Coordination between Electricity Consumption and Economic Development in Tianjin

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Abstract. The paper use the unit root test, cointegration test, and granger test to study the relationship between power consumption and economic growth in Tianjin, and it is concluded that Tianjin's electricity consumption and economic growth influence each other and cause and effect each other. Economic growth depends strongly on electricity consumption and promotes the development of power industry. The increase of electricity consumption further promotes economic growth.

1. Introduction
As an important resource of material and social development, power energy has been providing power for the development of economy and society. Economic growth and power consumption show periodic fluctuation in the process of development. In view of the co-integration and periodic relationship between electricity consumption and economic growth, relevant scholars at home and abroad have carried out extensive research[1-2]. Based on Co-integration theory, Chen Bin and Chen Yinfeng respectively analyzed the relationship between economic growth and electricity consumption[3-4]. Based on empirical research, Yuan Jiahai and others show that there is a co-integration relationship between the trend series and the cycle series of power consumption and GDP[5]. This paper scientifically and reasonably analyses the long-term equilibrium relationship and fluctuation law between economic development and electricity consumption in Tianjin, which is conducive to the coordinated, stable and healthy development of economic growth and power industry.

2. Current Situation Analysis of Electricity Consumption and Economic Development in Tianjin

2.1. Economic Development
Figure 1 shows the overall situation of Tianjin's gross domestic product in the 19 years from 2000 to 2018, as well as the overall growth rate of Tianjin's gross domestic product (data sources and the National Bureau of Statistics). We can see that in the 19 years from 2000 to 2018, Tianjin's gross
domestic product is on the rise. In 2018, Tianjin's total GDP reached 188.09 billion yuan, an increase of 3.6% over the same period last year, and the growth rate of economic transformation is declining.

2.2. Electricity Consumption
Economic development can not be separated from the support of electric energy. Tianjin electric power industry started in 1888 and has a history of 128 years. For the convenience of statistical data, the power industry uses the whole society's electricity consumption to refer to the sum of electricity consumed in various fields, including agricultural electricity, commercial electricity, residential electricity, industrial electricity and other electricity. From 2010 to 2018, Tianjin's economy has developed rapidly. At the same time, the electricity consumption of the whole society has also been rising. The specific development process of the electricity consumption of the whole society in Tianjin is shown in Figure 2.
3. An Empirical Study on the Coordination between the Development of electricity consumption and economic development in Tianjin

In view of the cointegration and periodic relationship between power consumption and economic development, this paper sequentially performs unit root test, granger test and cointegration test on time series, and finally establishes error correction model for analysis.

3.1. Basic data

This paper chooses GDP as the representative of Tianjin’s economic development, and electricity consumption as the representative of electricity demand of the whole society as EC. The sample ranges from 2000 to 2017, and the data are from the National Bureau of Statistics.

The unit of GDP series is 100 million yuan, and the unit of EC series is 100 million kWh. In order to eliminate the data distortion caused by price changes, the GDP data of Tianjin from 2000 to 2017 are converted into real GDP based on 1978. The specific data are shown in Table 1[6].

| Year | Nominal GDP (100 million yuan) | GDP Index (1978 = 100) | Real GDP (100 million yuan) |
|------|-------------------------------|------------------------|-----------------------------|
| 2000 | 1702                          | 114.7                  | 12939                       |
| 2001 | 1919                          | 115.8                  | 15805                       |
| 2002 | 2151                          | 114.8                  | 19333                       |
| 2003 | 2578                          | 112.7                  | 25496                       |
| 2004 | 3111                          | 112                    | 33879                       |
| 2005 | 3906                          | 110.8                  | 47384                       |
| 2006 | 4463                          | 116.4                  | 61027                       |
| 2007 | 5253                          | 117.4                  | 82052                       |
| 2008 | 6719                          | 116.5                  | 115083                      |
| 2009 | 7522                          | 116.5                  | 140947                      |
| 2010 | 9224                          | 115.5                  | 191223                      |
| 2011 | 11307                         | 114.4                  | 256793                      |
| 2012 | 12894                         | 103.6                  | 315851                      |
| 2013 | 14442                         | 109.1                  | 381254                      |
| 2014 | 15727                         | 109.3                  | 445483                      |
| 2015 | 16538                         | 110                    | 500804                      |
| 2016 | 17885                         | 112.5                  | 578079                      |
| 2017 | 18549                         | 113.8                  | 640052                      |

a Data of GDP index based on 1978 comes from the National Bureau of Statistics.

