP of the secondary industry (x_7) and the GDP of the tertiary industry (x_8) are observed; In terms of the residents' ability to spend on higher education, from the per capita disposable income of urban residents (x_9), the per capita disposable income of rural residents (x_{10}), urban consumer price index (x_{11}) and consumer price index for rural residents (x_{12}) these four indicators.

In terms of index selection, it is different from the existing studies: first, carefully select the secondary indicators of higher education and summarize them, in order to represent the scale and quality of higher education in a more comprehensive and objective way. Second, measure the status of economic development from three dimensions of economic development level, economic structure and residents' consumption ability of higher education, in the economic development level——new resident population and urbanization rate, based on: first, population agglomeration is both a process and a result, the rapid economic development can promote population migration and change regional population size, so the permanent resident population can be used as one of the indicators of economic development level[8]; second, urbanization can not directly promote growth, but urbanization can indirectly promote economic development by gathering material resources, human capital and other factors. Urbanization can be seen as a result of economic development,therefore, urbanization can measure to some extent the economic development level of a certain region[9]. Third, two new indicators of residents 'consumption power for higher education——urban CPI and rural CPI are added to more comprehensively represent residents' ability to pay in higher education.

Table 1. Evaluation indicators of higher education and economic development

classification	Level 1 indicators	Secondary indicators
Higher education	Scale of higher education	The number of regular higher education institutions / school (y_1)
		The number of graduates / ten thousand people (y_2)
		The enrollment number / ten thousand people (y_3)
		The number of students in the school / ten thousand people (y_4)
	Quality of higher education	The full-time teachers / person (y_5)
		Education expenditure per student in ordinary institutions of higher learning / yuan (y_6)
Economic development	Economic development level	GDP/ 100 million (x_1)
		Per capita GDP / yuan (x_2)
		Local fiscal revenue / ten thousand yuan (x_3)
		Permanent resident population / ten thousand people (x_4)
		Urbanization rate /% (x_5)
	Economic structure	The GDP of the primary industry / 100 million yuan (x_6)
		The GDP of the secondary industry / 100 million yuan (x_7)
		The GDP of the tertiary industry / 100 million yuan (x_8)
	Residents' consumption power for higher education	The per capita disposable income of urban residents / yuan (x_9)
		The per capita disposable income of rural residents / yuan (x_{10})
		Urban consumer price index (x_{11})
		Consumer price index for rural residents (x_{12})

3. Definition and Modeling Steps of The Grey Association Analysis

3.1. Concept of grey association analysis

The grey correlation theory was proposed by Professor Deng Julong in 1985. Gray correlation analysis refers to the method of quantitative description and comparison of the development and change of a system. Its basic idea is to judge whether the correlation is closely related by determining the geometric similarity of the reference data columns and the comparative data columns. It reflects the degree of correlation between curves[10]. Gray correlation degree analysis is a multi-factor statistical analysis method. By obtaining the gray correlation coefficient between the comparison sequence and the reference sequence, then obtain the gray correlation degree, and then the corresponding decision is made according to the size of the correlation degree. The sample size required for gray correlation analysis is small, the operation is convenient, and it can deal with the uncertainty system containing unknown information, which makes up for the large sample size required for regression analysis, and the relationship between dependent variables and independent variables should be linear.

3.2. Modeling steps of grey association analysis

Step 1: Determine the characteristic sequence and the parent sequence.

The characteristic sequence refers to the data sequence composed of the factors affecting the behavior of the system, also known as the comparative sequence.Set up:

$$X_i = \{X_i(k)|k = 1,2,\dots,m\}\ i = 1,2,\dots,l \quad (1)$$

It is the subsequence, as a comparison sequence. In this paper, the time series of the evaluation index of the economic development level in Guangxi is set as a subsequence.

The parent sequence is the data sequence that can reflect the behavioral characteristics of the system.Set up:

$$Y_j = \{Y_j(k)|k = 1,2,\dots,m\}\ j = 1,2,\dots,q \quad (2)$$

It is the parent sequence, used as a reference sequence. In this paper, the time series of the evaluation index of higher education level in Guangxi is taken as the parent sequence.

