Research on the Change Trend of Economic Development in Shandong Province under the "Dual Carbon" Goal

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Abstract. With the proposal of a "dual carbon" goal and the demand for addressing climate change, Shandong Province is facing the challenge of promoting economic transformation and upgrading and promoting the development of the low-carbon economy. An accurate and reasonable economic forecast is helpful to provide some reference for the economic growth and change of Shandong Province. This paper analyzes multiple types of economic factors and uses the Granger causality test and gray relational analysis to screen the key factors affecting the economic level. Then, the regression analysis method is used to predict the economic level of Shandong Province under the baseline scenario and the deep low-carbon scenario, and analyze the economic development trend of Shandong Province, to provide a valuable reference for Shandong Province to achieve low-carbon economic development under the dual-carbon background.

Keywords: economic forecast; gray relational analysis; GDP; multiple regression model

1 Introduction

With China's proposed "dual carbon" aim and worldwide demand for tackling climate change, Shandong Province is also faced with the problem of fostering economic transformation and upgrading and establishing a low-carbon economy while attaining sustainable economic growth. Examining the rates at which various key factors contribute to economic growth can aid in discovering and forming new economic driving forces. As a result, economic forecasting based on thoroughly examining the elements influencing the economic level is critical for studying the changing pattern of economic development in Shandong Province.

Scholars investigated the influencing variables of the quality of economic development primarily from two perspectives: the factors that encourage economic growth and the effects of various factors on the quality of the economy. Ref. [1] pointed out that policy, environment, and resources are significant elements influencing economic de-

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velopment. Ref. [2] considered labor force quality to be an essential indication of economic level and concluded that there is a substantial difference in total factor productivity between economically backward and economically developed countries. According to Ref. [3], different influencing elements affect countries at various stages of development, and people's quality of life and educational workforce have a substantial positive impact on economic growth, particularly in less developed regions. According to Ref. [4], innovation is crucial to economic growth. According to Ref. [5-6], education reform and human capital renewal are significant approaches to achieving high-quality economic development. The preceding literature examined many economic aspects from various perspectives and served as a resource for future research.

Scholars frequently employed quantitative forecasting methods to forecast the economy and its output value. Time series forecasting and structural analysis forecasting are the two basic types of quantitative economic forecasting. Based on developing a time series model, Ref. [7] predicted the change in my country's GDP growth rate. The ARIMA model was used in Ref. [8] to forecast Shanghai's GDP growth rate from 2010 to 2015. However, time series models are frequently employed for short-term forecasting and do not consider fundamental changes in economic fundamentals. The structural forecast approach compensates for this flaw. Ref. [9] anticipated China's GDP growth rate from 2015 to 2065 using the Cobb-Douglas economic projection model and assumption on the labor force, capital input, labor income share, and technical development growth rate. Ref. [10] anticipated the economic growth rate under the scenarios of green policy, investment, technology, and consumption. All of the economic forecasting approaches discussed above are linear forecasting. In Ref. [11], an economic forecasting model based on a neural network was established to conduct nonlinear forecasting of economic data. Most estimates of economic aggregate and production value in the preceding literature only consider short- and medium-term economic changes under the current development scenario. Few academics have integrated the current situation with low-carbon ambitions to forecast GDP levels under various scenarios.

To summarise, given China's proposed "dual carbon" target and global demand for tackling climate change, Shandong Province has the task of fostering economic transformation, upgrading, and establishing a low-carbon economy. This study analyses numerous economic aspects and uses the Granger causality test and grey relational analysis to screen the essential elements impacting economic levels to improve the accuracy and rationality of economic forecasting. The regression analysis method is then used to predict Shandong Province's economic level under the baseline scenario and the deep low-carbon scenario, analyze Shandong Province's economic development trend, and provide a specific reference for Shandong Province's low-carbon economic development under the dual-carbon background.

2 Analysis of economic characteristics of Shandong province

2.1 Overview of economic development

Connecting the Beijing-Tianjin-Hebei region and the Yangtze River Delta, Shandong Province is an essential industrial base in the country and a key area of economic development in the northern region. Its strategic position in radiating and driving regional economic development has become increasingly prominent. It can be seen from Figure 1 that the overall GDP growth rate of Shandong Province has shown a downward trend in recent years, but its economic development is still at a relatively high level. The development trend is as follows: From 2000 to 2022, the total GDP of Shandong Province increased from 827.8 billion yuan to 8,743.5 billion yuan. After 2005, Shandong Province showed an overall downward trend, falling to 3.6% in 2020 and rising to 8.3% in 2021, higher than the national average growth rate. In 2021, the total GDP of Shandong Province ranked third, second only to Guangdong and Jiangsu province.

