Research on the Influencing Factors of Shandong Economy Based on Grey Relational Analysis

Anjing Zheng[1], Kang Gai[2]

[1]Westa College of Southwest University, Chongqing, China
[2]Business School of Shandong University of Technology, Zibo, China

Abstract: *Shandong is a powerful economic province in North China. Studying the influencing factors of its economic development is quite significant for improving the quality of Shandong's economic development and optimizing the economic structure. This paper chooses the grey relational method to conduct an empirical study on the relationship between the economic development of Shandong Province and the index system composed of specific indicators in the primary, secondary and tertiary industries. The results show that the current industrial structure of Shandong Province is still the "secondary-primary-tertiary " and the gap between the three is small. From the perspective of different influencing factors, this paper proposes for the economic development of Shandong Province to use consumption hotspots as a lever to promote the transformation of industrial structure, promote the upgrading of the industrial chain based on the secondary industry and marine resources, and increase investment in the service industry and encourage enterprises to develop new energy. It can offer benign advice politically and provide practical theoretical support and fresh thinking perspectives for the introduction of relevant policies for high-quality economic development in Shandong Province.*

Keywords: *Shandong Economy; Industrial Structure; Grey Relational Analysis; Indicator System*

1. Introduction

Since the reform and opening up, China's industrial structure has been constantly changing, which basically conforms to the law of evolution. The changes in the brand sponsorship list of the Spring Festival Gala in the past 40 years can also give a glimpse of the development trend of the country's industrial structure. Internet companies from 2015 to the present, this is in line with the evolutionary history of China's industrial structure "secondary-tertiary-primary" has changed to "tertiary-secondary-primary". The relationship between economic development and industrial structure is often inseparable. Especially after China entered the "14th Five-Year Plan" period, the upgrading and transformation of industrial structure has become a key factor in the transformation of the economy from high-speed development to high-quality development.

Shandong Province is located on the eastern coast and has the third longest coastline in China. It is a populous province with abundant natural resources. As a strong economic province in the northern region, Shandong Province has long ranked third in the country in terms of total economic output. The unique geographical location and resource reserves make Shandong Province the only province in China with as many as 41 industrial categories, which also shows that its industrial base level is relatively high. While the electricity consumption of Shandong Province ranks first in the country, its total GDP does not reach the top, which is related to the development of its overall industrial structure. It is of great importantance to study the internal logic of industrial structure on economic growth for the rational planning of future high-quality and high-speed economic development. In addition, the study of the industrial structure of Shandong Province at this stage can reflect its weak development, which is conducive to the government to put forward targeted scientific countermeasures in the future, and can also provide a theoretical basis for consciously taking measures in the economic fluctuations in the transition period. Therefore, it is of great practical significance to study the relationship between industrial structure and economic development in the critical period of economic transformation.

2. Analysis of Research Status

In recent years, many studies on the relationship between economic development and industrial structure have been in the past. In terms of the relationship between overall economic development and

industrial structure, Qian Mengyao et al. analyzed the data of Henan Province from 2000 to 2019, and used factor analysis and gray analysis methods to obtain the GDP of Henan Province and the secondary, tertiary and primary industrial correlation decreases in turn and the contribution of the tertiary industry to GDP growth increases year by year. Based on economic data since the reform and opening up of Chongqing, Liu Xiaoli et al. applied the grey relational theory and concluded that the contribution trend of the primary, secondary and tertiary industries in Chongqing to economic growth is rising, falling and rising respectively, and formed a "secondary-tertiary-primary " industry pattern. Peng Jizeng et al. chose per capita GDP and the proportion of employed persons in the tertiary industries to analyze the gray correlation between industrial structure and economic development in Jiangxi Province and concluded that the correlation tends to be similar, and the development of the tertiary industry plays a role.

Focusing on economic development in more subdivided areas, some scholars have already studied the relationship between the economic development of individual industries and industrial structure. Based on the data of Heilongjiang Province from 2008 to 2016, Li Xianghong et al. applied the grey correlation model to obtain the correlation degree of the three industries and the green credit ratio in Heilongjiang Province from strong to weak: the primary, tertiary and secondary industries. Peng Liangyu also used the grey relational method to conclude that the industrial structure of Anhui Province is more reasonable, and the dominance of the tertiary, secondary and primary industries decreases in turn. Based on the data of six central provinces, Wu Zhiqiang calculated the grey correlation degree that reflects the relationship between the scale of green financing and industrial structure in each province and concluded that the development level of the tertiary industry has the highest correlation with the development degree of green finance. Ran Ruipei calculated the grey correlation between the GDP of each city and the primary, secondary and tertiary industries and high-tech industries based on the annual data of the Chengdu and Chongqing region from 2007 to 2018. Compared with Chengdu, Chongqing's industry of high-tech has a higher growth rate, a smaller scale and better integrated development. Zhu Fangyang et al., based on the data of cargo throughput, GDP, and three output values of Beibu Harbor from 2000 to 2019, calculated the gray correlation degree and found that the port economy has a more significant impact on economic development in the short term. And the port logistics scale, infrastructure condition and investment level impact on the tertiary decreases in turn.

