A Panel Data Model Analysis on Relativity Between Regional Energy Consumption and Economic Growth

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Abstract. This paper applied panel data model to research the relativity between economic growth and energy consumption in 4 economic zones. Panel root test, panel cointegration test were made to estimate long-term relativity between them, the variable coefficient model proved that regional economy depends heavily on energy consumption, the uneven regional economic development led to differences in regional energy consumption. Faced with differences and imbalances both in energy consumption and economic growth among various regions, the specific regional conditions in formulating energy development strategies and specific energy policies should be considered on national level, strive to narrow regional differences, and promote the coordinated development of the national economy.

Introduction

Energy is a strategic resource that drives China's economic growth. With the acceleration of industrialization and urbanization, China shows increasing energy demand, and energy consumption has become one of key issues arousing widespread concern in society. Due to difference in many factors such as nature gift, history, location and social conditions, obvious gaps in economic growth could be found among different regions in China. The East is the developed areas with higher economic speed, while the West is rather backward. Many researchers found that economy development has relativity with energy consumption. Huo-gen Wang and Li-sheng Shen made a spatial panel statistical analysis on Chinese economic growth and energy consumption by using matlab software [1]. Quan-hui Yu and Wei-dong Meng made a comparative study on the relationship between energy and economic growth in eastern and western China, and found that there exist significant regional differences in the long-term relationship between energy and economic growth [2]. Shou-li Chen and Li-ping Ma made an empirical study on China energy consumptions and economic growth, showed quantity relativity between them [3]. Jian-xun Ding empirically test the impact of China's economic growth on the growth rate of energy consumption based on the industrial composition of economic growth, found the growth of industry and transportation is a major force in boosting the growth rate of energy consumption in China [4]. Xian-tao Liu and Jun Shi Made an autoregressive model test on correlation between energy consumption and economic growth from 1990 to 2011 in China, the results confirmed that there is a two-way causal relationship between energy consumption and economic growth [5]. Hai-peng Wang et al. proved that there was a long-term equilibrium relationship between China's energy consumption and economic growth during 1953-2002 [6].

Ying-zhi Xu and Jin Wang analyzed the dynamic relationship between economic growth and energy consumption using the panel data of China's provinces from 1990 to 2010, put forward that the energy consumption environment Kuznets curve does not exist. Energy consumption in the high-income regions show an inverted U-shaped relationship with economy development [7]. Qiang Li and Kang-ning Xu empirically test the impact of resource production and resource consumption on China's economic growth based on the provincial panel data from 1993 to 2011 in China, proved that resource consumption has positive impact on regional economy Growth, cross-regional flow of
resources is the fundamental reason for the differences in the impact of resource production and resource consumption on the economic growth in China [8]. In summary, researches on relationship between energy consumption are rather abundant on national and provincial level. This study aims to explore the effect of unbalanced regional economy growth on energy consumption.

Methodology

Data

There are 4 big economic regions in China: the East, the Midland, the West and the Northeast. Obvious difference in economic development among 4 economic regions could be found owing to influence of many factors such as resource gift, geographical and social condition. The East is consisted of 10 provinces including Beijing, Tianjing, Hebei, Shandong, Guangdong, Hainan, Fujian, Shanghai, Jiangsu and Zhejiang. The Midland includes 6 provinces such as Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan. The West is consist of 13 provinces including Chongqing, Guangxi, Sichuan, Guizhou, Yunnan, Xizhang, Shanxi, Gansu, Qinghai, Ningxia, Xinjiang and innermongolia. The Northeast has 3 provinces including Liaoning, Jilin and Heilongjiang.

Two kinds of data including regional energy consumption and economic growth were collected and analyzed in the paper. Regional economic growth is described by regional gross domestic product (GDP). The data comes from the national statistical yearbook from 1995 to 2015 [9]. Data on energy consumption (EC) come from China energy statistics yearbook from 1995 to 2015 [10]. Each time sequence is taken by the logarithmic operation in order to eliminate the heterovariance. EVIEWS 6.0 is used to operate unit root test and panel regression model analysis.

Unit Root Test on the Panel Data

According to panel data, unit root test can be divided into two type: one is the unit root test process under the same root condition, which is usually operated by Levin, Lin & Chu test; the other is for different root cases, allowing each section sequence has a different unit root process, which is usually operated by Im, Pesaran and Shin test, ADF-FisherChi-square test and PP-Fisher Chi-square test [11]. As shown in table 1, both LNEC and LNGDP are subject to the trend of the first-order single-process I (1), which meet the necessary conditions for panel cointegration.