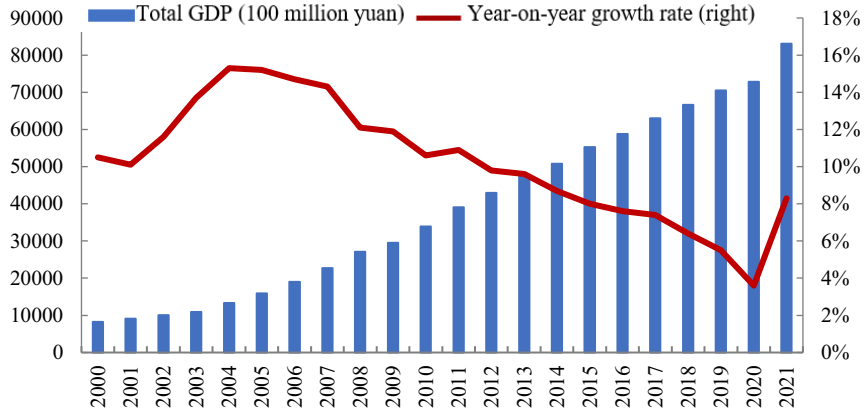

Fig. 1. The total GDP and year-on-year growth rate from 2000 to 2021.

2.2 Regional growth profile

This paper further analyzes the economic development advantages of various regions in Shandong Province from the perspective of internal structure changes. As can be seen from Figure 2, the year-on-year GDP growth rates of the three major economic circles, namely the provincial capital economic circle, the Jiaodong economic circle, and the southern Shandong economic circle are the same.

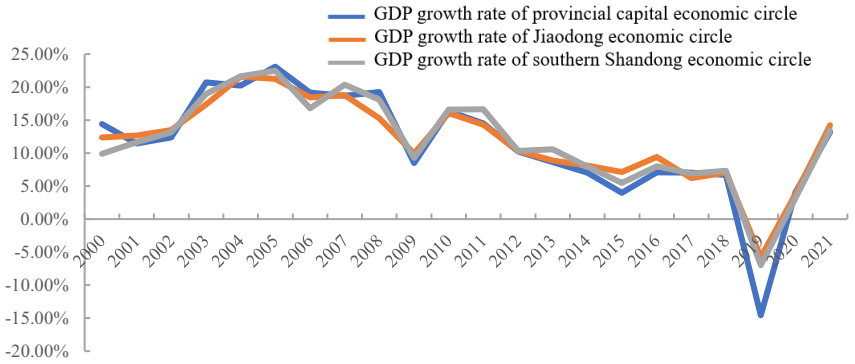

Fig. 2. Year-on-year GDP growth rate of the three major economic circles

3 Economic forecast model

This paper examines the causal relationship and correlation between economic growth, industrial structure, urbanization rate, and other factors in Shandong Province, as well as the most important influencing factors, using the Granger causality test and grey correlation analysis approach. And using the multiple regression analysis approach, establish the relationship between the key influencing elements and GDP and its growth rate, and forecast Shandong Province's economic level.

3.1 Identifying the factors affecting the economy

In this study, the influencing elements of economic growth are chosen from the perspectives of time, space, and industry. Eight influencing factors are selected for a grey correlation analysis taking into account the data's accessibility and making use of previous studies. The analysis's findings are displayed in Table 1. Except for the permanent resident population at the end of the year, parameters have a substantial link with economic growth, and the coefficient values are all greater than 0.65. Based on data availability, this article selects five major influencing elements for forecasting and analysis: carbon emissions, urbanization rate, foreign direct investment, total retail sales of social consumer goods, and local general budgetary revenue.

Table 1. Gray correlation coefficient

Influencing factors	Gray relational degree
Per capita disposable income of urban residents	0.827
foreign direct investment	0.806
The total retail sales of social consumer goods	0.776
General budget revenue of local finance	0.698
urbanization rate	0.690
physical capital stock	0.684
carbon emission	0.669
Permanent population at the end of the year	0.638

3.2 Construction of multiple regression model

Many factors influence economic development and change, and using multiple regression analysis approaches for forecasting can yield substantial results. This article analyses several economic aspects and uses multiple regression analysis to estimate the future economic level based on historical data published by the National Bureau of Statistics and the Statistical Yearbook of Shandong Province. The multiple regression model's calculation formula is as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_m X_m + \varepsilon \tag{1}$$

Among them: β_0 is a constant; β_1, β_2 , ..., β_m is the sample partial regression coefficient; ε is the random error after removing the influence of m independent variables on Y.

