

# Grey Correlation Analysis of the Industrial Structure and Economic Growth in Jianyang City

Qiuzhu Chen<sup>1</sup> Jinyang Liu<sup>1,2,\*</sup> Xiong Zhang<sup>1</sup>

<sup>1</sup>*School of Statistics, Chengdu University of Information Technology, Chengdu 610103, Sichuan, China*

<sup>2</sup>*School of Mathematics, Harbin Institute of Technology, Harbin 150001, Heilongjiang, China*

\*Corresponding author. Email: lista@cuit.edu.cn

## ABSTRACT

According to the economic development data of Jianyang City from 2010 to 2019, This paper measures the rationality and advancement of industrial structure in Jianyang City and analyzes the correlation between industrial structure and economic growth by grey relational analysis. The results show that there are significant differences between output structure and employment structure. The secondary industry plays an essential role in economic development, and the development of the tertiary industry has an important impact on economic development.

**Keywords:** *Industrial structure, Economic growth, Grey relational analysis*

## 1. INTRODUCTION

The change of industrial structure will have a significant positive impact on economic growth, because when the production factors change from low output efficiency industries to high output efficiency industries, the allocation efficiency of production factors will be improved, and the output efficiency of the overall economy will be improved, thus promoting economic growth [1].

General secretary Xi Jinping stressed: "development is the first priority." In the new era, the importance of economic development has not changed. What has changed is the connotation and focus of economic development - high-quality economic development. High-quality economic development is manifested in the process of optimizing and improving industrial structure, product quality and economic efficiency [2]. The optimization and upgrading of industrial structure and the improvement of economic efficiency are the inevitable requirements of high-quality economic development. Therefore, it is necessary to measure the rationality and high-level of industrial structure in Jianyang City and analyze the correlation between industrial structure and regional economic development.

## 2. RATIONALITY MEASURE

The rationality of industrial structure refers to the aggregate quality of industries, including the degree of coordinated development between industries and the coupling degree of input structure and output structure of factors. According to the equilibrium theory of classical economics, when the economy reaches equilibrium, the output efficiency of each industry should be the same.

That is to say, when the output efficiency difference of each industry is more significant, the development of each industry is more uncoordinated, and the industrial structure is more unreasonable.

In essence, the rationality of industrial structure is the coupling quality between the input and output of each industry, which is measured by the index of structural deviation [1]. Considering that the degree of structural deviation ignores the difference of the importance of various industries in the economy, the index  $\omega_{it}$ , which measures the importance of industries, is added to the index of structural deviation degree as the weight, and use  $ER_t$  to measure the rationality of the industrial structure of the T phase. The expression is as follows:

$$ER_t = \sum_{i=1}^3 \omega_{it} \cdot \left| \frac{Y_{it}/L_{it}}{Y_t/L_t} - 1 \right| = \sum_{i=1}^3 \frac{Y_{it}}{Y_t} \cdot \left| \frac{Y_{it}/L_{it}}{Y_i/L_t} - 1 \right|$$

In the above formula, Y is the actual output of the region, L is the number of labour, i is the industry, t is the period, Y/L is the labour productivity,  $\omega_{it}$  is the proportion of the added value of various industries in the t period,  $Y_t/L_t$  is the overall labour productivity of the t period. When  $Y_{it}/Y_{it} = Y_t/L_t$ , it means that the labour productivity level of each industry is equal to the overall average labour productivity level in the t period, and  $ER_t = 0$ , indicating that the output structure and employment structure are completely coupled. The larger the  $ER_t$  value, the more significant the difference between output structure and employment structure, the more unbalanced economic development and the more unreasonable industrial structure.

The actual output y was expressed by the constant price GDP of Jianyang City in 2010. Labor input L is not only determined by the number of employees but also related to output efficiency, labour quality and other factors. In view of the lack of relevant statistical data, we can only assume that labour intensity and labour efficiency are

homogeneous, and social employment number is used to replace labour input L. Based on the collected data, the rationality of Jianyang's industrial structure from 2010 to

2018 is calculated by using the above formula. The calculation results are shown in Figure 1.