In addition, some scholars have used the grey relational method to study the relationship between economic development and industrial structure in Shandong Province. Based on the relevant data from 1999 to 2003, Xu Lei et al. applied the grey relational model to analyze and predict, and then concluded that Shandong's economic development was still not in the middle stage of industrialization at this stage. Based on the data of GDP and tertiary industries in Shandong Province from 2002 to 2012, Zhao Jing et al. concluded that the difference between the contribution of the secondary and tertiary industries to GDP in the past decade was very small. Li Aijing used the grey relational method to study the economic development and industrial structure of Shandong Province from 2000 to 2015 and corresponding countermeasures.

From the literature review above, it shows that many existing articles apply the grey relational method to analyze the relationship between economic growth and industrial structure, involving different regions and different industries respectively. From the regional perspective of the study, there was no relevant content in the five years of rapid development from 2016 to 2020 to reflect the changes in the industrial structure of Shandong Province and its correlation with economic growth. From the perspective of the types of industries studied, most scholars focus on one industry to study the relationship between it and the industrial structure, while few study the subdivision industries under the three industries. The research literature is relatively small. Therefore, on the basis of the above-mentioned existing literature, this paper will conduct relevant research on the economic development and industrial structure of Shandong Province, and have the following two innovations: First, select relatively new data to reflect the rapid changes in recent years to see if there are major changes. Secondly, study the three industries as a whole respectively and study the sub-industries below them as well, so as to provide practical suggestions for the future development of Shandong's economy. Additionally, this paper adopts the grey correlation analysis method, which has the advantages of small amount of calculation and strong universality. There is no strict requirement for the number of samples and the regularity of samples. The quantitative results of this method are in line with the results of qualitative analysis, and there is no large deviation.

3. Data Selection

Based on the relevant economic data of Shandong Province from 2005 to 2020 by the National Bureau of Statistics, this paper takes the GDP of Shandong Province as the indicator of its economic development,

and the added value of each industry as the indicator of the industrial structure. The industries involved include: primary industry; secondary industry; tertiary industry; agriculture, forestry, animal husbandry and fishery; industry; construction, wholesale and retail; transportation, warehousing and postal services; accommodation and catering; banking business; real estate business and other industries. The data is shown in Figures 1 and 2 below.
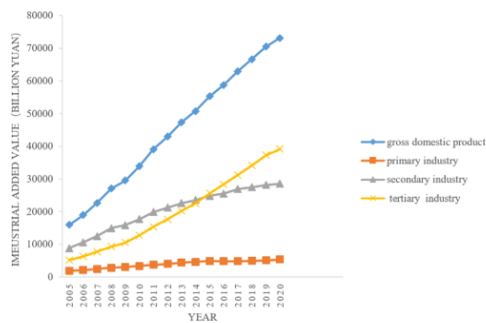

Figure 1 GDP and added value of three industries in Shandong Province from 2005 to 2020
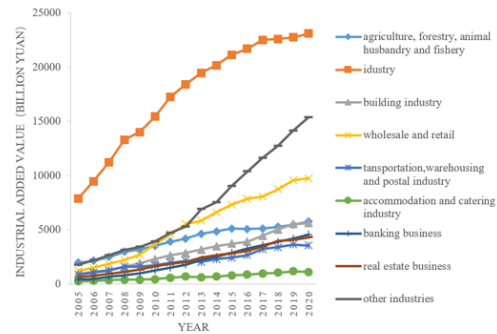
Figure 2 Industrial added value of sub-sectors in Shandong Province from 2005 to 2020

Figure 1: Shows that the total economic output of Shandong Province has grown steadily in recent years, the development of the secondary and tertiary industries has been relatively stable, and the added value of the tertiary industry has grown rapidly. The added value of the tertiary industry in 2015 is noticeable. It exceeded the secondary industry and continued to rise.

From Figure 2 that the industrial added value of Shandong Province has maintained an upward trend, and its value is much higher than the added value of other industries, while other industries and the wholesale and retail industries are developing more rapidly.

