Research on Industrial Structure and Economic Co-Development in Hefei City, Anhui Province

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Abstract

Using linear regression, grey correlation and neural network models, this paper empirically analyzes the synergistic relationship between industrial structure and GDP as the main indicators of economic development in Hefei City, Anhui Province. Overall, it is necessary to vigorously develop the secondary and tertiary industries. From the perspective of the specific industries of the tertiary industry, the impact of agriculture, forestry, animal husbandry and fishery on the GDP of Hefei has been declining, and the financial industry has begun to dominate. The total industrial production and the total real estate production have a negative impact on the GDP of Hefei to a certain extent.Finally, in terms of industrial structure, it provides policy suggestions for the coordinated development of Hefei's economy.

Keywords

Industrial structure; Economic synergy; Neural network; Hefei City.

1. Introduction

In recent years, China's economic growth has gradually slowed down from the past double-digit growth rate to about 3% under the circumstances of macroeconomic slowdown, and the problems that hinder the improvement of China's national economic level are mainly focused on the industrial structure[1]. At present, China is in a critical period of economic transformation, and optimizing and adjusting the industrial structure has become an important task to promote economic growth. The 14th Five-Year Plan clearly sets out the following goals: to enhance the global allocation of resources, the source of scientific and technological innovation, and the leading function of high-end industries. With modern service industries as the main body and advanced manufacturing as the support, China's comprehensive energy level and international competitiveness[2] will be improved. In this context, it is particularly urgent[3]to explore the relationship between industrial structure and economic growth and improve the economic output benefits of industrial structure.

Hefei is a dark horse in the history of urban development in China. Despite its late establishment and poor resources, it has accelerated its rise and innovative development in the fierce competition of national municipal economy. In 2020, Hefei entered the top 20 cities[4] in China's comprehensive strength for the first time. Therefore, this paper chooses Hefei city as an example to conduct an empirical analysis of the coordinated development of industrial structure and economy based on the neural network model, which has important research significance. This study is helpful to provide policy guidance for the development of industrial structure in Hefei City, and also provide experience for the optimization and development of regional industrial structure in other provinces and cities in China, so as to promote the transformation and upgrading of China's industrial structure and promote the sustainable development of economy. In addition, this study also provides a new theory and perspective for the development of China's industrial structure, which is helpful to improve the research on China's regional industrial structure and economic development.

2. Literature review

Scholars at home and abroad have conducted two main studies on the relationship between industrial structure and economic growth: national research and regional research. National studies have explored the relationship between the industrial structure and economic growth of the whole country, while regional studies have focused on the relationship between the industrial structure and economic growth of different regions. These studies provide important insights and findings into the impact of industrial structure on economic growth.

National studies on the relationship between industrial structure and economic growth. In order to achieve the optimization and upgrading of industrial structure, it is suggested to adopt the way [5]of skewed allocation of resources. Based on the data of Chinese provinces and cities from 1992 to 2000, Liu Wei (1995) found that the tertiary industry played the most significant [6]role in promoting economic development. Zhu Xiaohua and Deng Baoyi (2013) calculated the effect value of the economic output of the three industries by regression method, and found that there was a unidirectional causal relationship between industrial structure change and economic development.[7]

Regional research on the relationship between industrial structure and economic growth. Li Yiyang (2011) took Gansu Province as an example and found that the tertiary industry contributed the most[8] to economic development by using the grey correlation analysis method. Taking the panel data of 11 provinces in China as an example, Wang (2017) found that the Marine industrial structure had phased differences in the Marine economic growth, and the high industrial structure hindered the economic development[9]; Taking eastern, middle and western China as an example, Li and Deng (2011) found that the change of industrial structure had significant regional differences on economic growth. The rationalization of industrial structure promoted economic growth in the eastern region, while for the central region, the optimization of industrial structure was the main driving force for economic growth, especially for the central region. The optimization of the industrial structure plays a major role in promoting the economic growth[10].

3. Data source and data description

The GDP of Hefei from 2002 to 2022 is selected from the Statistical Yearbook of Hefei as the economic development index, and the added value of the primary, secondary and tertiary industries, the proportion of the output value of the primary, secondary and tertiary industries, the gross production value of agriculture, forestry, animal husbandry and fishery, the gross production value of industry, the gross production value of construction industry, the gross production value of accommodation and catering industry, the gross production value of financial industry and the real estate industry are selected as the industrial structure index , the units are 100 million yuan and % respectively.