The second step: find the initial value image of the comparison sequence and the parent sequence, and treat the selected index data dimensionless.

$$X_i'(k) = X_i(k)/X_i(1) \quad (3)$$

$$Y_j'(k) = Y_j(k)/Y_j(1) \quad (4)$$

$$k = 1,2,\dots,m\ i = 1,2,\dots,l\ j = 1,2,\dots,q \quad (5)$$

Step 3: Find the absolute difference sequence.

$$\Delta_{ij}(k) = \left|X_i'(k) - Y_j'(k)\right| \quad (6)$$

Where Δ_{min} and Δ_{max} are the minimum and maximum values in $\Delta_{ij}(k)$, respectively.

Step 4: Calculate the correlation coefficient between subsequence and parent sequence.

$$r_{ij}(k) = \frac{P\Delta_{max}+\Delta_{min}}{P\Delta_{max}+\Delta_{ij}(k)} \quad (7)$$

Where P is the resolution coefficient, the value is 0.5.

Step 5: Calculate the gray correlation degree between the subsequence and the parent sequence, and rank the correlation degree by the size.

$$r_{ij} = \frac{1}{m}\sum_{k=1}^{m} r_{ij}(k)\ \ i = 1,2,\dots,l\ j = 1,2,\dots,q \quad (8)$$

The value range of gray correlation is (0,1]. According to the degree of correlation, gray correlation is divided into three grades: weak, moderate and strong association, where $r \in (0,0.35)$ is weak, $r \in [0.35,0.65)$ is moderate, and $r \in [0.65,1]$ is strong correlation [11]. Gray correlation with strong correlation is an ideal result. The closer the gray correlation degree is to 1, the closer the gray correlation coefficient between the subsequence and the parent sequence is.

4. Data Source and Grey Association Analysis

4.1. The source of the index data

In 2008-2020, the selection of higher education in Guangxi and six indicators representing the level of Guangxi economic development of 12 indicators, the original data from the China Statistical Yearbook, 2008-2020,2008-2020 Guangxi Statistical Yearbook, China Education budget in 2008-2020.

4.2. Grey correlation analysis between higher education and economic development in Guangxi

In this paper, the mathematical software MATLAB R2022b. According to the modeling steps of grey association analysis, the data were processed and analyzed by MATLAB R2022b software, and the correlation results of grey degree between higher education and economic development in Guangxi are shown in Table 2.

Table 2. Gray correlation matrix of higher education and economic development in Guangxi

r	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	mean value
y_1	0.669	0.668	0.603	0.87	0.964	0.771	0.685	0.62	0.768	0.656	0.848	0.846	0.747
y_2	0.7	0.701	0.595	0.666	0.747	0.893	0.734	0.618	0.877	0.678	0.65	0.647	0.709
y_3	0.648	0.652	0.562	0.726	0.825	0.836	0.683	0.573	0.813	0.628	0.707	0.705	0.697
y_4	0.663	0.666	0.569	0.687	0.777	0.859	0.699	0.583	0.843	0.641	0.669	0.666	0.694
y_5	0.669	0.67	0.586	0.774	0.874	0.813	0.693	0.604	0.799	0.655	0.754	0.752	0.720
y_6	0.73	0.732	0.602	0.613	0.68	0.943	0.78	0.627	0.943	0.702	0.597	0.595	0.712
mean value	0.680	0.682	0.586	0.723	0.811	0.853	0.712	0.604	0.841	0.660	0.704	0.702	

The following conclusions can be drawn from the grey correlation matrix of higher education and economic development in Guangxi:

First, it can be seen from the gray correlation matrix that all the correlation values are greater than 0.56, and most of the correlation values are between [0.65,1], indicating that there is a high mutual relationship between higher education level and economic development in Guangxi.among, Most of the correlation values greater than 0.8 are the GDP of the primary industry, the per capita disposable income of urban residents, the urbanization rate and the evaluation index of higher education, it shows that the development of higher education in Guangxi is strongly dependent on these three factors; in the correlation degree matrix, the correlation between the number of universities and the urbanization rate, the average education expenditure of students and the gross product of primary industry, the average education expenditure of students and the per capita disposable income of urban residents, Of 0.964,0.943, and 0.943, respectively, that is, the changes in these factors are highly correlated, the development rate is at almost the same level.