In order to eliminate the heteroscedasticity of the original data, the logarithmic processing of GDP series and EC series is carried out. In order to understand the change trend of time series intuitively, two logarithmic series ln(gdp) and ln(cec) are made into sample graphs from 2000 to 2017, as shown in Figs.3 and 4. The abscissa in the figure represents time, while the ordinate units are 100 million yuan and 100 million kWh, respectively.
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### 3.2. Unit root test

In order to test whether the time series is stable enough, that is, the law between the level of economic growth and the level of electricity consumption does not change with time, the ADF test is used to test the stationarity of the results. Eviews 8.0 was used to test the stability of two variables. The first-order
and second-order differences of $\ln gdp$ and $\ln ec$ were recorded as $i\ln gdp$, $i^2\ln gdp$, $i\ln ec$ and $i^2\ln ec$, respectively. The lag is determined by AIC minimum criterion. The test results are shown in Table 2.

Table 2. Unit root test results of $\ln gdp$ and $\ln ec$.

| Variable   | Test Form (C, T, K) | Prob  | Result       |
|------------|---------------------|-------|--------------|
| $\ln gdp$  | (N,N,3)             | 0.2685| nonstationary|
| $i\ln gdp$ | (C,N,2)             | 0.9631| nonstationary|
| $i^2\ln gdp$| (C,N,1)             | 0.0111| stationary   |
| $\ln ec$   | (N,N,3)             | 0.1406| nonstationary|
| $i\ln ec$  | (N,N,2)             | 0.1784| nonstationary|
| $i^2\ln ec$| (N,N,1)             | 0           | stationary   |

When $P<0.05$, the series is stationary. As can be seen from Table 2, the original series and the first-order difference series of $\ln gdp$ and $\ln ec$ are nonstationary at all levels, while the second-order difference is stationary. It shows that $\ln gdp$ and $\ln ec$ are second-order single-integer series at 5% significant level, which meets the precondition of cointegration test.

3.3. Cointegration test

Since the model in this paper only involves two variables, a convenient Engle-Granger test is used for cointegration test.

Firstly, the OLS can be used to establish regression equation such as equation (1).

$$\ln gdp = 1.004 \ln ec - 2.0734$$

Then, the ADF test is used to determine whether the residual series is stationary, and then to determine whether there is a cointegration relationship between $\ln gdp$ and $\ln ec$. The test results are shown in Table 3.

Table 3. Unit root test results of residual series.

| Variable     | Test Form (C, T, K) | Prob  | Result       |
|--------------|---------------------|-------|--------------|
| residual series| (N,N,3)             | 0.0397| stationary   |

Table 3 shows that the residual series is stable. The above co-integration test results show that there is a long-term stable equilibrium relationship between Tianjin's economic development and electricity consumption, but the specific way through which the impact needs to be further verified.

3.4. Granger test

In this paper, Granger test is used for further exploration. The optimal lag period $p$ is determined by the relevant regression statistics such as AIC information criterion and SC criterion[7]. The test results are shown in Table 4.

Table 4. Granger test results of $\ln gdp$ and $\ln ec$.

| Null Hypothesis          | lags | F-Statistic | Prob   |
|--------------------------|------|-------------|--------|
| $\ln gdp$ does not Granger Cause $\ln ec$ | 4    | 5.07166     | 0.0523 |
| $\ln ec$ does not Granger Cause $\ln gdp$ | 4    | 1.40165     | 0.3542 |

From Table 4, we can see that under 95% confidence, there is a two-way Granger causality between electricity consumption and economic growth in Tianjin: $\ln gdp$ is the Granger cause of $\ln ec$, indicating that the increase of GDP will increase electricity consumption. $\ln ec$ is the Granger cause of $\ln gdp$, indicating that power consumption is also an important reason for further promoting economic growth.

4. Conclusion

This paper uses the unit root test, co-integration test, and Granger test to study the relationship between power consumption and economic growth in Tianjin, and draws the following conclusions:
(1) There is a positive and stable long-term equilibrium relationship between electricity consumption and economic growth in Tianjin. For every 1% increase in electricity consumption, the total real economy will increase by an average of 1.004%.

(2) Tianjin's electricity consumption and economic growth interact and cause and effect each other. Economic growth is strongly dependent on electricity consumption, which also promotes the development of power industry. The increase of electricity consumption further promotes economic growth.

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