4. Empirical analysis

4.1. Correlation analysis of the three industries

To explore the relationship between economic growth and industrial structure, the most important thing is to study the relationship between the added value and proportion of the three industries. Table 1 lists the correlation values of the added value and proportion of the three industries. The proportion of the primary industry and the added value of the tertiary industry have weak negative correlation, while the proportion of the secondary industry and the added value of the tertiary industry have strong positive correlation. The correlation coefficient between the proportion of the secondary industry and the added value of the secondary industry is as high as 0.6264, and the proportion of the tertiary industry is negatively

correlated with the increase of the primary and secondary industries, and the correlation coefficient between the proportion of the tertiary industry and the added value of the secondary industry is as high as -0.84823.

Table 1 Correlation coefficients of the added value and proportion of the tertiary industry1

	Proportion of primary industry	Proportion of secondary industry	Proportion of tertiary industry
The added value of the primary industry	0.3367272	0.26482893	0.0478383
Added value of secondary industry	0.3398422	0.62648380	0.8482382
Value added of tertiary industry	0.4885844	0.08233773	0.7463782

The structure of the three industries is highly correlated, and the analysis shows that the secondary and tertiary industries have a strong correlation with the added value of the three industries, that is, the secondary and tertiary industries have a great impact on economic development.

4.2. Partial least squares regression analysis of the three industries

According to the correlation analysis, there is a high correlation between the structure of the three industries. In order to better quantify their relationship, the following partial least squares regression analysis is used for data analysis. The added value of the three industries is divided into as the explanatory variable $R1, R2, R3$, and the proportion of the three industries is respectively expressed as the explained variable $D1, D2, D3$.

$$D_1 = -0.3735R_1 + 0.3315R_2 - 0.0472R_3$$

$$D_2 = -0.4138R_1 + 0.6234R_2 - 0.5472R_3$$

$$D_3 = -0.5263R_1 + 0.2542R_2 + 0.4325R_3 \tag{1}$$

Formula (1) explains the quantitative relationship between the added value of the three industries and the ratio. If the proportion of the secondary and tertiary industries remains unchanged, increasing the proportion of the primary industry will lead to a decrease of 37.35%, 41.38% and 52.63% in the added value of the three industries respectively. Increasing the proportion of the secondary industry will lead to the increase of the added value of the tertiary industry by 33.15%, 62.34% and 25.42% respectively. If the proportion of the primary industry and the secondary industry remains unchanged, increasing the proportion of the tertiary industry will lead to the decrease of the added value of the primary industry by 4.72%, the secondary industry by 54.72% and the tertiary industry by 43.25%. The contribution of the added value of the three industries to GDP can be described by the following model, specifically:

$$Y_1 = 39.4039 - 25.3722D_1 + 11.3672D_2 + 7.8352D_3 \tag{2}$$

In order to better explore the specific impact of each industry on economic growth, the main industry of the primary industry is agriculture, forestry, animal husbandry and fishery. The main industries of the secondary industry are industry and construction, and the main

industries of the tertiary industry are accommodation and catering industry, finance industry and real estate Industry, which are divided into $r_1, r_2, r_3, r_4, r_5, r_6$.

The grey correlation degree between the GDP of Hefei and the GDP of six major industries is shown in Table 6 by using R software analysis and calculation.

Table 2 Correlation degrees of characteristic factors and impact factors2

Industry	Agriculture, forestry, animal husbandry and fishery	Industry	Construction	Accommodation and catering	Finance	Real estate
Degree of association	0.95	0.61	0.93	0.23	0.84	0.98

Size sort the data to get: $r_6 > r_1 > r_3 > r_5 > r_2 > r_4$

According to the ranking results of grey correlation degree, it is preliminarily known that the gross production of agriculture, forestry, animal husbandry and fishery, the gross production of construction, the gross production of financial industry and the gross production of real estate industry have a large correlation degree with the regional gross production of Hefei city.