Second, the di-Clark theorem refers to that with the economic development of a country, the production structure will change as follows: all kinds of human capital and material resources will continue to shift from the primary industry to the secondary industry, and then from the

secondary industry to the tertiary industry[12]. In the correlation of the three industrial structures and higher education in Guangxi is: the primary industry (0.853) > secondary industry (0.712) > tertiary industry (0.604), which proves the conclusion drawn by Wang Tokyo in Economic Globalization and China's Economic Structure Adjustment: the distribution-Clark theorem is in the law of production structure before the middle period of industrialization; when a country enters the middle stage of industrialization, the general rule of industrial structure adjustment should be "Li theorem". The meaning of this theorem is to assume that international trade is free, and a country participates in the division of labor according to its comparative advantage, which not only benefits the country, but also improves the overall welfare of the society [13]. Comparative advantage refers to "comparing yourself with yourself" and finding out what you are best at to compare the comparative advantage with others. The applicable object of the industrial structure evolution law of the di-Clark theorem is [14], the primary industrialized country with the imperfect three industry division and under the closed economic conditions. However, Guangxi was in the middle of industrialization [15] in 2018, so the di-Clark theorem is no longer suitable for the industrialization development of Guangxi.

Thirdly, based on the evaluation index of the economic development level of Guangxi, calculating the average correlation degree of the evaluation index of each higher education level in Guangxi, it can be found that the average is greater than 0.65, which is a strong correlation, indicating that the expansion of the scale and the improvement of higher education quality in Guangxi have an obvious positive impact on the economic growth. Among them, the correlation of the number of ordinary institutions of higher learning, the number of full-time teachers and the educational expenditure of ordinary institutions of higher learning is the top three, with 0.747,0.72 and 0.712 respectively. It can be seen that the increase of the number of higher education and the improvement of the quality of higher education are the main factors of higher education in economic development.

Fourth, the comprehensive evaluation index of higher education level in Guangxi, calculate the evaluation index of each Guangxi economic development level of correlation of higher education, can be found in addition to the local fiscal revenue, the tertiary industry GDP correlation mean 0.586 and 0.604 respectively, the rest of the average is greater than 0.65, also for strong correlation, shows that the improvement of the overall economic development level of Guangxi has obvious positive impact on the development of higher education. Among them, the correlation between the GDP of the primary industry, per capita disposable income of urban residents and urbanization rate is the top three, with 0.853,0.841 and 0.811 respectively. It can be seen that the development of the primary industry, residents' income and urbanization process are the key elements to improve the development level of higher education.

5. Policy Proposal

According to the results of grey correlation analysis and related conclusions, combined with the actual situation of higher education and economic development in Guangxi, the following policy suggestions are put forward:

First, according to the grey correlation analysis, the urbanization degree and the income level of residents in Guangxi have a great impact on the development of higher education. The higher the urbanization rate, the more human and material resources related to economic growth can be gathered, so as to promote the scale and quality of higher education. For example, the higher the urbanization rate of a region, the more convenient the transportation, the more it can promote the population flow and aggregation, maintain the demand for higher education, and make the high-quality development of higher education. The higher the income, the greater the investment in education funds. Through higher education, we can better realize our personal ideals and aspirations, give full play to our personal abilities, and realize our own value, and at the same time, the more economic benefits, the greater the investment space for education funds, which is a process of complementary and mutual promotion. Therefore, in order to promote the development of higher education, Guangxi needs to speed up the process of urbanization rate, narrow the gap between urban and rural areas, improve the level of social security, increase the employment support, so that residents have a greater choice in the expenditure of higher education.

Second, among the GDP of the tertiary industries, the GDP of the primary industry has the highest correlation with higher education, followed by the GDP of the secondary industry and the tertiary industry. With the economic development of a country, it is not that the higher the proportion of the tertiary industry, the more reasonable the economic structure. The adjustment of industrial structure in Guangxi should not deliberately cater to the "distribution-Clark theorem", but should base on its own comparative advantages, foster strengths and circumvent weaknesses, take measures according to local conditions, vigorously develop agriculture, forestry, animal husbandry and fishery, and meet the coordinated development of the three industries so as to obtain the maximum economic benefits, so as to more effectively promote the improvement of higher education level in Guangxi.

Thirdly, the increase of the number of universities and full-time teachers in Guangxi and the investment of educational funds in institutions of higher learning are the main driving force for higher education to promote economic development. The coordinated development of the scale and quality of higher education is an important way to promote economic growth. In the development of higher education, Guangxi should pay attention to the coordinated development of scale and quality, according to the actual situation to adjust the enrollment plan, introduce more high-quality highly educated teachers, uphold the concept of "Strict into strict out", to improve college students' comprehensive quality, for the local economic environment to provide higher quality of knowledge, applied and innovative talents.

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