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Analysis on the Correlation between Energy Consumption Cycle and Economic Cycle

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Abstract

Economic development has shown periodic oscillation and has certain regular pattern. With the economic development, the national energy consumption has been also promoted. Energy, as the material foundation to develop economy, is closely related with the development of national economy. It has a strong positive correlation relationship between energy consumption and economic cycle fluctuation. This paper studies the relation between energy consumption and

economic cycle fluctuation, and finds the grander causality relationship of the energy consumption and economic cycle fluctuation. An example of the economic growth rate and energy consumption of China is shown that the energy consumption exists in one year period lagging behind the economic cycle. The result will help interpret the interaction between economic development and energy consumption and offer a more coordinated way to develop the ecological economic. Key words: ECONOMIC CYCLE, ENERGY CONSUMPTION, PERIODIC OSCILLATION, GRANDER CAUSALITY

1. Introduction

China's economy has accelerated dramatically and made remarkable achievements since the implementation of the reform and opening-up policy. With the sustained growth of national income and the average living standards, the continual improvement of economic structure and the significant optimization of social structure, China have greatly raised its status in the international world. During the 12th Five-Year-Plan period, China's economy has entered a new historic era, the new phase transferring from the development of industrial economy to ecological economy, which also means China will step into a new period of economic transition.

Economic development fluctuates periodically and shows a periodic oscillation phenomenon. Economic cycle fluctuation is the regular alternation that the overall economic activity expands or contracts with the general trend of economic growth. 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 one 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 to 10 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 currency and industrial structure[3-4]. In addition, a number of experts studied the correlation between economic cycle and other

related factors. Schmitt had analyzed the influence of international trade fluctuation on the economic cycle and presented the effect degree[5]. The above-mentioned researches on economic cycle have made considerable achievements, but neglected to investigate the influence of energy consumption fluctuation on economic cycle.

Economic development is closely related with energy consumption. The higher the gross domestic product is, the more energy consumption is. According to this, economic growth is considered as a vital factor that can influence and stimulate energy consumption. Renuka studied the import and exports of energy in many developed and developing countries. By using panel data analysis, he found that economic growth in energy export countries varies significantly from energy import countries and the surface energy structure has obvious influence on economic growth[6]. Ghumlam examined the relation between energy consumption and economic growth in several Asian countries and the results showed that many countries participating in empirical analysis have proved neutrality hypothesis[7]. Mehmet carried out causality test to verify the relation between energy consumption and economic growth in the Group of Seven and concluded that GDP growth will pull energy consumption in many countries[8]. Chinese exports also adopted GDP as the dependent variable to conduct surveys and discovered that the ratio of overall energy consumption and overall renewable energy consumption in the total energy consumption together with capital stock is positively correlated with GDP growth[9]. The aforesaid studies indicated that energy consumption is closely related with economic development, but academic circle did few studies on energy consumption and economic cycle. Therefore, the thesis will explore the correlation between energy consumption and economic cycle.

At present, China's economy is transforming into ecological civilization, low carbon and green economy. However, energy consumption is interdependent with economic development. As the material foun-

dation to support economic development, energy is consumed with the development of national economy. For this reason, studying the relation between energy consumption and economic cycle fluctuation is beneficial to unveil the relation between economic development and energy consumption and offer a more coordinated way for economic transformation in China.

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

The analysis on economic cycle is often based on the analysis of economic growth rate curve, which starts from measuring the vibration curve of economic growth rate and finds out the key points and the characteristics including amplitude, length, crest and trough of wave to define the economic development feature and make sure whether the economic development is in the expansion phase or contraction phase. Among all characteristics, amplitude is the fluctuation range, which is the deviation consumption growth rate fluctuates in every cycle. In other words, it is the gap between the wave crest and the wave trough. Amplitude is an important indicator to reflex the stability of economic growth, which presents the intensity the economy fluctuates in every cycle. Generally speaking, the cycle is divided amplitude 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 results about economic cycle and by analyzing the development of GDP growth rate in China, which is clearly shown in Figure 1. It is clear 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.

