Analysis on the Correlation between Electricity Consumption Cycle and Economic Cycle

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Abstract

Electricity consumption is a barometer of the economic development, and they also present a strong positive correlation relationship. Economic development also shows a certain periodicity pattern by the cyclical shocks, because of the relationship, Electricity consumption also have the similar periodicity pattern. This paper studies the relationship between electricity consumption cycle and economic cycle, and finds the grander causality relationship of the electricity consumption cycle and economic cycle. An example of the economic growth rate and electricity consumption rate of China is shown that the electricity consumption cycle exists in one year period lag behind the economic cycle. The result will help interpret the interaction between economic development and electricity consumption and offer a more coordinated way to develop the ecological economic.

Key words: ECONOMIC CYCLE, ELECTRICITY CONSUMPTION CYCLE, PERIODIC OSCILLATION, GRANDER CAUSALITY, ECOLOGICAL ECONOMIC.

1. Introduction

China's economy has increased rapidly with an average annual rate of above 7% since reform and opening. With the economic development, the per capita income of China has also increased significantly; the living conditions of People are gradually improved. The level of electrification and electricity consumption are also increasing year by year, and the electricity consumption and economic development shows a strong positive correlation. According to economic cycle theory, the economic development usually accompanied the fluctuations between crest and trough. As a result, electricity consumption will also exhibit similar periodic fluctuations. To analyze the correlation between the economic cycle and the electricity cycle will help to correctly understand how to realize a harmony development of the electricity and the economy.

Scholars and experts from many countries have conducted thorough researches on economic cycle.

Joseph divided economic cycle into large cycle and small circle, and pointed out that the small one generally lasts 40 months and the duration of the large on usually is equal to the duration of two or three small cycles. Juglar proposed that economic cycle should be divided into three phases, which are the prosperity, the crisis and the liquidation, the average length of each phase lasts 8 to10 years. After analyzing the economic development in Britain and America, Kondratieff suggested that the average length of economic cycle is about 50 to 60 years. Besides these, Kuznets also raised that averagely economic cycle lasts 15 to 25 years. For the causes of economic cycle, many experts probed into this topic. Generally, they found that there are mainly external and internal causes [1-2]. The external cause is brought by the invention of external factors, such as technological innovation and political cycle. The internal cause is originated from the internal factors including such as currency and industrial structure [3-6]. In addition, a number of ex-

perts studied the correlation between economic cycle and other related factors such as international trade fluctuation and business cycle fluctuations [7-8]. The above-mentioned researches on economic cycle have made considerable achievements, but neglected to investigate the influence of electricity consumption fluctuation on economic cycle.

Economic development is closely related with electricity consumption. Generally speaking, the higher the gross domestic product is, the more electricity consumption is. Economic development is one of the most important factors for electricity consumption. In the beginning, some scholars have studied the relationship with the electricity elasticity coefficient, and with the in-depth understanding and the introduction of the econometrics, some advanced mathematics analysis technologies are introduced in the researches of the relationship. Kraft have studied and found the grander causality relationship of the economic development and electricity consumption [9], however, Akarca got the negative conclusion with reduce the same sample [10]. Afterward, many scholars have used typical econometric methods to analyze the relationship between economy and electricity or electricity consumption by Europe, America, Africa and other regions macroeconomic data, and the considered causal factors in the extended, such as GDP, labor and energy [11-12]. They have founded the grander causality relationship between the economic development and electricity consumption.

Currently, ecological civilization and low-carbon economic development is the trend of the global economic. Healthy ecological economic development needs electricity to support. It is important for a nation to find whether is a "causal" relationship between electricity consumption and economic development, the issue needed further study. It has more important implications for policies decisions related to the development of China's economic and electricity industry.

2. Analysis on the Characteristics of China's Economic Cycle and Energy Consumption Cycle

The analysis on economic cycle is always based on the economic growth rate curve, it measures economic characteristic fluctuations from the economic growth rate curve from amplitude, wavelength, peaks, troughs and so on, and the economic development in the expansion phase or contraction phase are also can be determined. The amplitude is the volatility which means each cycle fluctuations in consumption growth deviation, for example, it is the gap between peaks and troughs, and it shows that each cycle of economic ups and downs of the fluctuation intensity, reflect an important indicator of economic growth stability. Generally speaking, the cycle can be divided into three types according to the variation between the crest and the trough: the strong amplitude, the mediate amplitude and the weak amplitude. The gaps for the them as no less than 10%, between 10% and 5% and no more than 5% respectively. Wave length is the time duration that consumption fluctuation cycle lasts, which also includes three type: long cycle, mediate cycle and short cycle. Wave crest and wave trough are the maximum and minimum values the wave curve fluctuates in a specific time zone. According to above-mentioned research, we can analyze China's economic cycle, Fig.1 shows the development of GDP growth rate of China, it can be seen that since 1980 China's economic growth has generally experienced three complete economic cycles. The amplitudes of three crest years and trough years are 1984, 1992 and 2007 with GDP growth up to 15.2%, 14.2% and 14.2% respectively. The former three crest years are 1981, 1990 and 1999 with GDP growth of 5.2%, 3.8% and 7.6%. The economic cycle after 2008 can not be determined. Supposing calculate from the perspective of crest-trough, the economic wave length of China were 8 years and 15 years respectively. But if calculate from the perspective of trough-trough, the economic length is 9 years.

