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Regression Analysis of GDP Development of Cities in China — Taking Foshan and Fuzhou as Examples

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Abstract: GDP (Gross Domestic Product), is the final result of production activities of all resident units of a country (or region) in a certain period of time. GDP is not only a core indicator of national economic accounting, but also an important indicator of the economic situation and development level of a country or region. China is the largest developing country and the second largest economy in the world. Since reform and opening to the outsideworld, China's economy has maintained rapid growth, making a significant contribution to global economic growth. In 2020, China's GDP brokekthrough 100 trillion, became the only major economy in the world to achieve positive growth; in 2022, China's GDP reached 121 trillion, with a growth rate of 3%, and per capita GDP exceeded 12,000 dollars. With new momentum such as high-tech manufacturing and services growing, the quality of China's economic development has been steadily improving, residents' incomes basically synchronized with economic growth, and grain output stabilized at over 1.3 trillion pounds for eight consecutive years. Thus it can be seen, China's economy has showed strong resilience, potential and space to embrace a brighter future. Focusing on specific regions, the GDP of some prefectural-level cities in China has been developing rapidly, showing the trend of "a thousand sailboats are competing across the river". This phenomenon is most notable in the eastern part of China. Among them, Fuzhou City, capital of Fujian Province, and Foshan City, Guangdong Province, as two second-tier cities on the southeast coast, have received more attention for their GDP. In February 2023, the Foshan City Statistical Bureau released its GDP data for 2022: the total amount was 1,269.839 billion, with an incremental GDP of 54.185 billion and a nominal growth rate of 4.46%. Almost at the same time, Fuzhou City Statistical Bureau also released data: the city's GDP realized 1,230.823 billion in 2022, with a nominal growth rate of 8.69%, moving up two places in the national GDP ranking. The two cities met in the national GDP ranking, ranking 17th and 18th respectively. And Fuzhou City has achieved an astonishing nominal growth rate of 8.69 %, also proved the importance of the strong provincial capital strategy for Fujian. These two cities, to a certain extent, also condensed the development status of the Fuxia Economic Circle and the Zhujiang Triangle Economic Circle, predicting and analyzing the economic significance of the GDP data of these two cities. This paper analyzes the GDP data of Foshan City and Fuzhou City based on the development in recent years, and tries to perform simple OLS linear regression analysis on its data through using statsmodels.api, matplotlib and so on in Python software, and selects the year of use reasonably according to the regression results to predict the GDP of the two cities in the future and provide the basic suggestions in a simple way.

Keywords: Linear OLS Model; GDP Forecast; Foshan; Fuzhou

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1. Data Description

In this paper, we first refer to the table of *GDP Ranking of Chinese Cities in 2022*, and obtain the GDP ranking of Foshan City and Fuzhou City, which is close to each other. Besides, Fuzhou City has a larger growth rate, which has relevant research significance. And then enter the statistics database of *Chinese Economic Information Network* (tjk.cei.cn), and combine the relevant data from the websites of local statistics bureaus to check the GDP data of the two cities from 1991 to 2022, a total of 32 years, and organize them into a CSV format file with no missing values.

Rank	City	Provice & Rank	2021 Annual Rank	Change	2022(Hundred Million Yuan)	2021(Hundred Million Yuan)	Nominal growth rate	Actual growth rate
Nationwide					1210207.00	1143670.00	5.31%	3.00%
17	Foshan City	Guangdong Province & Rank3	17	0	12698.39	12156.54	4.46%	2.10%
18	Fuzhou City	Fujian Province & Rank1	20	2	12308.23	11324.48	8.69%	4.40%

Figure 1. Table of GDP Ranking of Chinese Cities in 2022 (excerpt)

1	Year	Foshan's GDI
2	1991	166.64
3	1992	253.39
4	1993	349.83
5	1994	436.37
6	1995	545.89
7	1996	637.44
8	1997	724.57
9	1998	782.56
10	1999	833.79
11	2000	1050.38
12	2001	1189.19
13	2002	1328.55
14	2003	1578.49
15	2004	1918.04
16	2005	2450.67
17	2006	3020.83
18	2007	3696.35
19	2008	4419.04
20	2009	4842.58
21	2010	5665.45
22	2011	6231.4
23	2012	6579.18
24	2013	7010.68
25	2014	7441.6
26	2015	8003.92
27	2016	8756.31
28	2017	9398.52

Figure 2. Overview of relevant CSV data files (excerpt)