4.3. Establishment of regression model

R was used for linear regression to determine the quantitative interdependence among the seven variables. The following results can be obtained by running R:

Table 3 Regression analysis coefficient table3

	Estimate	Std.Error	t value	Pr(>|t|)
Intercept	64.26261	24.56347	2.543	0.226
X1	2.47388	0.84632	2.378	0.252
X2	0.36273	0.15373	1.463	0.324
X3	0.37828	0.24388	0.527	0.745
X4	0.04772	0.08463	0.430	0.742
X5	2.32883	0.94732	3.078	0.212
X6	0.77448	0.37646	2.059	0.267

Table 4 Regression equation model test table

Residual standard error	Multiple R-squared	Adjusted R-squared	p-value
0.8902	0.9984	0.9954	0.04181

It can be seen from the above results $R^2 = 0.9984$, $\bar{R}^2 = 0.9954$ that the coefficient of determination is very high, indicating that the model fits the sample well.

The test value of F=352.1 is very large, indicating that the regression equation is significant, that is, the individual variables do have a significant impact on the factor quantity. At the given significance level $a = 0.05$, $x_1, x_2, x_3, x_4, x_5, x_6$ the corresponding P values were 0.226, 0.252, 0.324, 0.745, 0.742, 0.212 and 0.267, respectively, $x_1, x_2, x_3, x_4, x_5, x_6$ indicating that the influence on the dependent variable was not significant.

Through the regression coefficient test and regression equation test, the relationship between the GDP and the GDP of agriculture, forestry, animal husbandry and fishery, industry,

construction, accommodation and catering industry, financial industry and real estate industry is as follow

$$Y_2 = -64.26261 + 2.47388X1 - 0.36273X2 - 0.37828X3 + 0.04772X4 + 2.32883X5 - 0.77448X6 \tag{3}$$

4.4. Nonlinear part of RBF neural network fitting

In practical problems, there is no linear relationship between each impact factor and regional GDP, so we should use the good approximation of neural network to fit the nonlinear relationship between regional GDP and regional GDP. Let the nonlinear relationship between the dependent variable and the independent variable be β, and β is the residual between the simulated value and the real value in the linear regression model. In this case, the new regression equation is:

$$Y = -64.26261 + 2.47388X1 - 0.36273X2 - 0.37828X3 + 0.04772X4 + 2.32883X5 - 0.77448X6 + \beta \tag{4}$$

The new model can make up for the shortcomings of the linear model and make it closer to the reality.

Gross regional product (GDP), gross agricultural, forestry, animal husbandry and fishery (GDP), gross industrial product (GDP), gross financial industry (GDP) and gross real estate industry (GDP) from 2020 to 2022 were selected as input element P, and the residual value was used as a single output p to jointly input the RBF neural network for training, a new network was obtained, and the P-value was brought back to the network for simulation verification, and the simulation result t was obtained. As shown in the following table 5:

Table 5 Statistical data of influencing factors of test year

Year	Gross regional product (100 million yuan)	Gross production of agriculture, forestry, animal husbandry and fishery (100 million yuan)	Gross industrial production (100 million yuan)	Gross production of the financial sector (100 million yuan)	Gross real estate production (RMB 100 million)
2020	110045.72	3332.32	22072.32	9700.26	9930.74
2021	110005.56	3335.21	22051.76	11587.57	11546.99
2022	111412.80	3351.05	22472.25	11424.12	11466.42

As can be seen from the table, combined with the data of Hefei City Yearbook, the simulation value and the real value have a high degree of fit, which indicates that the network is well trained, can well represent the nonlinear relationship between the independent variable and the dependent variable, and the regression formula is reasonable and correct.

It can be seen from the above regression formula that the GDP of agriculture, forestry, animal husbandry, fishery and financial industry has a positive impact on the GDP of Hefei to a certain extent, while the GDP of industry and real estate has a negative impact on the GDP of Hefei to a certain extent.

5. Conclusion

Based on the analysis results and the existing literature, the following conclusions are drawn:

5.1. Reduce the proportion of the primary industry and increase the proportion of the secondary and tertiary industries

According to the data analysis of the GDP and the three major industries in Hefei, it can be found that reducing the proportion of the primary industry and increasing the proportion of the secondary and tertiary industries will help to increase the GDP of Hefei.

5.2. Agriculture, forestry, animal husbandry and fishery are no longer the main factors affecting the GDP of Hefei city, and the financial industry begins to dominate

Combined with the linear and non-linear relationship between the GDP of Hefei and the specific industries of the three industries, it is not difficult to find that the regional GDP of Hefei is positively correlated with the total output value of agriculture, forestry, animal husbandry and fishery, and the total output value of the financial industry, and negatively correlated with the total output value of the industrial and real estate industries.

