Research on the Relationship between Energy Consumption and Economic Growth in Jilin Province Based on Error Correction Model

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Abstract. Under the call of the green economy, the analysis of the relationship between energy consumption and economic growth can cater to the current policy agenda to achieve a resource-saving and environment-friendly society. Based on this, the thesis applies the error correction theory model to apply the variable stability, causality and cointegration test to the relationship between energy consumption and economic growth in Jilin Province, and obtains energy consumption and economic growth in Jilin Province in the past ten years. The cointegration relationship and causality between the two countries show that urban economic growth can drive energy consumption, and the economic development of Jilin Province is not entirely dependent on energy consumption, but has a two-way causal relationship with the four variables. To this end, in the future industrial development and economic promotion, it is necessary to accelerate the development and promotion of low-energy, high-efficiency industries, promote the diversified development of the energy structure, actively play the role of government agencies in policy regulation, and increase investment in technological innovation. And adopting taxes or funds to promote industrial capital to reform in a technology-intensive manner.

1. Introduction

Through a large amount of data research, the economic development and energy consumption of various countries in the world are closely related. Especially in today's society, the people's material level rises, and the demand for energy increases, resulting in a rapid increase in energy consumption. For the time being, because of its dense population, China has become a major energy demander in the world, and its energy resources imports have increased. In 2016, China's total energy consumption was converted into standard coal of 4.25 billion tons, accounting for 25% of the world's total energy consumption. The massive consumption of energy has brought about environmental pollution problems and people's health problems. To this end, countries around the world have launched activities to promote energy and resource conservation, energy conservation and emission reduction. At the same time as the research, the relationship between energy consumption and economic growth has become the focus of scholars in the field. As Rosenberg, the most striking feature of energy and economic growth is the close relationship between rising energy use and economic growth [1].
Therefore, it is of practical significance to explore the relationship between energy consumption and economic growth and the law of mutual influence. Although a large number of scholars have never stopped researching the relationship between energy consumption and economic growth, different scholars have achieved different results. For example, in 1978, American scholar Kraft found that the economic growth of the United States from 1947 to 1974 had a one-way causal relationship with energy consumption [2]; in 1980, scholar Akarca found that economic growth and energy consumption did not exist for economic research at the same time. Causal relationship [3]. Chinese scholars' research on energy consumption and economic growth is different in terms of object. On the one hand, the causal relationship between the two is studied from the perspective of China's overall economy. For example, scholar Lin Xiaojuan believes that there is a one-way cause and effect between China's economic development and energy consumption. Relationship [4], while scholar Han Zhiyong believes that the causal relationship between the two is two-way, but does not have long-term cointegration characteristics [5]. Another type of research is to stand on the part to carry out the relationship. For example, Zhang Xingping's research on the relationship between economy and energy in Beijing found that there is a one-way causal relationship in the short term, and long-term data shows that there is a two-way causal relationship between the two parties [6]. Based on this, the paper selects Jilin Province as the research object and uses the error correction model to analyze the relationship between energy consumption and economic growth in the region.

2. Model overview

2.1. The influence function of energy consumption and economic growth in Jilin Province

The impact function of the relationship between energy consumption and economic growth is as follows:

$$Y_t = F(K_t, L_t, E_t)$$  

(1)

Among them, $Y_t$ is expressed as the actual GDP of Jilin Province;
$K_t$ represents the actual capital stock;
$L_t$ indicates the total number of employed people
$E_t$ represents the total energy consumption.

Simplify the above formula and take the causal function, then

$$Y_t = K^\alpha L^\beta E^\gamma$$  

(2)

$$\ln Y_t = \alpha \ln K_t + \beta \ln L_t + \gamma \ln E_t$$  

(3)

The method generally adopted in the factor test is the stationarity of the ADF unit root test sequence. Once the sequence appears in the same order, the co-integration relationship is further used to test the sequence relationship. A non-binding VAR imposes a cointegration constraint on the variable. If a cointegration relationship occurs, an error correction model needs to be established. Traditional economic models often describe ideal long-term equilibrium relationships, while actual economic data often exhibit non-equilibrium states. To this end, it is necessary to establish a dynamic model of the relationship between energy consumption and economic growth.

2.2. ADF test

The ADF test regression expression for the horizontal time series is as follows:

$$\Delta X_t = \alpha + \beta t + \delta X_{t-1} + \sum_{i=1}^{m} \beta_i \Delta_{t-i} + \epsilon_t$$  

(4)
In this model, there are:
$t$ represents a time variable, meaning a trend in which the time series appears over time. Suppose $\delta=0$, there is a unit root, indicating that the time series is not stationary.