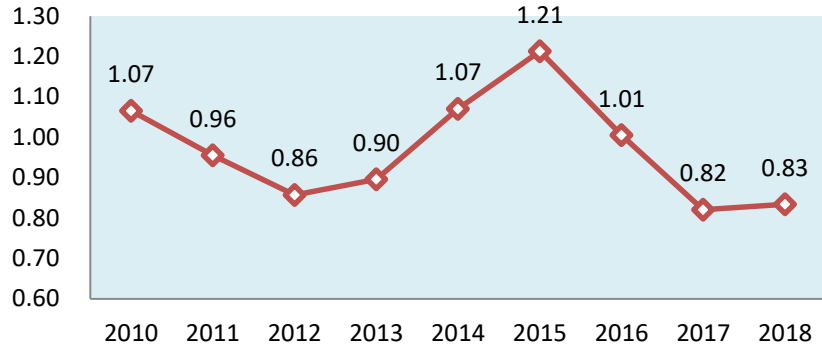


Figure 1 Reasonable changes in industrial structure in Jianyang City from 2010 to 2018

It can be seen that ERT values are more significant than 0, the output structure and employment structure of Jianyang City are not fully coupled, there are significant differences between the output structure and the employment structure, the economic development is not balanced, and the industrial structure needs to be further optimized. From the dynamic point of view, the industrial structure of Jianyang City gradually tends to be reasonable from 2010 to 2012. From 2012 to 2015, the change of industrial structure turned to be unreasonable, and the ERT value in 2015 was 1.21. In 2016, after Jianyang was entrusted by Chengdu, the coupling between its output structure and employment structure gradually increased, and the ERT value decreased from 1.21 to 0.83, and the industrial structure developed to the reasonable direction again.

### 3. MEASURE OF HIGHER DEGREE

The progressive nature of industrial structure refers to the upgrading of industrial structure, which measures the upgrading of industrial structure. The development of an industrial structure to a higher level means that the original factors transfer from industries with low labour productivity to industries with higher labour productivity, and new elements should also be allocated to industries with higher labour productivity. This process leads to the joint improvement of labour productivity of different industries. Therefore, to measure the high-level of industrial structure includes the evolution of the proportional relationship and the improvement of labour productivity [3]. This paper uses the index of industrial structure height  $EH_t$  to measure the progressive nature of

the industrial structure. The calculation formula is as follows:

$$EH_t = \sum_{i=1}^3 \omega_{it} \cdot LP_{it}^N = \sum_{i=1}^3 \frac{Y_{it}}{Y_t} \cdot \frac{LP_{it} - LP_{ib}}{LP_{if} - LP_{ib}}$$

In the above formula, LP is the labour productivity Y/L,  $LP_{it}^N$  is the labour productivity of industry I standardized in phase t. The purpose of labour productivity standardization is to make labour productivity dimensionless.  $LP_{ib}$  refers to the labour productivity at the beginning of the data analysis stage,  $LP_{if}$  refers to the labour productivity at the end of the data analysis stage, and  $i_t$  represents the labour productivity of the I industry in phase t, which is the labour productivity without standardized processing.

In the calculation and analysis, the real output Y is also expressed by the GDP of the non-variable price region in 2010 in Jianyang City, the number of social employment is used to replace labour input L, and the labour productivity is standardized by the min-max standardization method. The treatment methods are as follows:

Transform the sequence  $x_1, x_2, x_3, \dots, x_n$

$$y_i = \frac{x_i - \min_{1 \leq j \leq n} \{x_j\}}{\max_{1 \leq j \leq n} \{x_j\} - \min_{1 \leq j \leq n} \{x_j\}}$$

Based on the collected data, the high-level that value of Jianyang industry is obtained by using the above formula. The calculation results are shown in Figure 2.