4 Empirical analysis

4.1 Scene settings

This research establishes a baseline scenario (i.e., a zero-carbon scenario) and a deep low-carbon scenario to compare and analyze Shandong Province's economic level under various scenarios. Shandong Province's benchmark scenario is to achieve economic and social zero-carbon development and a carbon circular economy. The deep low-carbon scenario aims to achieve overall carbon neutrality by 2060.

4.2 Prediction results and analysis

4.2.1 Forecast results of economic aggregate and growth rate in Shandong Province.

Based on the constructed multiple regression analysis model and relevant data, this research is used to predict GDP and economic growth. The prediction model is as follows:

$$Y_1 = 0.523CE - 0.041CP + 1.39CI - 0.357SC - 5.35 \tag{2}$$

$$Y_2 = -0.394CE + 0.214CR + 0.082FI + 0.086SC - 0.080GBR + 2.976 \tag{3}$$

Among them, Y1 is GDP, Y2 is GDP growth rate, CE is carbon emissions, CP is physical capital stock, CI is disposable income of urban residents, SC is total retail sales of social consumer goods, CR is urbanization rate, FI is foreign direct investment, SC is the total retail sales of social consumer goods, GBR is the general budget revenue of local finance, and the above parameters are taken as natural logarithms.

The total GDP and growth rate from 2000 to 2021 can be calculated using the above model, as illustrated in Figure 3 and Figure 4, respectively. The figure shows that the

GDP total and growth rate prediction model has an excellent fitting effect and can produce more accurate forecast results.

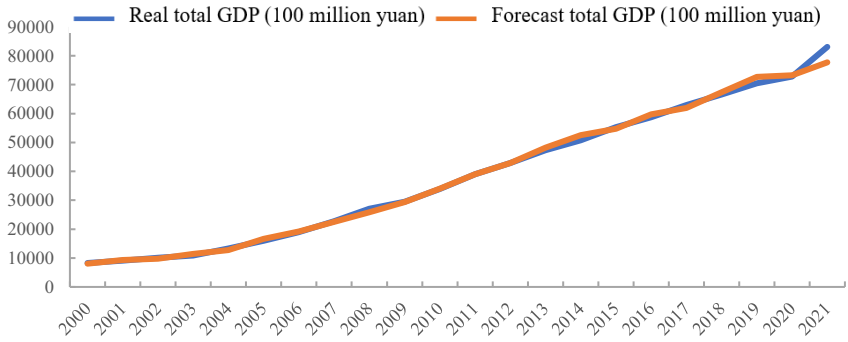

Fig. 3. Total GDP from 2000 to 2021

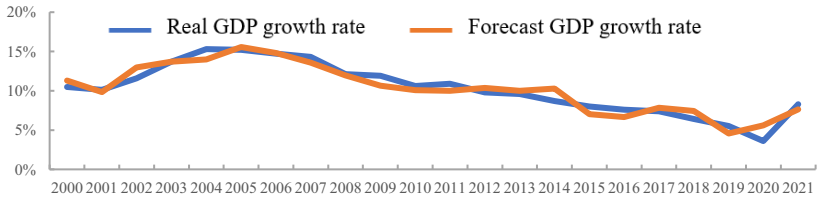

Fig. 4. GDP growth rate from 2000 to 2021

This article compares and analyses the GDP growth rates under the baseline scenario and the deep low-carbon scenario, as shown in Figure 5 and Figure 6, to further analyze the economic development of Shandong Province under different scenarios. The figure shows that the GDP growth rate in the baseline scenario is faster than that in the deep low-carbon scenario. The economy of Shandong Province is predicted to sustain stable growth in the mid-to-long term to the long time, with the growth rate progressively declining. In 2050-2060, the average annual GDP growth rate will be around 1.5%, with per capita GDP exceeding the national average.