2.3. Cointegration test and error correction model
For non-stationary time series, it is not possible to take a simple differential test directly. It is easy to ignore the important information of the variable level value and cannot reflect the long-term relationship of the sequence. To this end, the use of cointegration testing and error correction models can solve this problem. A linear combination of non-stationary time series is stationary, and an error correction model can be established to express the long-term and short-term relationship between the two. The specific expression is as follows:

Assuming that there are $K$ time series, and $x_1, x_2, x_3, \ldots, x_k$ is an $d$ order document sequence, it is necessary to find a linear combination of the above sequence $Z=\alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 + \ldots + \alpha_k x_k$. The single-order number is $d=b, b>0$, which means that it is smaller than the single-order $d$ of the original sequence, indicating that between $x_1, x_2, x_3, \ldots, x_k$, there is a cointegration relationship, denoted as $x_t \sim CI (d, b)$. This model is an important co-integration representation model and has economic significance.

2.4. Causal test
The Granger causality test considers whether sequence $x$ is responsible for $y$ production. If $x$ can cause $y$ to occur, and $y$ cannot cause $x$ to occur, then $x$ is called $y$ Granger. There are expressions as follows:

\[ y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \ldots + \alpha_k y_{t-k} + \beta_1 x_{t-1} + \ldots + \beta_k x_{t-k} \]  
(5)

\[ x_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \ldots + \alpha_k y_{t-k} + \beta_1 y_{t-1} + \ldots + \beta_k y_{t-k} \]  
(6)

3. Empirical research

3.1. Data source
The energy consumption data and economic GDP data of Jilin Province selected by the paper are all from the Jilin Province Statistical Yearbook. The time span is from 2008 to 2018. The actual GDP is the data after eliminating the price factor that is, based on 2008. The retail price index of Jilin Province is obtained after the base number processing. The selected energy consumption sequence is converted into standard coal for calculation, and the unit is 10,000 tons [7].

3.2. Analysis of empirical results

3.2.1. ADF unit root test. The original intention of this test method has been described in detail in 2.2 and will not be described here. The results are shown in Table 1.

| Variable | ADF test value | 5% threshold | P value | Result |
|----------|----------------|--------------|---------|--------|
| $\ln Y_t$ | -0.245         | -2.598       | 0.7250  | unstable |
| $\ln K_t$ | 1.485          | -2.147       | 0.4581  | unstable |
| $\ln L_t$ | -4.145         | -2.950       | 0.0970  | unstable |
| $\ln E_t$ | -2.587         | -2.950       | 0.0351  | smooth |
As can be seen from Table 1, at a confidence level of 5%, \( \ln Y \) and \( \ln K \) are non-stationary sequences. After the difference, the \( \ln L \) and \( \ln E \) differential stationary sequences can be judged. It can be seen that the original sequence is a first-order single-sequence sequence rather than a non-stationary sequence.

### 3.2.2. Cointegration test

#### (1) Determination of VAR model

The cointegration test model is based on the VAR model, and the test results are sensitive to the selection of the VAR lag order. For this reason, in order to select a more appropriate value, the paper has four information indicators such as \( \ln Y \) and \( \ln E \). Comprehensive evaluation is carried out, and the specific evaluation results are shown in Table 2.

| Lag | \( \ln Y \)  | \( \ln K \)  | FPE  | AIC   | SC    |
|-----|-------------|-------------|------|-------|-------|
| 0   | 63.6541     | NA          | 6.5870 | -5.1871 | -4.4895 |
| 1   | 176.4514    | 176.4890    | 1.4852 | -13.6547 | -12.4578 |
| 2   | 198.2543    | 22.1845     | 1.4158 | -13.5421 | -12.1457 |

From Table 2, it can be found that other lag orders except 0 are satisfied. In order to avoid the transition parameters of the model, a VAR model with a lag order of 2 can be adopted. That is, in the case of VAR (2), the cointegration test of the trend term is performed. The co-integration test sample contains a number of adjusted observations from Jilin Province from 2008 to 2018. First, let's assume that linearity is a rational trend. The sequence of variables is \( \ln Y, \ln K, \ln L, \ln E \), and the lag step is 1 to 2. The results of cointegration test are shown in Table 3 and Table 4.