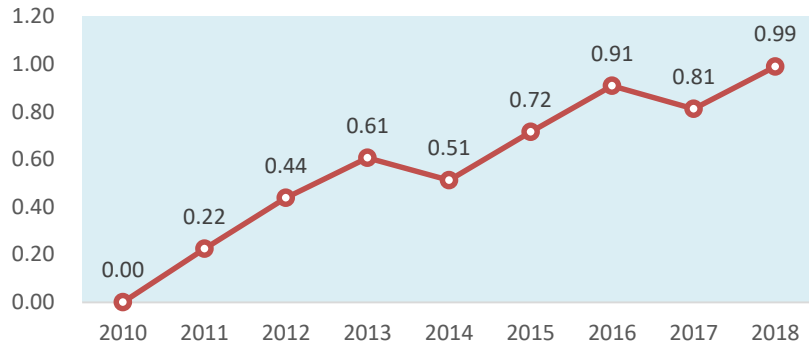


Figure 2 High-level changes in industrial structure in Jianyang City from 2010 to 2018

It can be seen that from 2010 to 2018, the labour productivity of the three industries has been continuously improved. The industrial high-level EHT value of Jianyang City increased from 0.00 in 2010 to 0.99 in 2018, and the industrial structure of Jianyang City gradually improved. As shown in Fig. 2, from 2010 to 2013, the industrial structure of Jianyang City was higher and higher. In 2014, it was slightly weakened, and then it continued to increase. In 2017, the industrial structure of Jianyang City fluctuated slightly again and then continued to increase. On the whole, although the industrial structure of Jianyang City fluctuates slightly, the high-level industrial structure of Jianyang City has been continuously enhanced from 2010 to 2018. The original factors have been transferred from industries with low labour productivity to industries with higher labour productivity, and the newly added factors also tend to industries with higher labour productivity.

## 4. GREY RELATIONAL ANALYSIS

### 4.1. Brief introduction to the method

In 1982, Professor Deng Julong put forward the grey relational analysis (GRA), which is a commonly used multi-factor statistical analysis method. By analyzing the data of different sequences of a specific system in a certain period, we can analyze the influence of different factors on the development of the system and judge the relationship between the influencing factors [4].

The grey correlation analysis method is widely used. The existing theory and practice show that the grey correlation degree model and the grey development decision model based on the grey system theory are handy analysis tools [5]. Therefore, we use the method of grey correlation analysis to analyze the industrial structure of Jianyang City, and more accurately grasp the correlation between the industrial structure and economic growth of Jianyang City, and judge the relationship between the two.

We use grey correlation degree to calculate the correlation between the added value of various industries and GDP. The calculation steps are as follows:

Step 1: determine the sequence

The reference sequence is recorded as  $X_0$

$$X_0 = \{x_0(1), x_0(2), x_0(3), \dots, x_0(n)\}$$

Compare the columns as  $X_i$

$$X_i = \{x_i(1), x_i(2), x_i(3), \dots, x_i(n)\}, i = 1, 2, 3, \dots, n$$

Step 2: dimensionless data processing

$$x_i(k) = \frac{x_i(n)}{x_i(1)}$$

Step 3: calculate the difference sequence value between the comparison sequence and the reference sequence

$$\Delta_{0i}(k) = |x_0(k) - x_i(k)|, k = 1, 2, 3, \dots, n$$

Step 4: to calculate the grey correlation coefficient

$$\beta_i(k) = \frac{\min_i \min_k |x_0(k) - x_i(k)| + \rho \max_i \max_k |x_0(k) - x_i(k)|}{\Delta_{0i}(k) + \rho \max_i \max_k |x_0(k) - x_i(k)|}$$

In the above formula,  $\rho$  is the resolution coefficient and its size are generally between 0-1, usually taken as 0.5. In this paper, the value  $\rho$  is taken as 0.5 in the calculation.

Through the grey correlation coefficient, we can see the degree of correlation between each point in the comparison sequence and the reference sequence.

Step 5: calculate the industrial relevance

The calculation formula of correlation degree RI is as follows:

$$r_i = \frac{1}{n} \sum_{k=1}^n \beta_i(k), k = 1, 2, 3, \dots, n$$

Correlation degree explains the influence of the variable on the system in different development processes [2]. In other words, the comparison of the size, direction and speed of the variable with the change of the size, direction and speed of the system. The correlation degree of the sequence can be calculated by comparing the average value of the sequence in a certain period of time, as shown in the above formula.