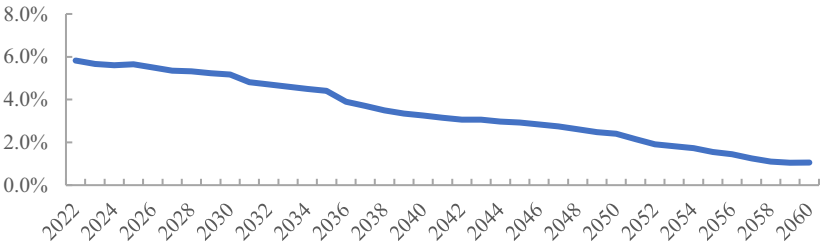

Fig. 5. Forecast GDP growth under the baseline scenario

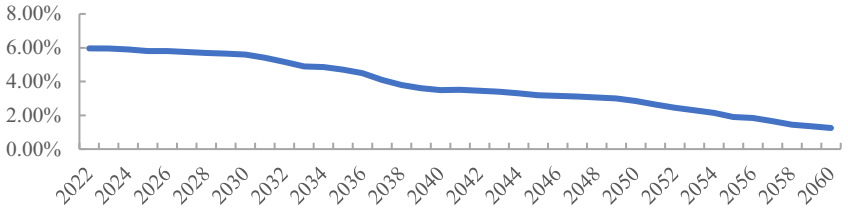

Fig. 6. Forecast GDP growth rate under a deep low-carbon scenario

4.2.2 Prediction results of industrial structure in Shandong province.

According to 4.2.1, Shandong Province's economic development level is high in the baseline scenario. This report forecasts the industrial structure of Shandong Province from 2023 to 2025 using the baseline scenario. Figure 5 depicts the prediction findings. Figure 7 shows that the proportion of tertiary industry in Shandong Province will increase from 2023 to 2025, reaching 54.5% in 2025.

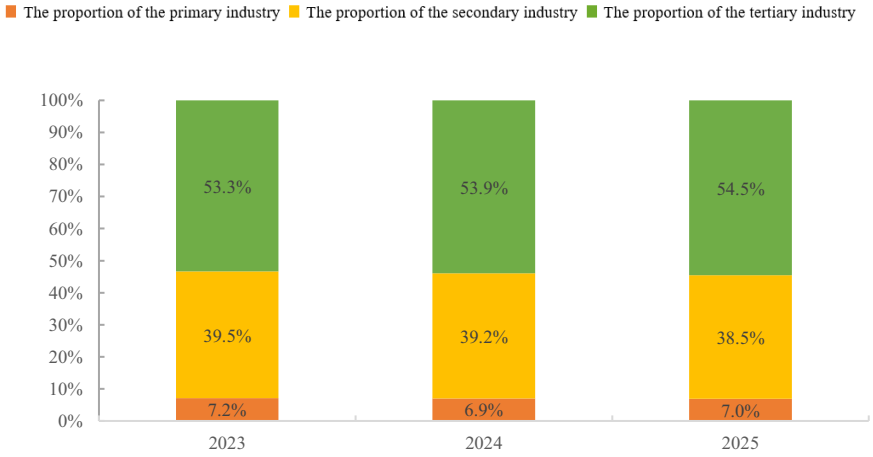

Fig. 7. Prediction results of the industrial structure under the benchmark scenario

4.2.3 Regional economic aggregate and growth forecast results in the province.

Focusing on the economic development level of the three major economic circles in Shandong Province, this paper uses the regression model to predict the GDP growth rate of the three major economic circles. It can be seen from Table 2 that, except for 2060, the GDP growth rate of the provincial capital economic circle in each stage is relatively high. At the same time, the GDP growth rates of the Jiaodong economic circle and the southern Shandong economic circle also showed a similar trend. The growth rate in each stage was slightly lower than that of the provincial capital economic circle, but the overall growth remained stable.

Table 2. Forecast of the GDP growth rate of the three major economic circles (unit: %)

Year	2025	2030	2035	2040	2045	2050	2060
Provincial capital GDP growth rate	4.3	3.7	3.1	2.7	2.4	2.1	1.8
Jiaodong GDP growth rate	4.3	3.6	3.1	2.7	2.4	2.1	1.8
Southern Shandong GDP growth rate	4.2	3.6	3.0	2.6	2.3	2.1	1.9

5 Conclusion

This paper uses the grey correlation analysis method to identify the key influencing factors of the economic level. Then it uses the multiple regression analysis model to predict the economic level and growth rate of Shandong Province, which provides a specific reference for promoting the development of a low-carbon economy. The research conclusion is as follows:

(1) Carbon emissions, urbanization rate, foreign direct investment, disposable income of urban residents, and total retail sales of social consumer items are all significant predictors of economic growth in Shandong Province.

(2) Compared to deep low-carbon manufacturers, Shandong Province's economic level is higher under the baseline scenario, and the economic aggregate is predicted to continue stable growth.

(3) Among the three major economic circles in Shandong Province, the GDP growth rate of the provincial capital economic circle is relatively high. In contrast, the GDP growth rate of the Jiaodong and southern Shandong economic circles is slightly lower but generally stable.

Acknowledgments

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