Empirical Analysis on Energy Consumption and Economic Growth in Yangtze River Delta--an estimation based on Cointegration

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Abstract

Based on Cointegration Analysis and the state space model, this paper empirically analyzes the Yangtze River Delta energy consumption and economic growth based on 1990-2008 data. The results show: According to the cointegration analysis, the Yangtze River Delta economic growth and energy consumption exists long-term equilibrium. The current period of economic growth has been influenced by this period energy consumption and the amount of the previous period of economic growth, and the economic growth have the ability of 29.98\% of the auto-repair capacity. In all, we can conclude three enlightenment.

Keywords: energy consumption, economic growth, cointegration, state space model

1. Introduction

Energy is the basic conditions for human survival and is also an important material for a national economic development, which is the characteristic of the industrialization society. The energy is always the important material for the Yangtze River Delta economic growth and the social development, and it is not only provides an important source of power for life and production, but also provides an important industrial raw materials. This paper will analysis on the Yangtze River Delta region's energy consumption and economic growth relationship from two aspects: on the one hand, we use the cointegration to analysis
the short-term and long-term equilibrium relationship between the GDP and the energy consumption in Yangtze River Delta.

2. The framework

2.1. Theory

Energy is the important material for the survival and development to human. The relationship of energy consumption and economic growth has two meaning: on the one hand, economic growth depends on energy. However, the rapid economic development will inevitably increase the pressure of the consumption of resources and environmental protection. The energy consumption and economic development always has a dilemma conflict. Economic growth has positive and negative effects to energy consumption. If the economic growth in an low energy consumption and little environmental pollution, the economy will continue to stabilize, rational use of resources and then to an optimize state of the ecological environment; if the economic growth in the high energy consumption, the destruction of environment and the unsustainable development, the rapid economic growth will lead to excessive consumption of energy resources, along with the development of resources to further will be exacerbate exploited.

2.2. Research Methods

2.2.1 Cointegration

The first step is stationary test. For time series data, the stability is the core. By the ADF test, each variable differential sequence is stable or not. If the variables exist the same order stable, we can examine the cointegration relationship among the variables. The second step, use Engle and Granger (1987) cointegration proposed method to test. ① Under all variable are the same order and stable, we can draw an regression equation: \[ \ln (E_t) = \beta_0 + \beta_1 \ln (GDP_t) + \mu_t \quad (t = 1990-2008), \] where, \(EC\) is the total energy consumption, and is the dependent variable, GDP is the Yangtze River Delta's GDP, and is the explanatory variables (as the same as later in this paper). ② Use ADF test to determine that the residual series is stationary or not. ③ If the residual series is stationary, we can deem the two variables in our regression equation have the cointegration relationship, and the cointegration vector is \((1, -\beta_0, \beta_1)\) and if not, the two variables don’t have the cointegration relationship exists. The third step, ECM analysis. Follow the E-G two-step thinking, the model is setted to

\[ \Delta \ln (E_t) = \gamma_1 \Delta \ln (GDP_t) + \gamma_2 \Delta \ln (E_{t-1}) + \alpha \text{ecm}_{t-1} + \varepsilon_{t-1} \text{ecm}_{t-1} = \ln (E_{t-1}) - \beta_0 - \beta_1 \ln (GDP_{t-1}); \]

Where \(\alpha\) is the adjustment factor. It means that when short-term fluctuations deviate from the long-term equilibrium, it will be the adjustment at \(\alpha\) to bring the non-equilibrium state back to equilibrium. The fourth step, granger causality test. Use Granger causality test proposed by Granger (1969). the basic idea is that if X changes caused the Y change, meaning the X change should occur in before Y change, then That "X change is the change in Y Granger causality." Conversely, If Y changes caused the X change, meaning the Y change should occur in before X change, then that "Y change is the change in X Granger causality."

2.2.2 State Space Model

In econometrics, the state-space model (State Space Model) is used to estimate the unobservable time variables: rational expectations, measurement error, long-term income and unobservable factors (trend and cycle elements.) Many time series models, including the typical linear regression model and ARIMA model can be written as a special case of the state space form and then be estimated the parameter values. Using state-space to represent the dynamic system has two advantages: firstly, the state space model put
those unobserved variables (state variables) into the observable model, and then get their estimates; Secondly, the state space model makes use of the strong powerful iterative algorithm—KalmanFilter to estimate, the KalmanFilter can be used to estimate univariate and multivariate ARMA models, Markov switching model and the varying parameter models (Gao Tiemei, 2009).