By using the division methods related to economic cycle to analyze electricity consumption cycle in China and taking the development of electricity consumption growth rate in different years into consideration, it reveals that since 1980 the overall electricity consumption consists with the general trend of economic growth and has experienced three complete cycles, including three crests and troughs. The three crests are 1987, 1992 and 2003 with growth rate of 10.6%, 11.5% and 15.6%. The former three troughs are1981, 1990 and 1998 with electricity consumption growth rate of 3.0%, 6.2% and 2.8%. The economic development cycle after 2008 is still uncertain. If calculate from the perspective of crest-crest, the electricity consumption wave length is 5 years and 9 years. But if calculate from the perspective of trough-trough, the wave length of electricity consumption is 9 years and 8 years. Form the trough-trough perspective, the economic cycle and electricity consumption cycle are similar with each other, and they are only a little difference.
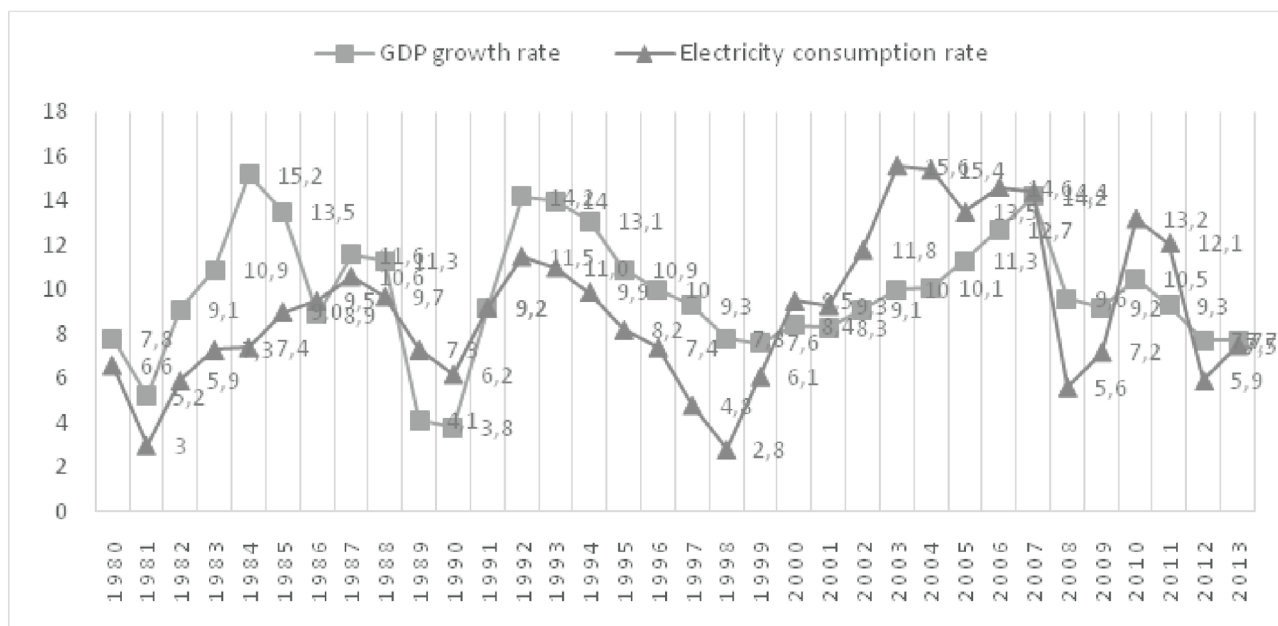
Figure 1. The curve of economic growth rate and electricity consumption rate

3. Analysis of the Economic Cycle and Electricity Consumption Cycle of China

3.1 The principle of the Granger test

Granger put forward a method to testify the cause-and-effect relationship between analysis variables, namely Granger Causality Test. This test method is to explain the causality between different variables: first, it defines two sets of time series *X* and *Y*, and then define Granger Causality between *X* and *Y* : if Variable *X* and *Y* are included in the past information and the predicative effect of Variable *Y* is better than the effect of *Y* predicted by only using the past information about *Y*, which is to say Variable *X* is useful in the interpretation of *Y*'s future change, Variable *X* can be regarded as the Granger Causality of Variable *Y*.

Granger Causality Test examines and assumes that the predicative information about *x* and *y* are concluded in the time series of these variables. The examination requires estimate the following regressions:

$$y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i y_{t-i} + \sum_{i=1}^{m} \beta_i y_{t-i} + \varepsilon_t \qquad (1)$$

$$x_t = \alpha_0 + \sum_{j=1}^{m} \alpha_j x_{t-j} + \sum_{j=1}^{m} \beta_j y_{t-j} + \varepsilon_t \qquad (2)$$

In which, *t* represents time, $\varepsilon_t \sim iid(0, \sigma^2)$ is the white noise time series.

