Analysis of the Impact of Energy Consumption on Economic Growth in Guangdong Province

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Abstract. In view of the importance of energy consumption in economic development, as well as the emergence of energy shortage, high energy consumption, ecological environment damage and other issues in the process of economic development, the relationship between energy consumption and economic growth has attracted the attention of scholars. After analyzing the current situation of economic development and energy consumption in Guangdong Province, this paper selects the corresponding variable indicators, carries out cointegration analysis and Granger causality test, further constructs VAR model to proceed with impulse response analysis, studies the relationship between energy consumption and economic growth, and puts forward the relevant countermeasures and suggestions in accordance with the results of empirical analysis.

1. Introduction
As one of the "four wheels" driving economic growth, the energy is an essential input factor in the process of wealth creation together with the material basis of economic development. At present, China's economic development is still in the stage of sustained growth, demanding high energy consumption. In the accompaniment of the rapid development of economy, there appear problems of energy shortage, excessive consumption, low utilization efficiency, etc., which leads to the increasingly serious ecological environment threat. How to achieve high-quality economic growth development under the premise of scientific and efficient energy consumption on earth has become an urgent task. Guangdong Province is a strong economic province in China. Over the years, the total GDP of Guangdong Province has been in the forefront of the country. Energy consumption has played a very important role in the economic development of Guangdong Province. This paper will study the relationship between energy consumption and economic growth in Guangdong Province, and provide some theoretical and practical reference for exploring how to realize long-term sustainable development of economy.

2. The status analysis of economic development and energy consumption in Guangdong Province
2.1 Entering into the 21st century, the economic development of Guangdong Province has been constantly accelerating, and the total economic volume has ranked among the best in China.
Guangdong Province has unceasingly adjusted and optimized the mode of economic development, and gradually changed from the extensive economic model with resource consumption and labor input as the main driving force to the intensive economy with capital and technology investment as the main driving force. From 1999 to 2018 (as shown in figure 1), the GDP of Guangdong Province shows an
2018, the GDP was 9727.777 billion Yuan, an increase of nearly 12 times; in the meantime, the industrial structure has been continuously optimized and upgraded, and the proportion of the tertiary industry has been constantly increasing. By 2018, the proportion of the tertiary industry was 54.2%.

2.2 Identical with the trend of economic growth, the total energy consumption of Guangdong Province has also been going through the sustained and rapid growth.

In 2017 and 2018, the total energy consumption of Guangdong Province increased by 3.1% and 3.4% year-on-year, which was far higher than the national average growth rate. The energy consumption output efficiency of Guangdong Province is relatively high, and the unit energy consumption can create GDP of nearly 30000 Yuan, which is also higher than the national average level. The energy consumption per unit of GDP shows a decreasing trend in the past 20 years (Figure 2), from 9953 tons of standard coal / 100 million Yuan in 1999 to 3367 tons of standard coal / 100 million Yuan, a decrease of more than three times. It can be seen that the energy utilization rate in the process of economic development in Guangdong Province is constantly improving. The energy consumption structure has been continuously optimized, and the level of green and low-carbon energy has been continuously improved. Among them, the proportion of clean energy such as natural gas, transmission of electricity from the west to the east, nuclear power, renewable energy, etc., is increasing, while the proportion of traditional energy consumption such as coal, etc. decreases.

![Figure 1: Trend of economic development and energy consumption in Guangdong Province from 1999 to 2018](image)

**Data source**: Statistical Yearbook of Guangdong Province
Figure 2: change trend of energy consumption per unit GDP of Guangdong Province from 1999 to 2018

Data source: Statistical Yearbook of Guangdong Province

3. An empirical analysis of the impact of energy consumption on economic growth in Guangdong Province

3.1. The variable selection and data processing
This paper intends to use the total final energy consumption (EC) as the measurement index of energy consumption, and the gross domestic product (GDP) as the measurement index of economic growth. On the basis of the relevant data of Guangdong Province from 1999 to 2018, Eviews8.0 software is used for empirical analysis. For the sake of avoiding excessive abnormal fluctuation of series and making the series tend to be stable, logarithm processing is carried out for two variable series, namely LNEC and LNGDP.

3.2. The stationarity test
Since the sample data in this paper are of time series type, the stationarity test should be firstly carried out to avoid the phenomenon of “spurious regression”. Two groups of variables are tested by ADF unit root test.

| variable    | ADF   | Prob.  | 1% level | 5% level | 10% level | conclusion |
|-------------|-------|--------|----------|----------|-----------|------------|
| D(LNEC,2)   | -4.7457 | 0.0018 | -3.8867  | -3.0521  | -2.6665   | stable     |
| D(LNGDP,2)  | -5.8764 | 0.0003 | -3.9203  | -3.0655  | -2.6734   | stable     |

The unit root test of variables EC, GDP, LNEC and LNGDP is conducted in turn. The results show that the P values of EC, GDP, LNEC and LNGDP and the first-order difference of LNEC and LNGDP are all greater than 0.05, which fail the test; the P values of the second order difference of LNEC and LNGDP are all less than 0.05, which passes the test, and the co-integration test can be continued.

