GDP Forecast of Jinan and Hefei based on LSTM and the Transformation Enlightenment of Old Industrial City Jinan

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Abstract. Jinan City, Shandong Province, is one of the important cities in modern industrial production and development in China. It plays an important role in the industrial history of modern China and has a very rich industrial cultural heritage. Hefei City, Anhui Province, from a small city, through reform and innovation, has become a rising star of Chinese cities, with per capita GDP approaching Jinan. In this paper, the single variable time series prediction model based on LSTM is used to fit the Area GDP of Jinan and Hefei in 31 years from 1990 to 2020, and the Area GDP data of the two cities in the next three years is predicted. Finally, combined with the development of foreign old industrial cities, this paper puts forward some suggestions for the future development of Jinan.

Keywords: GDP; Forecasting; Single Variable Time Series Forecasting Model based on LSTM; Jinan; Hefei; Transformation of Old Industrial Cities.

1. Introduction

In 2005, Yin [1] studied the development and characteristics of modern Jinan urban industry, and concluded that in the 1930s, Jinan, as a model of "non-treaty ports" economic development in the late Qing Dynasty, port opening and trade changed the traditional consumption demand of Jinan, produced new consumption areas, opened up new consumption and market space for Jinan, and provided a lot of funds and consumption channels for Jinan, it also has a huge impact on the national industry of Jinan, so it promotes the positive development of modern machine industry in Jinan. Therefore, since the opening of the port and trade, the industrial level of Jinan has gradually improved, which made Jinan become one of the most important cities in modern industrial production and development in China, which plays a very important role in the industrial development of China. The Area GDP of Jinan has always been in the forefront of China's provincial capital cities. In 2016, Gu[2] analyzed the economic development of Hefei in the 12th Five Year Plan, and found that although Hefei's economic development has been restricted for a long time due to natural endowment, historical foundation, development opportunities and other factors, since the 12th Five Year Plan, Hefei has been promoted to implement the scientific outlook on development, and its economic growth vitality and competitiveness have increased significantly. During the 13th Five Year Plan period, based on the position of world-class city cluster sub center in Yangtze River Delta, in 2020, the total GDP will be close to Jinan. Hefei, as an emerging city, mainly develops high-tech industry and education industry, which practices the correctness of innovation driven development and provides direction for the development of many old industrial cities.

Therefore, analyzing the trend of Area GDP of Jinan and Hefei, and using the time series model to predict the future Area GDP of Hefei and Jinan, can provide some reference for the development of the same old industrial cities as Jinan. Different from the traditional prediction method of time series model, Xiao et al [3]. Studied in 2020 that the deep learning neural network LSTM can better study the non-linear trend of Area GDP, and improve the short-term Area GDP prediction ability. Therefore, this paper uses the single variable time series prediction model based on LSTM to fit the Area GDP data of Hefei and Jinan from 1990 to 2020, and forecasts the Area GDP of the two cities in the next three years according to the model, and draws the time series diagram of Area GDP of Hefei and Jinan. Finally, according to the Area GDP forecast results and the development experience of foreign old industrial cities, this paper puts forward some suggestions for the future development of Jinan.

2. Single Variable Time Series Forecasting Model based on LSTM

2.1 Data Sources

The research objects are Jinan and Hefei, and the research interval is from 1990 to 2020. The data are from the statistical yearbook of Anhui Province and Shandong Province from 1990 to 2020, as well as the Statistical Yearbook published on the official website of China Bureau of statistics.

2.2 The Single Variable Time Series Prediction Model LSTM (Long and Short Memory Neural Network)

Based on LSTM is a kind of recurrent neural network applied in deep learning, which can learn long-term dependence. At the same time, in order to solve the long-term dependence problem of general RNN, LSTM is also a special RNN.

2.2.1 LSTM Structure

LSTM uses three "Gates" to control the input and output states at different times. Forgetting gate is used to make RNN "forget" the useless information before; input gate is used to let RNN decide which information will be left in the current input data; output gate is used to make LSTM decide the output of current node by combining the output of previous node and the input of current node after getting the latest node status.

2.2.2 LSTM Training Process

- (1) Create data set and load data, process data, normalize to 0 ~ 1.
- (2) Create and divide training set and test set.
- (3) Create LSTM neural network model and draw network structure.
- (4) The model is used to predict and the data is de normalized.
- (5) Calculate training score and test score by using RMSE and calculate the R^2 of the single variable time series prediction model LSTM.

3. Result Analysis

3.1 Single Variable Time Series Model Fitting and Prediction Results based on LSTM

3.1.1 Model Fitting Related Data

Table 1. Area GDP of Hefei from 1990 to 2020

Year	Area GDP (trillion)	Year	Area GDP (trillion)	Year	Area GDP (trillion)	Year	Area GDP (trillion)
1990	58.19	1998	270.47	2006	1073.76	2014	5180.56
1991	59.69	1999	294.45	2007	1334.61	2015	5660.3
1992	71.32	2000	324.73	2008	1664.84	2016	6274
1993	97.4	2001	363.44	2009	2102.12	2017	7213.45
1994	131.82	2002	412.81	2010	2701.61	2018	7822.9
1995	167.58	2003	484.96	2011	3600	2019	9409.4
1996	211.59	2004	589.7	2012	4100	2020	10045.72
1997	248.99	2005	853.57	2013	4672.91		