### 4.2. Empirical analysis

By sorting out the data in the statistical yearbook, we can obtain the current price GDP and the output value of the three major industries in Jianyang City in 2019. The

comparable price GDP and the output value of the three major industries can only obtain the data of 2018; therefore, the grey correlation degree of the industrial structure of Jianyang City is analyzed by using the above

formula, respectively, using the regional GDP of current price and the added value of three industries, the comparable regional GDP and the added value of three industries calculated according to the price in 2010.

Table 1 Comprehensive evaluation index system and weight

Index	Primary industry	Secondary industry	Tertiary industry
Grey correlation degree of current price	0.83	0.93	0.83
Grey correlation degree of comparable price	0.52	0.77	0.79

From the results of the grey correlation degree calculated by the current GDP and the added value of the three industries, The grey correlation between the primary industry and economic growth in Jianyang City is 0.83, The grey correlation between the second industry and economic growth is 0.93, The grey correlation between the tertiary industry and economic growth is 0.83. At present, the second industry has the highest correlation with the economic growth of Jianyang City.

The results from the comparable price data show that the grey correlation between the primary industry and economic growth is 0.52, The grey correlation between the secondary industry and economic growth is 0.77, The grey correlation between the tertiary industry and economic growth is 0.79. Comparing the results of current price calculation and comparable price calculation, we can find that the secondary industry plays an essential role in the economic development of Jianyang City, and the development trend of the tertiary industry plays an essential role in the high-quality economic development of Jianyang City.

**5. RESEARCH CONCLUSION**

Through the measurement of the rationality of Jianyang industrial structure and the grey correlation analysis of the industry and economic development, it is found that the industrial structure of Jianyang is developing in a right direction, but it needs to be further optimized. In the economic development of Jianyang, the secondary industry plays an important role, and the tertiary industry plays an essential role in the economic development of Jianyang. Although Jianyang's tertiary industry is developing continuously, it has not yet formed a modern industrial system.

Jianyang's past achievements are gratifying, and the near future is auspicious. Jianyang is facing a rare historical development opportunity and will become a new bright spot and a new high point of Chengdu's economic development in the next few years. In order to explore how to get out of the new way of high-quality development of county economy with Jianyang characteristics, and to build reliable support for writing a more colourful chapter with high-quality of Jianyang economy in the new era, this

paper puts forward some suggestions on the optimization of Jianyang's industrial structure. First, we should focus on the real economy, promote the industry to the middle and high end of the global value chain, and enhance the economic quality advantage. Second, we should put scientific and technological innovation in the first place in the construction of the industrial system, so that scientific and technological innovation can become a sustained and substantial driving force for industrial upgrading [1]. Third, we should speed up the reform of the financial system, develop the modern financial industry, and provide efficient, convenient, functional and reasonable financing services for the real economy. Fourth, we should give full play to the advantages of human resources, cultivate and bring up a number of high-quality leading talents and industrial forces in the new era.

**REFERENCES**

[1] Qingran Ni. Empirical Study on industrial structure change, total factor productivity and high-quality economic development of Ningbo -- Based on comparative analysis of Ningbo, Hangzhou and Suzhou [J]. *Productivity Research*, 2019 (07): 68-75

[2] Yaqing Zhang. Grey correlation analysis of the industrial structure and economic growth in Hebei Province [J]. *Cooperative economy and science and technology*, 2020 (14): 9-11

[3] Yingxia Ye. Study on the influencing factors of economic growth in Heyuan City Based on grey relational analysis [J]. *Northern economic and trade*, 2020 (05): 122-124

[4] Xing Fan, Jinjue Zheng. Comparison of GDP structure of China's provinces based on grey relational cluster analysis [J]. *Statistics and decision making*, 2018,34 (21): 139-141

[5] Xinshu Gong, Yazhen Jin. An empirical analysis of the coordinated development of industrial structure and economy based on grey relational theory [J]. *Statistics and decision making*, 2018,34 (02): 123-126