4. Model Selection

The grey analysis method is a systematic analysis method proposed by Deng Julong in 1982 that is not limited by the sample size and regularity. The basic idea is to judge whether the connection is close according to the similarity of the geometric shapes of the sequence curves. The more similar the curves are, the greater the degree of correlation between the corresponding sequences, and vice versa. It can also be understood as a factor with a consistent change trend in the system. The higher the degree of synchronous change, the higher the degree of correlation.

The specific steps of model building are as follows:

4.1. Determine the Analysis Sequence

(1) Let the reference sequence be $x_0 = \left\{ x_0(k) \middle| k = 1, 2, \cdots n \right\}$, which k represents the time, and this paper selects the GDP of Shandong Province as the reference sequence.

(2) Let the comparison number column be $x_i = \left\{ x_i(k) \middle| k = 1, 2, \cdots n \right\}, i = 1, 2, \cdots, m$, assuming that there are m comparison sequences. This paper selects the added value of each industry in Shandong Province as the comparison sequence.

4.2. Preprocess the Data

The meanings and data dimensions represented by the factors in the system are not necessarily the same, which makes it inconvenient to compare the indicators, and sometimes even leads to wrong conclusions. Therefore, it is very necessary to carry out data preprocessing.

(1) Find the mean of each indicator. All indicators in the system are positive indicators, which are processed according to $\bar{x} = \frac{\sum_{j=1}^{k} x(k)}{k}$, and the mean value of each original series is obtained.

(2) Divide all raw data in each sequence by the mean to obtain dimensionless comparison and

reference sequences.

4.3. Calculate the Grey Correlation Between Each Index in the Comparison Series and the Parent Series

(1) Obtain the absolute difference sequence and the two-level minimum difference between the comparison sequence and the reference sequence $\alpha = \min_{s} \min_{k} |x_0(k) - x_s(k)|$ and the two-level maximum difference $\beta = \max_{s} \max_{k} |x_0(k) - x_s(k)|$.

(2) Calculate the correlation coefficient $\gamma(x_0(k), x_i(k)) = \dfrac{\alpha + \rho\beta}{|x_0(k) - x_i(k)| + \rho\beta}$, γ indicates the correlation coefficient x_i between the comparison sequence x_0 and the reference sequence at the k moment, the resolution coefficient ρ takes 0.5.

(3) Calculate the grey relational degree $\overline{\gamma}$ .Calculate the mean value of the correlation coefficient of each comparison sequence according to $\overline{\gamma}(x_0, x_i) = \dfrac{1}{n}\sum_{k=1}^{n}\gamma(x_0(k), x_i(k))$,and then the grey correlation degree between the comparison sequence x_i and the reference sequence x_0 can be obtained.

(4) Pros and cons are obtained according to the order of relevance.When there are m comparison sequence, there are also m relative correlation value, and the result can be obtained by arranging according to its numerical value. The degree of correlation directly reflects the pros and cons of each comparison sequence to the reference sequence.

5. Empirical Analysis

This paper selects the relevant data of Shandong Province from 2005 to 2020. It takes the provincial annual GDP as the parent series, and takes the added value of each industry in the same period as the subsequence, and then calculates the gray correlation coefficient and the mean correlation of the correlation coefficient between the two series. It is generally believed that the higher the degree of association, the closer the relationship between the research variables. Among them, it is generally considered that the gray correlation degree is less than 0.3 as weak correlation, between 0.3-0.5 is low correlation, between 0.5-0.8 is generally related, and above 0.8 is highly correlated.

5.1. An Analysis of the Grey Correlation Between the GDP and the Three Industries in Shandong Province

According to the data and model, this paper calculates the grey correlation coefficient and grey correlation degree between GDP and the primary, secondary and tertiary industries in Shandong Province from 2006 to 2020, as shown in Table 1 below.

Table 1: Grey correlation coefficient between GDP and three industries in Shandong Province

Structure / Year	Primary Industry	Secondary Industry	Tertiary Industry	Structure / Year	Primary Industry	Secondary Industry	Tertiary Industry
2005	0.5639	0.7206	0.6416	2013	0.7074	0.8454	0.7812
2006	0.6159	0.6716	0.6125	2014	0.7887	1.0000	0.9385
2007	0.6020	0.6412	0.5841	2015	0.9789	0.8856	0.8958
2008	0.5797	0.5993	0.5449	2016	0.6909	0.7221	0.6701
2009	0.5870	0.6118	0.5566	2017	0.4920	0.6393	0.5590
2010	0.6151	0.6357	0.5818	2018	0.4254	0.5296	0.4586
2011	0.6767	0.6576	0.6110	2019	0.3807	0.4479	0.3869
2012	0.7255	0.7207	0.6749	2020	0.3853	0.4067	0.3560