In this paper, we use an variable coefficient model—state space model to estimate, and then we can reflect that the elasticity of energy consumption reflects changes over time. In general, the state space model is made up of a set of measurement (Observation) equation and a set of the state (State) equation. We use the State space model to examine the relationship between GDP and energy consumption, and then we establish the following model:

The set of measurement equation:
\[
\text{Ln} (E_{ct}) = d_t + a_t \text{Ln} (GDP_{it}) + \mu_t (t = 1, 2, \ldots T) \tag{1}
\]

State equation:
\[
a_t + ct = T t a_{t-1} + \varepsilon_t (t = 1, 2, \ldots T) \tag{2}
\]

Equation (1) is the set of measurement equation, that denote the general relationship between energy consumption and GDP, where, Variable parameters called state variables are not observed variables, which changes reflecting that those factors except GDP have combined effect on energy consumption and GDP; \(d_t\) is a fixed parameter of the explanatory variables. Equation (2) is called the state equation or transition equation, which describes the generation of those state variables. In equation (2), assume that parameter \(a_t\) subject to the AR (1) model. \(\mu_t, \varepsilon_t\) are the perturbation of the measurement equation and state equation of, and they are independent, and they subject to \(N(0, \mu)\) distribution.

2.3. Variable selection and data sources

In this paper, we use the data of Yangtze River Delta region’s GDP, energy consumption (EC) during 1990-2008, to eliminate the price factors’ affection, we use the 1990’s GDP as the base period to reduce the GDP. All data are from the relevant years of the “Shanghai Statistical Yearbook, “Jiangsu Statistical Yearbook”, “Zhejiang Statistical Yearbook” and “China Statistical Yearbook”.

3. Empirical analysis: The cointegration of Yangtze River Delta economic growth and energy consumption

3.1. Stationary test

Make use of Eviews5.1 to ADF unit root test about economic growth and energy consumption. the results is in Table 2. In table 2 the ADF statistics of Variable Ln (GDP) and Ln (EC) are greater than the 5% significance level critical value, so it can not reject the null hypothesis; Ln (GDP) and Ln (EC) are also the non-stationary series. The ADF statistics of \(\Delta\text{Ln} (GDP)\) and \(\Delta\text{Ln} (EC)\) are greater than the 5% significance level critical value, and therefore can not reject the null hypothesis. But The ADF statistics of \(\Delta^2\text{Ln} (GDP)\) and \(\Delta^2\text{Ln} (EC)\) are less than 5% significance level the critical value, and then reject the null hypothesis.so that the variable \(\Delta^2\text{Ln} (GDP)\) and \(\Delta^2\text{Ln} (Y)\) are 2-order stationary sequence, that is \(\text{Ln}(GDP) \sim I(2), \text{Ln}(EC) \sim I(2)\).

3.2. Cointegration

Use Eviews5.1, the OLS regression equation is:
\[
\text{LnEC} = 4.3141 + 0.6158 \text{LnGDP} + (3) \quad t = (14.89) (19.66) R^2 = 0.9578 \quad DW = 0.16
\]

In Regression equation, 0.615 means, In 1990-2008, the average of economic growth at 1% will lead to energy consumption increase at 0.6158%. And we use Eviews5.1 to the ADF unit root test of regression equation (3), then the result is in table 3.
Table 2 Variables ADF unit root test results

<table>
<thead>
<tr>
<th>Variables</th>
<th>(C,T,K)</th>
<th>ADF statistics</th>
<th>5% critical value</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln(GDP)</td>
<td>(C,t,0)</td>
<td>4.356 8</td>
<td>-3.690 8</td>
<td>Non-stationary</td>
</tr>
<tr>
<td>LN(EC)</td>
<td>(C,t,0)</td>
<td>-2.179 6</td>
<td>-3.759 7</td>
<td>Non-stationary</td>
</tr>
<tr>
<td>ΔLn (GDP)</td>
<td>(C,t,3)</td>
<td>-1.363 4</td>
<td>-3.710 5</td>
<td>Non-stationary</td>
</tr>
<tr>
<td>ΔLn (EC)</td>
<td>(C,t,0)</td>
<td>-0.313</td>
<td>-1.962 8</td>
<td>Non-stationary</td>
</tr>
<tr>
<td>Δ²Ln (GDP)</td>
<td>(C,0,0)</td>
<td>-2.494 8</td>
<td>-1.964 4</td>
<td>Stationary</td>
</tr>
<tr>
<td>Δ²Ln (EC)</td>
<td>(C,0,0)</td>
<td>3.030 6</td>
<td>-1.964 4</td>
<td>Stationary</td>
</tr>
</tbody>
</table>