2. Data Analysis Charts, Content and Results

2.1 Attempts at Direct OLS Regression for All Years

At the beginning of this paper, OLS regression analysis was conducted for all years, but the results were not satisfactory,

showing a large "a cliff-like" characteristics, which is a serious deviation from the actual economic situation. The results are plotted using the matplotlib package:

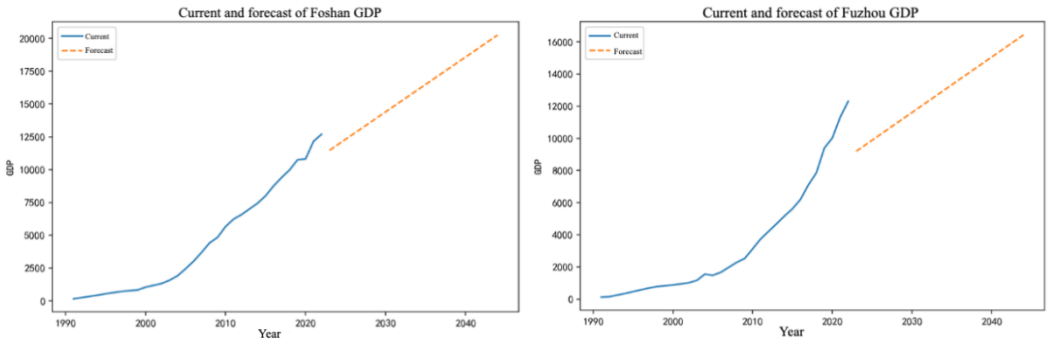

Figure 3. Plot of regression results from an attempted direct OLS regression for all years in both locations

As shown in Figure 3, the predicted data for 2023 is significantly lower than 2022, and the linear equation of the prediction shows that the slope of GDP in Fuzhou City is smaller than Foshan City. This prediction shows that it is impossible for Fuzhou City's GDP to exceed that of Foshan City, and the above conclusion deviates seriously from the real economic life. This paper believes that China's economy has had exponential growth for a certain period of time since reform and opening to the outsideworld, it is obviously inapplicable to use OLS regression method for all the years. Therefore, the sample data of 10 years will be analyzed below.

2.2 Plotting a Line Graph of the Trend of GDP Change in the Two Regions

Plotting a line graph of the trend of GDP change in the two regions over 10 years as follows:

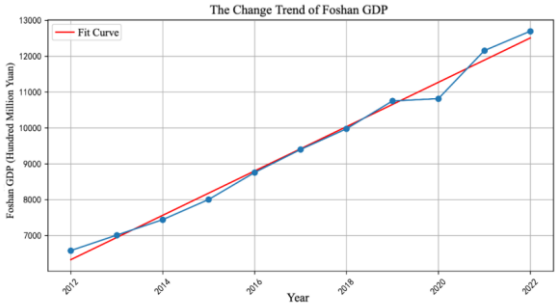

Figure 4. Trends in Foshan's GDP

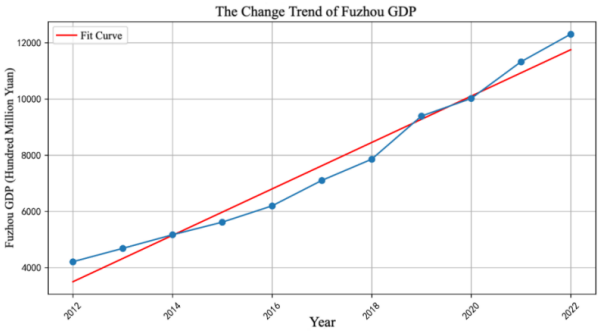

Figure 5. Trends in Fuzhou's GDP

As shown in Figures 4 and 5, the GDP of two cities have been steadily increasing over the last decade. Due to the impact of the Novel Coronavirus Pneumonia in 2020, the GDP of two cities slowed down significantly. Specific to the city: Foshan City, in addition to the Novel Coronavirus Pneumonia period, the rest of the year roughly linear growth, while Fuzhou City, the development of a slower pace before 2018, and after 2018 there is a period of rapid growth, the speed and magnitude of the increase is greater than that of Foshan City, which may be related to its proposed "strong provincial capital" strategy.