From the analysis of the grey correlation coefficient and its mean grey correlation degree obtained from the above table, the grey correlation degree between Shandong Province's GDP and the primary industry is 0.6135, the grey correlation degree with the secondary industry is 0.6710, and the grey correlation degree with the tertiary industry is 0.6158. So, the correlation of the three industries to

economic development in Shandong Province is the secondary industry, the tertiary industry and the primary industry in descending order. Based on the data from 2000 to 2015, Li Aijing concluded that the correlation order of the three industrial structures in Shandong Province to economic growth is that the secondary industry is the most important, the tertiary industry is the second, and the primary industry is the last [2]. Although the results still show a pattern of secondary-tertiary-primary, the difference is that the correlation between the three industries in the results of this paper is relatively small. But by analyzing its changing trend, it can be seen that the changing trends of the three industries and economic development are relatively consistent, and the relationship between the same increase and decrease is approximately maintained. The secondary industry has maintained the highest correlation for a long time, and only a few years have its gray correlation coefficient lower than that of other industries.

5.2. An Analysis of Grey Correlation Between Shandong's GDP and Other Economic Industries

According to the data and model, this paper calculates the gray correlation between GDP and other economic industries in Shandong Province from 2006 to 2020, as shown in Table 2 below.

Table 2: The grey correlation degree and ranking of other economic industries and GDP in Shandong Province

Economic Aggregate	Industrial Ownership	Specific Industry Category	Grey Relational Degree	sort
GDP Value Added	Primary Industry	Agriculture, Forestry, Animal Husbandry and Fishery	0.7114	5
	Secondary Industry	Industry	0.6946	7
		Construction Industry	0.8156	2
	Tertiary Industry	Accommodation and Catering	0.8463	1
		Transportation, Warehousing and Postal Industry	0.8142	3
		Real Estate Business	0.7665	4
		Wholesale and Retail Trade	0.7069	6
		Other Industry	0.6045	8
		Financial Industry	0.5961	9

According to the calculation results, except for the financial industry, the gray correlation between the calculated nine industries and GDP exceeded 0.6, and three of them exceeded 0.8, namely accommodation and catering, construction and transportation, warehousing and postal industry three economic industries. It can be seen that these three industries are closely related to the economic development of Shandong Province. Shandong Province has been rich in catering to raw materials such as grain, vegetables and seafood since ancient times. The advantages of rich resources and the profound history of Shandong cuisine make the catering industry in the forefront of the country and have a strong impact on economic development; in addition, the degree of correlation is relatively high. The high level of construction industry shows that the economic development of Shandong Province is still closely related to the construction industry, which is related to the large population base in Shandong Province and the imperfect urban infrastructure. The development of transportation, warehousing and postal industries mainly represents the development of the logistics industry. The development of the logistics industry in the province is inseparable from its geographical location and the development of logistics infrastructure. The history of manufacturing and industrial development has also laid the foundation for the development of the logistics industry.

The industries with a relatively middle level of correlation are real estate, agriculture, forestry, animal husbandry and fishery, wholesale and retail, and industry in order of gray correlation, all of which are higher than 0.69, indicating that the development of these economic industries in Shandong Province is inferior to accommodation and catering. Industry, construction and transportation, warehousing and postal services, but the correlation is still not low, which shows that these industries still have a relatively important position.

Finally, the two economic industries with the lowest gray correlation degree are other industries and the financial industry, both of which are approximately equal to 0.6. Other industries mainly include economic industries other than the other eight industries mentioned above, such as information technology, sports and entertainment, residential services and business services, all of which belong to the category of the tertiary industry. It reflects infrastructure, public utilities, technological innovation and other aspects still should be strengthened in Shandong Province. Shandong. Additionally, compared with other economic industries studied, although the correlation between the financial industry and economic development ranks last, it is still numerically high, indicating that the relationship between them is also relatively close. The rapid economic growth is inseparable from the support of the financial industry. The development of the financial industry will play a synergistic role in the development of other industries, so it must be paid attention to.