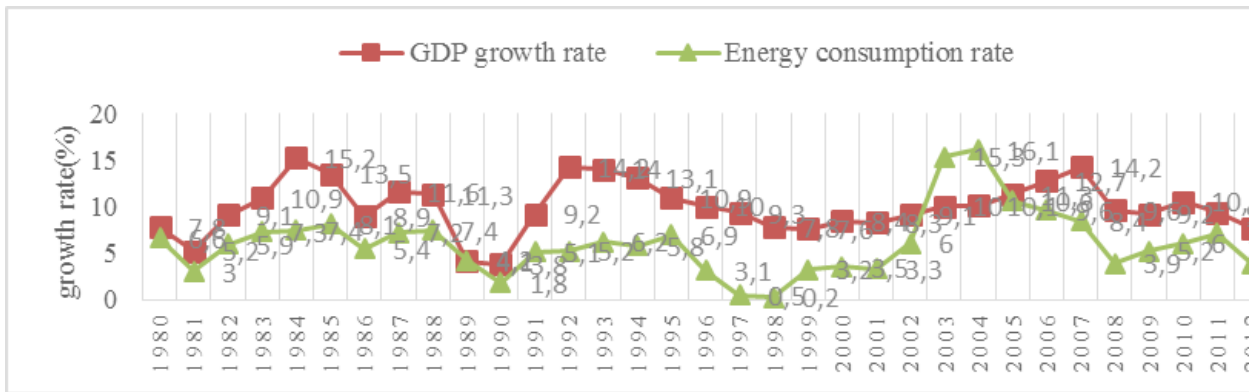


Figure 1. The vibration curve of economic growth rate and energy consumption rate

By using the division methods related to economic cycle to analyze energy consumption cycle in China and taking the development of energy consumption growth rate in different years into consideration, it reveals that since 1980 the overall energy consumption consists with the general trend of economic growth and has experienced three complete cycles, including three crests and troughs. The three crests are 1985, 1995 and 2004 with growth rate of 7.4%, 6.9% and 16.1%. The earlier three troughs are 1981, 1990 and 1998 with energy consumption growth rate of 3.0%, 1.8% and 0.2%. The economic development cycle

after 2008 is still uncertain. If calculate from the perspective of crest-crest, the energy consumption wave length is 10 years and 9 years. But if calculate from the perspective of trough-trough, the wave length of energy consumption is 9 years and 0 years. In terms of economic cycle and energy consumption cycle, the two are consistent with each other, but there are still some variations.

3. Analysis on China's Economic Cycle and Energy Consumption Cycle

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:

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

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

In which, t represents time, $\varepsilon \sim iid(0, \sigma)$ 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

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

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

$$y_t = \sum_{i=1}^t \varepsilon_i \quad (4)$$

The $\sum_{i=1}^t \varepsilon_i$ 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

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

Its characteristic function is

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

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 situation, 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:

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

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

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

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

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

Table 1. ADF test on GDP growth rate and energy consumption growth rate

Test level	GDP growth rate	energy consumption growth rate
1% level	-4.297	-3.654
5% level	-3.568*	-2.957*
10% level	-3.218*	-2.617*

* represents passes the level test of the confidence degree

As is indicated in the examination results, the original series of GDP growth rate and energy consumption 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 result of GDP growth rate and energy consumption growth rate

Hypothesis:	F-Statistic	Prob.
ENER does not Granger Cause GDPR	0.2685	0.608
GDPR does not Granger Cause ENER	0.3014	0.587
ENER(-1) does not Granger Cause GDPR	0.0253	0.874
GDPR(-1) does not Granger Cause ENER	3.9990	0.055
ENER(-1) does not Granger Cause GDPR(-1)	0.2381	0.629
GDPR(-1) does not Granger Cause ENER(-1)	0.3343	0.567

The result of Grange Causality Test proves that there is no causality relationship between the original series of GDP growth rate and energy 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 energy consumption growth rate, which implies that economic growth is certain to push the consumption of energy. China's economic growth will constantly bring about energy consumption change. As the economy grows, the net wealth per capita is increasing, which drives their demands. And people's demands on electrical appliances, mobile phones, automobiles and textile produces also stimulate the rise of energy consumption and speed up energy consumption growth rate. From this aspect, the fluctuation of economic cycle will cause the cycle fluctuation of energy consumption.

4. Conclusions

This paper analyses the relationship between economic cycle and energy consumption fluctuation. The results found that the economic cycle is generally consistent with energy consumption cycle, but there is some lag between economic cycle and energy consumption cycle that economic cycle lags behind energy consumption cycle for a period. This conclusion will benefit to reveal the relationship between energy consumption cycle fluctuations caused by economic cycle fluctuations, coordinate energy production and supply and provide guidance for China's economic transformation to achieve balanced development between energy industry and national economy.

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