**Table 2. VAR model lag order and criteria information**

**Table 3. Unrestricted cointegration rank test**

| Construction CE number | Characteristic root | Trace statistics | 5% threshold | P value |
|------------------------|---------------------|-----------------|--------------|---------|
| 0                      | 0.7812              | 66.2548         | 44.1587      | 0.0004  |
| \( \geq 1 \)           | 0.6025              | 32.1457         | 25.6845      | 0.0214  |
| \( \geq 2 \)           | 0.4512              | 14.4532         | 15.4157      | 0.1245  |
| \( \geq 3 \)           | 0.0145              | 0.2458          | 3.5487       | 0.5145  |

**Table 4. Standard Cointegration Vector Coefficients**

| \( \ln Y \)  | \( \ln K \)  | \( \ln L \)  | \( \ln E \)  | TEEND (86) |
|--------------|--------------|--------------|--------------|------------|
| 1.0000       | -0.2548      | -0.8471      | -0.4587      | 0.0654     |
| (0.0245)     | (0.0847)     | (0.0548)     | (0.0014)     |

Table 3 shows that at the 5% confidence level, the conclusion is that the null hypothesis is rejected, indicating that the significant level of a co-integration equation for the rank test is 5%. Such a cointegration equation can be obtained in Table 4.

\[
\ln Y_t = -0.2548 \ln K_t - 0.8471 \ln L_t - 0.4587 \ln E_t
\]  

(7)

The conclusion shows that there is a two-way causal relationship between the economy and the four variables in Jilin Province in 2008-2018, and it also positively responds to the equilibrium relationship between energy consumption and economic growth, investment and population.
employment rate in Jilin Province. As a kind of social resources, energy consumption can bring about the economic output of Jilin Province; at the same time, the increase of economic aggregate also expands the demand for energy consumption. To this end, energy consumption needs to be invested in a production function as a type of production factor.

(2) Vector error correction
After co-integration test, it is found that the variable sequence can satisfy the cointegration relationship. The error correction model (VEC) is established on the cointegration equation. The series of adjusted observation data is covered in the sample interval. The specific data is in the table 5 shows.

Table 5. Vector Error Correction Model

| Error correction | D (ln $Y_t$) | D (ln $K_t$) | D (ln $L_t$) | D (ln $E_t$) |
|------------------|-------------|-------------|-------------|-------------|
| COINT EQ1        | -0.8471     | 1.1471      | -0.0874     | -0.4512     |
| D (ln $Y_t(-1)$) | 0.2145      | -0.4784     | -0.2415     | 0.2045      |
| D (ln $K_t(-1)$) | -0.0145     | -0.0847     | 0.5412      | -0.0124     |
| D (ln $L_t(-1)$) | -0.2147     | -0.0148     | 0.5047      | 0.02584     |
| D (ln $E_t(-1)$) | -0.1457     | 1.5478      | 0.3521      | -0.5487     |
| C                | 0.0145      | 0.0748      | -0.354      | 0.2484      |
| R-squared        | 0.8471      | 0.235       | 0.285       | 0.5451      |
| F-statistic      | 7.4147      | 0.3578      | 0.5314      | 1.4157      |

From the above estimation results, it can be found that the short-term dynamic equation of actual output can take a coefficient of 0.8471, indicating that the actual economic growth rate of Jilin Province is 84.71% due to capital investment and energy consumption and labor input.

4. Suggestions on Energy Consumption and Economic Growth in Jilin Province
In response to the above conclusions and the energy consumption situation in Jilin Province, three suggestions are proposed. First, we must accelerate the adjustment of industrial structure, carry out technological reforms of high-energy-consuming industries, optimize industrial restructuring, and develop industries with low energy consumption. It is necessary to strengthen the primary industry, upgrade the secondary industry, develop the tertiary industry, vigorously develop modern agriculture in Jilin Province, upgrade the modern service and the development of the cultural industry, and continuously increase the proportion of the tertiary industry. At the same time, the government's means of regulation and control will be adopted, and preferential policies will be adopted to promote the adjustment of the industrial structure from energy-intensive to technology-intensive. Second, improve energy efficiency. Through research, it is found that the energy utilization in Jilin Province is not high, and improving energy efficiency is the fundamental way to reduce energy consumption. To this end, it is necessary to strengthen scientific and technological progress to save energy, further optimize product structure, use high technology to improve traditional industries, and increase the added value of products. The third is to strengthen the development and utilization of renewable resources and energy. Jilin Province has more renewable energy sources, can strengthen the use of renewable energy, improve supporting and legal systems and policy support, rely on science and technology to promote technological progress, strive to break through technological bottlenecks, improve existing energy supply and economic benefits are not obvious. Situation.

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