6. Conclusion

This paper selects the three industries and other economic industries to study the gray correlation degree between them and Shandong Province's GDP respectively, to explain the relationship between Shandong Province's economic development and industrial structure. According to the empirical analysis results, it can be concluded that the current three industrial patterns in Shandong Province are still "secondary-tertiary-primary", but the gray correlation gap between each industry and GDP has narrowed. Also, there is a relatively close relationship between the selected nine other economic industries and the economy of Shandong Province, but the order of their gray correlation degree is accommodation and catering industry > construction industry > transportation, warehousing and postal industry > real estate industry > Agriculture, Forestry, Animal Husbandry and Fisheries > Wholesale and Retail Industry > Industry > Other Industries > Financial Industry. Starting from the results, this paper puts forward the following relevant suggestions for the future economic development of Shandong Province.

(1) Accelerate the adjustment of industrial structure and cultivate new consumption hotspots.

At this stage, there is still a certain gap between Shandong Province and a reasonable and high-quality " secondary-tertiary-primary " industrial structure. Therefore, the transformation and upgrading of the province's industrial structure should be appropriately accelerated. Taking the cultivation of new consumption hotspots as the starting point, further economic growth should be promoted. With the improvement of residents' living standards, consumption is more and more personalized, customized and diversified, so the emergence of consumption hotspots tends to be gradual. Supported by new technologies and new concepts, promoting the development of industries and services meets the needs of the public to keep pace with the times, giving play to the role of economic leverage, supporting consumption hotspots with advanced high-tech industries, optimizing and upgrading the industrial structure should be available.

(2) Relying on the advantages of the secondary industry, innovation-driven upgrading.

The traditional industrial sector is the advantage and focus of economic development in Shandong Province, but in the current environment, the government of Shandong Province needs to speed up the upgrading of industrial technology, enhance the independent innovation ability of enterprises, improve the depth and precision of processing, and accelerate the optimization and upgrading of traditional industrial structure as well. On the premise of maintaining the industrial advantages of the province, it should further improve its efficiency with innovation and technology, and on this basis drive the development of other industries. Starting from the adjustment of the industrial chain, it is a good choice to extend the original imperfect industrial chain and use a variety of economic means to create a high-end industrial chain. Combined with its own resource advantages, it should promote the further development of the blue ocean industry and create a modern integrated ocean industry chain structure.

References

[1] Li Xianghong, He Yuting. The optimization effect of green credit on industrial structure in Heilongjiang Province——Based on grey relational analysis [J]. China Collective Economy, 2021(22): 120-122.

[2] Li Aijing.Grey Correlation Analysis of Industrial Structure and Economic Growth in Shandong Province [J]. Business Economics Research, 2018(03): 187-189.

[3] Liu Xiaoli, Liu Dingxiang. Grey Correlation Analysis of Chongqing's Economic Growth and Industrial Structure [J]. Statistics and Decision Making, 2010(13): 122-124. DOI: 10.13546/j.cnki. tjyjc.2010.13.026.

[4] Peng Jizeng, Sun Zhongmei, Huang Xin. An Empirical Analysis of the Coordinated Development of Industrial Structure and Economy Based on Grey Relation Theory——Taking Jiangxi Province as an Example [J]. Economic Geography, 2015, 35(08): 123-128. DOI: 10.15957/ j.cnki.jjdl.2015.08.017.

[5] Peng Liangyu. Research on the relationship between industrial structure and economic growth in Anhui Province based on grey relational analysis [J]. Henan Science and Technology, 2021, 40(30): 116-119.

[6] Qian Mengyao, Sun Yingjun. Evaluation of Industrial Structure in Henan Province and Its Relationship with Economic Growth [J]. Science and Technology and Industry, 2021, 21(08): 180-184.

[7] Ran Ruipei. Research on the Economic Growth Effect of Chongqing High-tech Industry Development under the Background of Chengdu-Chongqing Shuangcheng Economic Circle [J]. Contemporary Financial Research, 2021(Z5): 91-101.

[8] Wu Zhiqiang. Analysis of the Effect of Green Finance on Industrial Structure Adjustment: Taking the Central Province as an Example [J]. Journal of Chengdu Administration Institute, 2021(04): 39-45.

[9] Xu Lei, Zhang Beini. Grey Prediction Analysis of Industrial Structure in Shandong Province [J]. Dongyue Lun Cong, 2006(06): 73-75.

[10] Zhao Jing, Liu Bingquan. Grey Correlation Analysis of Industrial Structure and Economic Growth in ShandongProvince [J]. HenanScience, 2014, 32(06): 11151118. DOI: 10.13537/j.issn.10043918. 2014.06.00.

[11] Zhu Fangyang, He Yanyan, Zhu Zhidong. Research on the Influence of Port Logistics on Regional Economic Development——Taking Beibu Gulf Port as an Example [J]. Northern Economic and Trade, 2021(09): 127-130.