2.3 Inspection of Box-Line Diagram

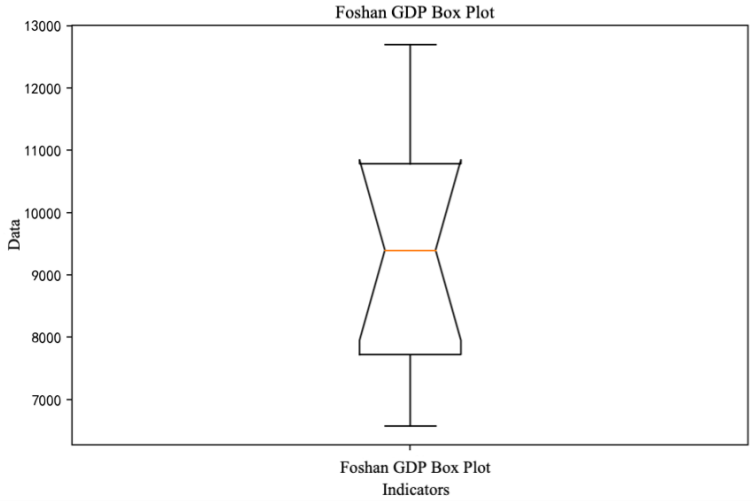

Figure 6. Box-Line Diagram of Foshan city GDP

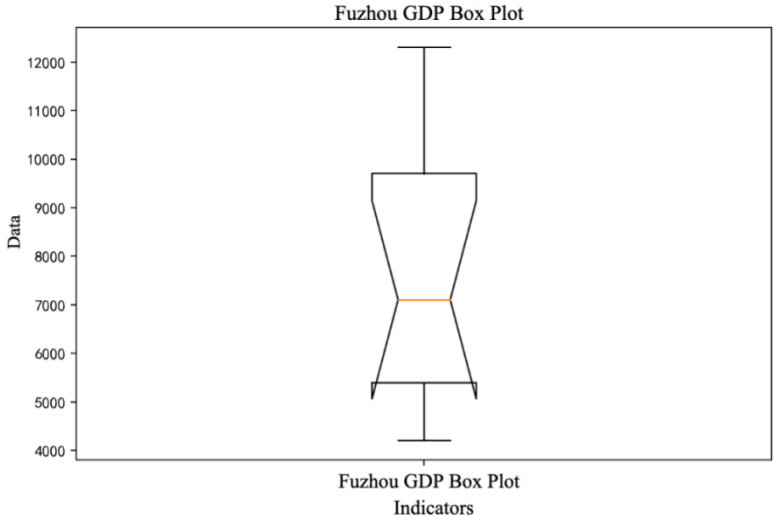

Figure 7. Box-Line Diagram of Fuzhou city GDP

According to the two box-line diagrams, there are no outliers in the GDP data of Foshan and Fuzhou city in the past 10 years, and the median GDP of Foshan City is larger than that of Fuzhou City, which demonstrates the prosperity of Foshan's economy, and also confirms the rapid development of Fuzhou city in recent years.

2.4 Linear Regression Results of Foshan City GDP Data by Using OLS Models

In this paper, we use the OLS function in the statsmodels.api to perform linear regression, and the results are as follows:

OLS Regression Results

Dep. Variable:	Foshan GDP	R-squared:	0.990
Model:	OLS	Adj. R-squared:	0.988
Method:	Least Squares	F-statistic:	852.6
Date:	Thu, 22 Jun 2023	Prob (F-statistic):	3.16e-10
Time:	12:16:52	Log-Likelihood:	-73.939
No. Observations:	11	AIC:	151.9
Df Residuals:	9	BIC:	152.7
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	-1.238e+06	4.27e+04	-28.979	0.000	-1.33e+06	-1.14e+06
Year	618.3519	21.177	29.200	0.000	570.447	666.257

Omnibus:	2.216	Durbin-Watson:	2.140
Prob(Omnibus):	0.330	Jarque-Bera (JB):	0.807
Skew:	-0.663	Prob(JB):	0.668
Kurtosis:	3.064	Cond. No.	1.29e+06

Figure 8. OLS linear regression results of Foshan's GDP

According to the regression results in Figure 8, this paper can get the following information:

1. Regression model: GDPfoshan=618.3519×year−1238000

2. The coefficient of determination R-squared is 0.990, which indicates that the model explains 99% of the variance and the fitting results is preferable.

3. The adjusted coefficient of determination Adj.R-squared is 0.988, which also shows a preferable fitting results after considering the influence of degree of freedom on the model.