3.3 The co-integration test

3.3.1 The equation construction.
The functional equation of independent variable LNEC and dependent variable LNGDP is established by virtue of the software. The variable equation is constructed as:

\[
\text{LNGDP} = -0.104752 + 1.6732\text{LNEC} \\
\begin{pmatrix}
-9.0478 \\
24.5383
\end{pmatrix}
\]

\[
R^2 = 0.9709, \text{DW} = 0.2057
\]
3.3.2 The Residual test. The equation residual is extracted for the ADF test, and the results are as follows:

| variable | ADF     | Prob.  | 1% level | 5% level | 10% level | conclusion |
|----------|---------|--------|----------|----------|-----------|------------|
| residual | -5.9462 | 0.0002 | -3.8867  | -3.0521  | -2.6665   | stable     |

As shown in Table 2, the P value of the residual test is 0.0002, less than 0.05, and passing the test, which signifies that the residual sequence is stationary, and indicates that there is a long-term stable equilibrium relationship between the total energy consumption and economic growth in Guangdong Province.

3.4 Granger causality
This part is to analyze the causality between the total energy consumption and economic growth in Guangdong Province. First of all, it is necessary to determine the lag order of Granger test. Generally speaking, the smaller the AIC value is, the better the lag order is. The results obtained by applying eviews software showed that the third order is the optimal lag order. Then, Granger test is carried out on NEC and LNGD variable series

| Original hypothesis | Lags | F statistic | P level | conclusion |
|---------------------|------|-------------|---------|------------|
| LNGDP does not Granger Cause LNEC | 3 | 6.2393 | 0.0117 | Reject |
| LNEC does not Granger Cause LNGDP | 3 | 3.4438 | 0.0598 | Agree |

From the above results, it can be seen that the economic growth of Guangdong Province is the cause of energy consumption, that is, economic growth will directly lead to the growth of energy consumption; however, energy consumption is not the cause of economic growth in Guangdong Province, that is, the growth of energy consumption will not lead to the growth of GDP in Guangdong Province.

3.5 VAR Model

3.5.1 The unit root test.
The VAR model of NEC and LNGD is constructed by means of Eviews software for the stability test, and the results are as follows:

![Figure 3: unit root test results](image)

In Figure 3, the reciprocals of four AR eigenvalues of VAR model are all distributed in the unit circle, indicating that the model is stable and its estimation results are reliable.

3.5.2 The impulse response function.
In Figure 4, the horizontal axis is the number of lag periods of impact, the longitudinal axis is the change of the explained variable, the solid is the impulse response function, and the dotted line is the
plus or minus double standard deviation band. Among them, the curve of response of LNGDP to LNEC reflects the dynamic impact of GDP on energy consumption. The short-term impact of GDP on energy consumption is large, which gradually weakens after the fifth period, and then tends to be stable after reaching 16. It can be seen that GDP has a lasting impact on energy consumption; the curve of response of LNGDP to LNEC reflects the dynamic impact of energy consumption on GDP. It can be seen from the curve trend that energy consumption will have a certain impact on GDP in the short term, but it will weaken after the third period and tend to be stable after the tenth period. In short, the impact of GDP on energy consumption is higher than that of energy consumption on GDP in terms of impact strength and duration.

4. The result analysis
The above empirical analysis shows that: 1) there is a long-term equilibrium relationship between energy consumption and economic growth in Guangdong Province.2) Granger causality test results show that economic growth in Guangdong Province can directly impact the change of energy consumption, conversely false.3) The impulse response function shows that the impact of GDP on energy consumption is higher than that of energy consumption on GDP, both in terms of impact degree and duration.

5. Countermeasures and suggestions
5.1 There is a necessity to increase energy science and technology innovation and improve the efficiency of energy production and utilization. Although the energy processing technology of Guangdong Province is higher than the national average level, there is still a gap between Guangdong Province and the advanced international technology level. Further technological innovation and equipment upgrading are needed to reduce the degree of energy waste and environmental pollution from the source. In addition, at the level of energy utilization, foreign cooperation and exchange should continue to be strengthened, by constantly introducing advanced new technologies, learning new processes, procuring new equipment of pollutant treatment. In combination with our own scientific and technological innovation achievements, the comprehensive capacity of pollutant treatment is continuously improved so as to achieve new breakthroughs in both quality and quantity.

5.2 The structure of energy consumption should be continuously adjusted, focusing on the development of clean energy. At present, the proportion of clean energy consumption in Guangdong Province is still low, especially renewable clean energy. Because its development and utilization are still in the initial stage, the consumption is very low, accounting for less than 1% of the total energy
consumption in 2018. In order to optimize the energy consumption structure, it is a necessity to actively and scientifically develop and utilize renewable energy such as wind energy, solar energy, biological energy, etc., according to the climate, geographical location and other characteristics or comparative advantages of various regions, so as to fundamentally resolve the problem of environmental pollution; in the meantime, it is also necessary to vigorously accelerate the "turning coal into gas" project in the industrial field and reduce the proportion of coal energy consumption. The construction of natural gas pipelines in Guangdong Province is strengthened to form an interconnected natural gas pipeline network throughout the province, and the relevant industrial enterprises are encouraged to carry out the production line and technical transformation of "turning coal into gas".

5.3 The adjustment of industrial structure is strengthened, and the proportion of the tertiary industry is increased, to realize the high-quality economic development of Guangdong Province. There is a need to continue to promote the process of industrial gradient transfer, accelerate the transfer-out of traditional high energy consumption industries and the entry of strategic emerging industries with low energy consumption and high added value, and reduce energy consumption and improve energy consumption efficiency; in addition, to vigorously develop the tertiary industry, including producer services, which can also reduce energy consumption while accelerating the transformation and upgrading of manufacturing industry.

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