<table>
<thead>
<tr>
<th>probability method</th>
<th>The original sequence</th>
<th>The first difference without trend term</th>
<th>The first difference with trend term</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LNEC</td>
<td>LNGDP</td>
<td>ΔLNEC</td>
</tr>
<tr>
<td>Levin, Lin &amp; Chu test</td>
<td>1.0000</td>
<td>1.0000</td>
<td>0.0053</td>
</tr>
<tr>
<td>Im, Pesaran and Shin test</td>
<td>1.0000</td>
<td>1.0000</td>
<td>0.1164</td>
</tr>
<tr>
<td>ADF-FisherChi-square test</td>
<td>1.0000</td>
<td>0.9866</td>
<td>0.1743</td>
</tr>
<tr>
<td>PP-Fisher Chi-square test</td>
<td>1.0000</td>
<td>0.9856</td>
<td>0.1966</td>
</tr>
</tbody>
</table>
Results

Estimation of Panel Data Model Parameters

Covariance analysis test is used to estimate the panel data model parameters by constructing F-statistic value on following hypothesis.

\[ H_1 : \beta_1 = \beta_2 = \cdots = \beta_N \]

\[ H_2 : \alpha_1 = \alpha_2 = \cdots = \alpha_N, \quad \beta_1 = \beta_2 = \cdots = \beta_N \]

Test statistics \( F_2 \) which under the hypothesis 2 obey the F distribution.

\[
F_2 = \frac{(S_2 - S_1) / [(N - 1)]}{S_1 / (NT - N(k + 1))} \sim F[(N - 1)k, N(T - k - 1)]
\]

Whereinto, \( S_1, S_2 \) and \( S_3 \) are residual sum of squares under constant coefficient model, variable intercept model and variable coefficient model respectively. In our research, \( N = 4, T = 12, k = 1; S_1 = 3.5634, S_2 = 6.7687, S_3 = 33.6563 \).

We use variable coefficient model to estimate panel data. As shown in table 2, the t-statistic of the coefficients of each variable is significant. Adjusted R-squared is 0.9876, which means the model fit well.

<table>
<thead>
<tr>
<th>region</th>
<th>The Northeast</th>
<th>The East</th>
<th>The Midland</th>
<th>The West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient value</td>
<td>0.84776</td>
<td>0.93654</td>
<td>0.86573</td>
<td>0.83435</td>
</tr>
<tr>
<td>T-statistic</td>
<td>57.8545</td>
<td>53.6682</td>
<td>54.6576</td>
<td>50.4666</td>
</tr>
</tbody>
</table>

Panel Cointegration Test

In order to definitely describe the long-term equilibrium relationship between regional energy consumption and economic growth, panel cointegration test is used. Shown in table 3, results reject \( H_0 \): There is no cointegration relationship.

<table>
<thead>
<tr>
<th>Test Statistic</th>
<th>Statistic</th>
<th>Prob.</th>
<th>Weighted Statistic</th>
<th>Weighted Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel χ-Statistic</td>
<td>8.04352</td>
<td>0.0000</td>
<td>12.65763</td>
<td>0.0000</td>
</tr>
<tr>
<td>Panel Rho-Statistic</td>
<td>4.54563</td>
<td>0.0000</td>
<td>3.56442</td>
<td>0.0110</td>
</tr>
<tr>
<td>Panel PP-Statistic</td>
<td>3.66722</td>
<td>0.0010</td>
<td>3.23312</td>
<td>0.0152</td>
</tr>
<tr>
<td>Panel ADF-Statistic</td>
<td>8.95871</td>
<td>0.0000</td>
<td>-4.05643</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Conclusion

Panel cointegration test results show that there exist a long-term equilibrium relationship between regional energy consumption and economic growth. In four economic regions, the impact of energy consumption on economic growth are more than 0.80, indicating that regional economy depends heavily on energy consumption. The uneven regional economic development led to differences in regional energy consumption.

By comparing regression coefficients, we can see an obvious regional difference. Growth rate of regional energy consumption is higher than that of economic growth. In areas with higher level of economic growth, energy consumption are also relatively higher, so economic growth is the main factor that causes the increase in energy consumption. The growth of economy in the East has the most effect on its energy consumption, while the economy growth of the West has the least impact on its energy consumption. Faced with the differences and imbalances in energy consumption and economic growth among various regions, we must consider the specific regional conditions in formulating energy development strategies and specific energy policies on national level, strive to narrow regional differences, and promote the coordinated development of the national economy.
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