4. The F-statistic is 852.6, corresponding to a probability value (Prob(F-statistic)) close to 0, indicating that the regression model is valid at the significance level.

5. Coef denotes the regression coefficient. The intercept (const) term is -1,238,000; the year term is 618.3519, which is means that for each additional year, Foshan's GDP is expected to increase by about 6.18 million.

6. P>|t| indicates the significance level of each variable. The P-values for both the intercept and year terms are close to 0, illustrating that they are valid at the significance level.

7. The confidence intervals ([0.025, 0.975]) indicate the 95% confidence intervals for the coefficient estimates of each variable. The confidence interval of the intercept term is [-133,000,000, -114,000,000] and the confidence interval of the year term is [570.447, 666.257].

Conclusion: the regression model is statistically valid, it can fit the relationship between Foshan's GDP and year better. According to the model prediction, the GDP of Foshan will increase by about 6.18 million for each additional year.

The prediction results are as follows:

Table 1. GDP Forecast for Foshan in 2023-2032

Year	Predicted Value of Foshan's GDP
2023	12925.89
2024	13544.25

2025	14162.60
2026	14780.95
2027	15399.30
2028	16017.65
2029	16636.01
2030	17254.36
2031	17872.71
2032	18491.06

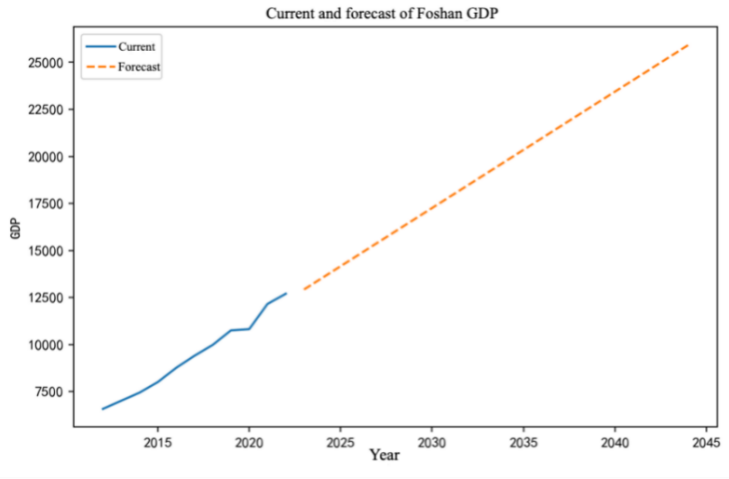

Figure 9. the Line Chart about Known and Predicted Value of Foshan's GDP

2.5 Linear Regression Results of Fuzhou City GDP Data by Using OLS Models

OLS Regression Results

Dep. Variable:	Fuzhou GDP	R-squared:	0.971
Model:	OLS	Adj. R-squared:	0.968
Method:	Least Squares	F-statistic:	301.1
Date:	Thu, 22 Jun 2023	Prob (F-statistic):	3.16e-08
Time:	12:17:55	Log-Likelihood:	-82.841
No. Observations:	11	AIC:	169.7
Df Residuals:	9	BIC:	170.5
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	-1.657e+06	9.59e+04	-17.274	0.000	-1.87e+06	-1.44e+06
Year	825.4904	47.569	17.354	0.000	717.882	933.099

Omnibus:	2.084	Durbin-Watson:	0.559
Prob(Omnibus):	0.353	Jarque-Bera (JB):	0.866
Skew:	0.025	Prob(JB):	0.648
Kurtosis:	1.626	Cond. No.	1.29e+06

Figure 10. OLS linear regression results of Fuzhou GDP

According to the results of OSL regression analysis about Fuzhou's GDP, this paper can get the following information:

1. Regression model: GDPfuzhou=825.4904×year−1657000

2. The coefficient of determination R-squared is 0.971, which indicates that the model explains 97.1% of the variance and the

fitting results is preferable.

3. The adjusted coefficient of determination Adj.R-squared is 0.968, which also shows a preferable fitting results after considering the influence of degree of freedom on the model.

4. The F-statistic is 301.1, corresponding to a probability value (Prob(F-statistic)) close to 0, indicating that the regression model is valid at the significance level.

5. Coef denotes the regression coefficient. The intercept (const) term is -1,657,000; the year term is 825.4904, which is means that for each additional year, Foshan's GDP is expected to increase by about 8.25 million.