Table 2. Area GDP of Jinan from 1990 to 2020

Year	Area GDP(trillion)	Year	Area GDP(trillion)	Year	Area GDP(trillion)	Year	Area GDP(trillion)
1990	131.1	1998	812.16	2006	2158.09	2014	5770.6
1991	149.7	1999	881.32	2007	2562.81	2015	6100.23
1992	194.37	2000	952.18	2008	3006.77	2016	6536.1
1993	274.76	2001	1066.16	2009	3340.91	2017	7201.96
1994	362	2002	1200.83	2010	3910.53	2018	7856.56
1995	418.52	2003	1365.33	2011	4406.29	2019	9443.4
1996	611.88	2004	1600.16	2012	4825.1	2020	10140.91
1997	731.7	2005	1876.61	2013	5230.19

Figure 1. Area GDP time series of Hefei and Jinan

3.1.2 Fitting Level Evaluation and Prediction Results of Single Variable Time Series Prediction Model based on LSTM

To verify the fitting effect of the model, the 28-year data of Hefei and Jinan from 1990 to 2017 are used as the training set, and the three-year data from 2018 to 2020 are used as the test set to test the fitting effect of the model.

Table 3. Prediction and error of single variable time series prediction model based on LSTM for test set

Year variable	Hefei's real GDP (trillion)	GDP calculated by the model (trillion)	Error rate
2018	7822.9	8062.192	3.1%
2019	9409.4	9081.348	3.5%
2020	10045.72	10490.802	4.4%
Year variable	Jinan's real GDP (trillion)	GDP calculated by the model (trillion)	Error rate
2018	7856.56	8035.839	2.3%
2019	9443.4	9087.294	3.8%
2020	10140.91	10573.764	4.2%

Table 4. Fitting effect of single variable time series prediction model based on LSTM on test set

City variable	Training score RMSE (trillion)	Test score RMSE (trillion)	R ²
Hefei	102.72	347.84	0.8615
Jinan	87.06	339.76	0.8737

Table 5. Area GDP forecast results of Jinan and Hefei in the next three years based on LSTM single variable time series forecast model

year variable	GDP forecast of Jinan (trillion)	GDP forecast of Hefei (trillion)
2021	10628.4	10584.477
2022	11518.756	11230.501
2023	12430.859	11875.721

3.2 Analysis of Model Results

According to Table 1, Table 2 and Figure 1, we can see that from 1990 to 2015, there is a big difference in the Area GDP between Jinan and Hefei. The Area GDP of Jinan is much higher than that of Hefei. At the same time, it is obvious that the Area GDP growth rate of Hefei rises during the 12th Five Year Plan period. From 2016, China's 13th Five Year Plan, Hefei's GDP is gradually approaching Jinan's, and in 2020, Hefei and Jinan will join the "Trillion City Club". At the same time, according to table 3 and table 4, it can be found that the single variable time series prediction model based on LSTM has low prediction error rate for GDP, R^2 of the model is close to 1, which indicates that the single variable time series prediction model based on LSTM has a good fitting effect on this group of data. Therefore, at last, we use the model to forecast the GDP of Jinan and Hefei from 2021 to 2023, and the results are shown in Table 5. We can see that the GDP level of Jinan is still at the leading level, while the GDP of Hefei is still in a state of rapid development.

4. Suggestions on the Future Transformation and Development of Jinan City

Through the analysis of the methods of Pittsburgh, Manchester and Liz [4-6], the successful transformation of the old industrial cities in foreign countries, we can put forward some enlightenment and suggestions for the urban transformation and economic development of Jinan in the future.

Establish appropriate urban development strategy. For example, Pittsburgh of the United States defined the innovation driven urban development strategy, and Manchester positioned its own development as a postindustrial sustainable development city. The establishment of urban development strategy has a very important significance and role in the urban planning system, which can comprehensively coordinate and arrange the elements that have an important impact on the long-term development of the city in the future. At the same time, we should break through the traditional concept of planning, correctly understand and treat the current situation of the city.

Make urban planning more comprehensive. The innovation of urban planning should not be limited to one aspect, but should be carried out in the aspects of system, knowledge, service, technology and so on.

Improve the regional intensification of planning space. We should formulate appropriate regional planning, promote the balanced development of each region of the city, and integrate the old city reconstruction and new city planning into the overall planning, to realize the optimal allocation of resources in regional space.

5. Summary

In this paper, the single variable time series forecasting model based on LSTM is used to fit and forecast the GDP of Jinan and Hefei:

- (1) Since the 12th Five Year Plan, Hefei's GDP has been close to that of Jinan.
- (2) The single variable time series forecasting model based on LSTM has a good fitting effect on GDP.
- (3) In the future, Jinan's GDP may continue to be higher than Hefei's, but at the same time, the growth rate of Hefei's GDP will remain at a high level.

Finally, through the analysis of the methods of Pittsburgh, Manchester and Liz, the successful transformation of the old industrial cities in foreign countries, the paper puts forward suggestions for the transformation of such old industrial cities as Ji'nan, that is, to establish appropriate urban development strategies, to make urban planning more comprehensive and to improve the regional intensification of planning space.

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