5.3. The gross industrial production and the gross real estate production have a negative impact on the GDP of Hefei to a certain extent

Through the establishment and analysis of the regression model, it can be seen that under the condition that other conditions remain unchanged, the increase of regional GDP has the opposite effect on the GDP of the real estate industry and the GDP of the industrial industry.

6. Policy suggestion

According to the empirical analysis above. The industrial structure affects the coordinated development of economy, so the following five suggestions are put forward to promote the coordinated development of Hefei's economy.

6.1. Formulate regional coordinated development plans

We will formulate coordinated regional development plans that take into account the economic characteristics of the eastern, central and western regions, define the industrial positioning and development direction of each region, and promote complementarity and synergy among regions in industrial structure. When formulating the plan, it is necessary to consider the positioning and advantages of the region, the direction of industrial development, infrastructure construction, talent introduction and training, deepening cooperation mechanisms, environmental protection and policy support. Through orderly planning and implementation, regional coordinated development will be realized and the overall economic and social development will be further promoted.

6.2. We will strengthen the synergy and connectivity of industrial chains

We will encourage cross-regional enterprises and industrial parks to cooperate, build platforms to supplement and support the industrial chain, and promote close cooperation and coordinated development between upstream and downstream links of the industrial chain.At the same time, through strengthening supply chain management, sharing information and technological innovation, we can achieve efficient collaboration between the upstream and downstream of the industrial chain, reduce costs, improve production efficiency and product quality. At the same time, multi-level industrial clusters should be established to encourage cooperation and sharing among enterprises to achieve scale effect and complementary advantages. Through strengthening the synergy of industrial chain, promote the upgrading and transformation of industrial chain, and promote the sustainable development of regional economy.

6.3. Optimize resource allocation and industrial layout

In accordance with the resource endowments and advantageous industries of each region, we should rationally arrange the industrial layout, and improve the overall economic performance and competitiveness through resource sharing and complementary advantages. In terms of optimizing the industrial layout, it is necessary to determine the leading industries and supporting industries according to the industrial base and advantages of the region, and promote industrial transformation and upgrading. In terms of resource allocation, it is necessary to rationally plan and coordinate the factors required for daily production such as land, energy and water resources to ensure the efficient allocation of resources, while paying attention to environmental protection to avoid adverse impacts on the ecological environment. By optimizing the allocation of resources and industrial layout, the coordinated development of regional resources and the orderly development of industries can be achieved to promote the sustainable development of regional economy.

6.4. Increase support for technological innovation

We will increase investment in and support for scientific and technological innovation, improve the scientific and technological innovation capacity of various regions, promote the development of new and high technology industries, and promote the upgrading, transformation and upgrading of the industrial structure. In terms of supporting technological innovation, it is necessary to strengthen cooperation and exchanges between scientific research institutions and enterprises, establish a good scientific research system and innovation ecology, provide financial funds and policy support, and encourage enterprises to increase R&D investment and train R&D talents. At the same time, we should pay attention to the transformation and application of technology, promote the industrialization and commercialization of scientific and technological achievements, and improve the efficiency of technological transformation and market competitiveness. By increasing support for technological innovation, the regional economy will be transformed from one driven by resources and low-cost labor to one driven by innovation, and the economic structure will be optimized and sustainable development will be achieved.

6.5. Enhance personnel training and mobility

We will strengthen the training and flow of talents, encourage talent cooperation and exchanges between different regions, promote the optimal allocation and sharing of human resources, and promote the optimization and upgrading of the industrial structure. In terms of personnel training, it is necessary to increase investment in education, reform the education system, improve the quality of education and the level of personnel training, train all kinds of talents suitable for the development of the new economy, and cultivate innovation and entrepreneurship and practical ability. In terms of talent flow, it is necessary to break the restrictions of household registration, establish a fair and just talent flow mechanism, encourage cross-border cooperation and knowledge innovation among talents, and promote the diversified flow of talents and cross-field collaboration. By improving the training and flow of talents, we can promote the upgrading of industrial structure, realize the positive interaction between talents and industries, and promote the innovation-driven and sustainable development of regional economy.

Acknowledgement

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