6. P>|t| indicates the significance level of each variable. The P-values for both the intercept and year terms are close to 0, illustrating that they are valid at the significance level.

7. The confidence intervals ([0.025, 0.975]) indicate the 95% confidence intervals for the coefficient estimates of each variable. The confidence interval of the intercept term is [-1,870,000, -1,440,000] and the confidence interval of the year term is [717.882, 933.099].

Conclusion: the regression model is statistically valid, it can fit the relationship between Foshan's GDP and year better. According to the model prediction, the GDP of Foshan will increase by about 8.25 million for each additional year.

The prediction results are as follows:

Table 2. GDP Forecast for Fuzhou in 2023-2032

Year	Predicted Value of Fuzhou's GDP
2023	12967.08
2024	13792.57
2025	14618.06
2026	15443.55
2027	16269.04
2028	17094.53
2029	17920.02
2030	18745.51
2031	19571.00
2032	20396.49

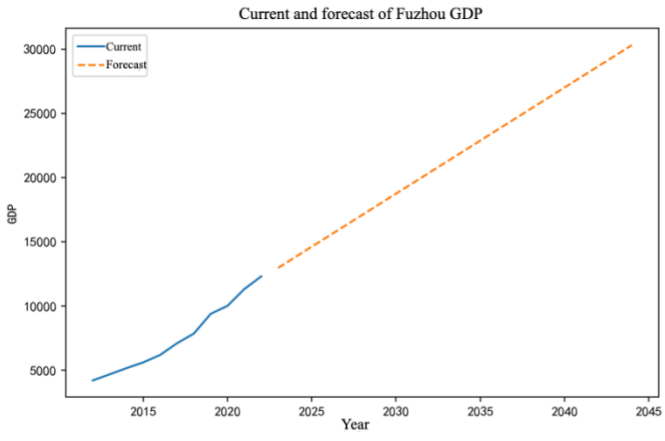

Figure 10. the Line Chart about Known and Predicted Value of Foshan's GDP

2.6 Comparison of Forecast Results between the Two Cities

According to the two regression models, it can be seen that for each additional year, the GDP of Fuzhou will increase by about 8.25 million and the GDP of Foshan will increase by about 6.18 million [1] . The rising trend of Fuzhou may be higher than Foshan, and the predicted GDP of the two cities in 2023 are 12925.89 and 12967.08 trillion respectively, which proves that the Fuzhou's GDP will exceed that of Foshan in 2023[2] , and the predicted GDP of the two cities after 10 years are shown below.

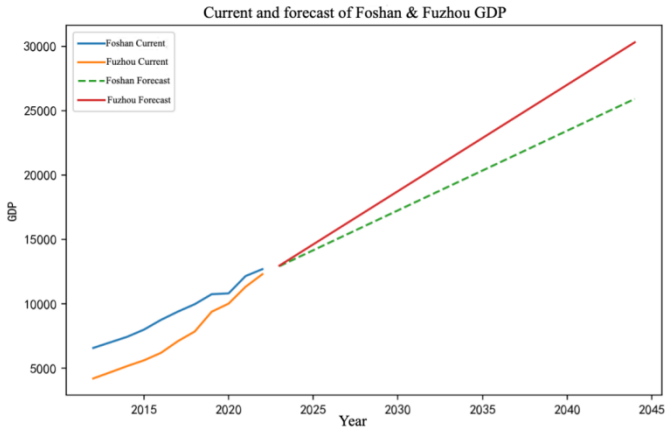

Figure 11. the Line Chart about Known and Predicted Value contrast between Foshan and Fuzhou's GDP

3. Conclusion

After analysis, this paper concludes that the development speed of Foshan City in recent years has seen a certain downward trend, which may be related to the overall low level of industry, low value-added products, unreasonable trade structure, insufficient innovation capacity and weak competitiveness of Zhujiang triangle district; In addition, there are also reasons such as excessive land development intensity, weak energy resource guarantee capacity[3] , prominent environmental pollution problems, prominent resource and environmental constraints and unsustainable traditional development models[4] . The reform tasks of administrative management system and social management system are still heavy, and the reform is becoming more and more difficult. Therefore, it is urgent to carry out supply-side structural reform and industrial transformation and upgrading in the Zhujiang triangle district.

Fuzhou, like most provincial capitals, has initiated the "strong provincial capital" strategy, and has achieved remarkable results, with a much higher GDP growth rate, which shows that the "strong provincial capital" strategy can be used as a reference for other provinces.

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