One of the preconditions to do Granger Causality Test is that the time series must be stable, or it will appear spurious regression. Hence, it should conduct unit root test to check the stability of the time zone for every indicator before doing Granger Causality Test. Assume a data generating process only can be inferred by assumptions or based on the assumption

of statistical inference, then for a series data y_t, if y_t is generated by *AR(1)* process, then

$$y_t = \rho y_{t-1} + \varepsilon_t \qquad (3)$$

When $|\rho| < 1$, the y_t is stable and when $\rho = 1$

$$y_t = \sum_{i=1}^{t} \varepsilon_t \qquad (4)$$

The $\sum_{i=1}^{t} \varepsilon_t$ is called stochastic trend, therefore, when $\rho = 1$, the data series is dominated by stochastic trend. If the lag operator *L* is used to express the Equation (4), it has

$$(1 - \rho L) y_t = \varepsilon_t \qquad (5)$$

Its characteristic function is

$$|1 - \rho L| = 0 \qquad (6)$$

When $|L| = 1, |\rho| = 1$, There is a root located on the unit circle, and the data is dominated by a stochastic trend, so that $\rho = 1$ called unit root process, generally referred to as *I(1)*. In this suitation, the unit root test sequences is available to exam whether the process is stable. One of common unit root test method is ADF test, which takes into account the following three models:

$$\Delta x_t = (\rho - 1)x_{t-1} + \sum_{i=1}^{p} \theta_i \Delta x_{t-i} + \varepsilon_t \qquad (7)$$

$$\Delta x_t = \alpha + (\rho - 1)x_{t-1} + \sum_{i=1}^{p} \theta_i \Delta x_{t-i} + \varepsilon_t \qquad (8)$$

$$\Delta x_t = \alpha + \beta t + (\rho - 1)x_{t-1} + \sum_{i=1}^{p} \theta_i \Delta x_{t-i} + \varepsilon_t \qquad (9)$$

ADF tests is adding lags to eliminate residual serial correlation. The actual test start from the last mod-

el, and then to the first model. The test process stops when the test rejects the hypothesis that the original sequence does not exist unit root, which shows that the test series is stable.

Table 1. ADF Test on GDP growth rate and electricity consumption growth rate

Test level	GDP growth rate	electricity consumption growth rate
1% level	-4.76891	-3.08988
5% level	-3.65373*	-3.67017
10% level	-2.95711*	-2.96397*

* represents passes the level test of the confidence degree

As is indicated in the examination results, the original series of GDP growth rate and electricity con-

3.2 The result of the analysis
According to above test method, the examination result of ADF test on GDP growth rate and electricity consumption growth rate are shown as Table 1.

sumption growth rate is quite stable, so it can be used as Granger Causality, the test result of the two series with Granger Causality Test is shown in Table 2.

Table 2. Granger Causality Test of GDP growth rate and electricity consumption growth rate

Null Hypothesis:	F-Statistic	Prob.
ENER does not Granger Cause GDPR	0.07426	0.9286
GDPR does not Granger Cause ELER	1.09593	0.3486
ELER(-1) does not Granger Cause GDPR	0.21353	0.8091
GDPR does not Granger Cause ELER(-1)	4.62708	0.0191
GDPR(-1) does not Granger Cause ELER	0.97494	0.3906
ELER does not Granger Cause GDPR(-1)	2.98308	0.0682
ELER(-1) does not Granger Cause GDPR(-1)	0.18536	0.8319
GDPR(-1) does not Granger Cause ELER(-1)	0.91599	0.4126

The result of Grange Causality Test proves that there is no causality relationship between the original series of GDP growth rate and electricity consumption growth rate, but the causality relation between them does exist in one year period lagging behind the economic cycle. So it can be concluded that there is one year gap between economic cycle and electricity consumption growth rate, which implies that economic growth is certain to push the consumption of energy. Electricity is as a guarantee of the economic development, it needs to build at first. If China want to increase economic growth constantly ill with a high speed, the infrastructure of electricity industry will be enhanced. According to the rapid economic development, the wealth of each person is also increasing, which drives the demands on electrical appliances, mobile home phones, automobiles and textile produces also arise. From this aspect, the fluctuation of economic cycle will cause the cycle fluctuation of electricity consumption.

4. Conclusions
This paper analyses the relationship between economic cycle and electricity consumption fluctuation. The results found that the economic cycle is generally consistent with electricity consumption cycle, but

there is some lag between economic cycle and electricity consumption cycle that economic cycle lags behind electricity consumption cycle for a period. It is revealing that the electricity consumption cycle fluctuations are earlier one year than the economic cycle fluctuations, and it will help our understand the relationship between electricity consumption and economic development, it also will provide a guidance for China's economic transformation to achieve balanced development.

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Project Evaluation Model Based on Group Decision-Making Vector Optimization of AHP Algorithm

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