Table 3 shows that: the residual series reject the null hypothesis at the 5% level of significance, and accept the conclusion that there is no unit root. So we are sure the residual series are stationary series. Yangtze River Delta economic growth and energy consumption have the cointegration, and the cointegration vector is (1, -4.314, -0.6158)', which indicate that during the sample period the Yangtze River Delta economic growth and energy consumption have long-term stability and equilibrium relationship.

Table 3 ADF unit root test result

<table>
<thead>
<tr>
<th>Augmente Dickey-Fuller test statistic</th>
<th>t-Statistic</th>
<th>Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test critical values</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% level</td>
<td>-83.7</td>
<td></td>
</tr>
<tr>
<td>5% level</td>
<td>-1.962 8</td>
<td></td>
</tr>
<tr>
<td>10% level</td>
<td>-1.606 1</td>
<td></td>
</tr>
</tbody>
</table>


3.3 Granger causality test

Using Eviews5.1, we do Granger causality test to analysis the relationship between the Yangtze River Delta economic growth and energy consumption.

Table 4 Granger Causality Test Results

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Lag</th>
<th>Obs</th>
<th>F-Statistic</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1: GDP does not Granger Cause EC</td>
<td>2</td>
<td>17</td>
<td>10.6261</td>
<td>0.002 21</td>
</tr>
<tr>
<td>H2: ES does not Granger Cause GDP</td>
<td>2</td>
<td></td>
<td>2.074 83</td>
<td>0.168 31</td>
</tr>
<tr>
<td>H1: GDP does not Granger Cause EC</td>
<td>5</td>
<td>14</td>
<td>20.4827</td>
<td>0.015 89</td>
</tr>
<tr>
<td>H2: ES does not Granger Cause GDP</td>
<td>5</td>
<td></td>
<td>3.760 48</td>
<td>0.152 38</td>
</tr>
</tbody>
</table>

The result is in Table 4. Table 4 shows that, If presume H2- change in energy does not cause change in economic growth, in both cases we can not reject the assumption, then the Yangtze River Delta energy consumption is not the endogenous variables during economic growth. If presume H1-economic growth change will cause change in energy consumption, in three cases we can reject the assumption. In conclusion: The Yangtze River Delta economic growth and energy consumption have a one-way Granger causality, which show that, a certain level of economic development will directly and higher demand for
energy consumption, and which indicates that, the rate of decline energy consumption in unit GDP will mitigate, and the resource consumption will increase in the future.

4. conclusions and Implications

In this paper, we do empirical analysis on the relationship of energy consumption and economic growth in Yangtze River Delta during 1990-2008. The basic conclusions are as follows: the cointegration analysis shows that, in short term, current amount of economic growth has been influenced by current and period amount of energy consumption growth, and it has 29.98% auto-repair capacity. In the long run, economic growth in the Yangtze River Delta region at the rate of 1% will lead to in energy consumption increase at the rate of 0.6158% the Granger causality test shows that, The Yangtze River Delta economic growth and energy consumption have a one-way Granger causality.

Based on the above empirical analysis, we get following three enlightenments. Firstly, it is important to put the scientific concept into practice. Secondly, adjust the economic structure, energy structure, and then change the way of the economic development. At the aspect of adjustment the economic structure, the direction of the adjustment should be accelerating the development of service industry and optimizing the industrial structure. At the aspect of energy structure, it is not only to control of energy input intensity and promote the utilization of energy, but also to actively explore new energy. Also be making use of the coastal location and economic development advantages, we should make effort to increase nuclear power, hydropower, wind power and other clean energy development, and then improve the development level. Thirdly, improve energy utilization technology and efficiency, establish energy consumption market mechanism and continue to promote the exploration trial about low-carbon economy in the core department of the businesses.

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References