

# Study on Regional Differences in Energy Consumption and Economic Growth in China

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## Abstract

Based on the data of 30 provinces in China from 1995 to 2014, this paper studies the relationship between economic growth and energy consumption, capital and labor force based on three-factor production function framework and unit root test, cointegration test, Granger causality test. The results show no causal relationship between economic growth and energy consumption in eastern China, called the "neutral hypothesis." The economic development of central and northeast provinces is the one-way Granger cause of energy consumption. Economic growth will affect energy consumption, and there is a long-term equilibrium relationship between them. The western provinces conclude that energy consumption is the one-way Granger cause of economic growth. Still, economic growth is not the Granger cause of energy consumption. That is, the economic growth of these provinces is driven by energy consumption.

## Keywords

Economic growth; energy consumption; cointegration; Granger causality test.

## 1. INTRODUCTION

Energy is a necessary material basis in social production and plays a crucial role in China's economic construction. Since the reform and opening-up, China's economy has been growing rapidly. From 1978 to 2018, China's economy grew at an average annual rate of 9.4%, far higher than the global average of less than 3% in the same period. The research on the relationship between energy consumption and economic growth mainly analyzes the causal relationship between them. Suppose there is a positive one-way effect of GDP on energy consumption. In that case, it supports energy protection policies (such as energy rationing), which means that a country does not need to rely on energy to support economic development. If there is a positive one-way effect of energy consumption on GDP, reducing energy consumption may lead to an economic slowdown or unemployment. If there is no causality between GDP and energy consumption, the so-called "neutral hypothesis," then energy consumption will not impact the economy.

Based on previous studies, this paper uses the data of energy consumption, capital stock, labor human capital stock, and GDP of 30 provinces from 1995 to 2014. It uses the unit root test, cointegration test, Granger causality test, and other methods to explore the relationship between energy consumption and economic growth in eastern, western, central and northeast regions of China to provide a reference for economic policy-making in the different areas.

## 2. THEORY AND DATA

### 2.1. Granger Causality Test

Granger causality studies whether the historical information of one sequence is helpful to predict another. Specifically, the test is carried out by examining whether the sequence lag

term's coefficients are all zero in the VAR model system. Take the stationary model as an example:

$$y_{1t} = a_{10} + a_{11}(1)y_{1,t-1} + a_{11}(2)y_{1,t-2} + \dots + a_{11}(p)y_{1,t-p} \\ + a_{12}(1)y_{2,t-1} + a_{12}(2)y_{2,t-2} + a_{12}(p)y_{2,t-p} + e_{1t}$$

$$y_{2t} = a_{10} + a_{11}(1)y_{1,t-1} + a_{11}(2)y_{1,t-2} + \dots + a_{11}(p)y_{1,t-p} \\ + a_{12}(1)y_{2,t-1} + a_{12}(2)y_{2,t-2} + a_{12}(p)y_{2,t-p} + e_{2t}$$

Test the original hypothesis:  $\{y_{2t}\}$  is not the Granger cause of  $\{y_{1t}\}$ , then the joint hypothesis is tested by F-test:  $a_{12}(1) = a_{12}(2) = \dots + a_{12}(p)$ . If the test results reject the original hypothesis that  $\{y_{2t}\}$  is not the Granger cause of  $\{y_{1t}\}$ , then  $\{y_{2t}\}$  is usually called the Granger cause of  $\{y_{1t}\}$ .

## 2.2. Data

This paper selects the data from 1995 to 2014, and to remove heteroscedasticity, GDP, total energy consumption, human labor capital, and fixed capital stock, all take natural logarithm. The data are mainly from the China Statistical Yearbook (2015) and human capital report organized by the Central University of Finance and Economics (2016).

1. GDP. This paper takes the GDP of 1978 as the base year for adjustment and obtains the real GDP (unit: 100 million yuan).

2. Total energy consumption E. For a long time, China has mainly relied on its energy resources to develop its economy, and its energy self-sufficiency rate has been maintained above 90%. This paper uses each province's total energy consumption from 1995 to 2014 (unit: 10000 tons of standard coal).

3. Capital stock K. The general capital measurement method is the perpetual inventory method. That is, the physical capital stock of a particular period is obtained by subtracting the current depreciation from the previous capital stock and adding the recent physical capital investment:

$$K_t = (1 - \delta)K_{t-1} + I_t$$

4. Labor and human capital L. The Jorgenson Fraumeni lifetime income method (starting now referred to as j-f method) is widely used in the 2016 human capital report organized by the Central University of Finance and economics to estimate human capital distribution and development in China. The J-f method estimates the expected future income through survival rate, enrollment rate, and employment rate.

## 3. EMPIRICAL ANALYSIS

By observing the time series of GDP, energy consumption, capital stock, and human capital of the labor force, it can be found that each variable has an apparent trend of increasing with time, and the data may be unstable, so the ADF test is needed. ADF results show that most provinces satisfy the second-order single integration of three or four variables. To study the long-term equilibrium relationship between the variables, cointegration test is also needed. The cointegration results show that P value is less than 0.05, which rejects the original hypothesis that there is no cointegration relationship, indicating that there is at least one long-term equilibrium relationship between the variables.

**Table 1.** Granger causality test

	Null Hypothesis	Obs	F-Statistic	Prob.
Beijing	D(D(LNGDP)) does not Granger Cause D(D(LNEN))	17	1.2609	0.3396
	D(D(LNE)) does not Granger Cause D(D(LNGDP))		0.6876	0.5799
Shanghai	D(D(LNGDP)) does not Granger Cause D(D(LNEN))	17	0.0569	0.9812
	D(D(LNE)) does not Granger Cause D(D(LNGDP))		2.6953	0.1025
Hubei	D(D(LNGDP)) does not Granger Cause D(D(LNEN))	17	4.2137	0.0361
	D(D(LNE)) does not Granger Cause D(D(LNGDP))		0.4760	0.7060
Hunan	D(D(LNGDP)) does not Granger Cause D(D(LNEN))	17	9.0253	0.0034
	D(D(LNE)) does not Granger Cause D(D(LNGDP))		1.2882	0.3313
Sichuan	D(D(LNGDP)) does not Granger Cause D(D(LNEN))	17	0.9854	0.4383
	D(D(LNE)) does not Granger Cause D(D(LNGDP))		2.7934	0.0952
Yunnan	D(D(LNGDP)) does not Granger Cause D(D(LNEN))	17	1.9816	0.1808
	D(D(LNE)) does not Granger Cause D(D(LNGDP))		3.4800	0.0583
Jining	D(D(LNGDP)) does not Granger Cause D(D(LNEN))	17	6.7165	0.0092
	D(D(LNE)) does not Granger Cause D(D(LNGDP))		0.1142	0.9498

The above results of the relationship between energy consumption and economic growth show that: there is no Granger causality between economic growth and energy consumption in eastern cities, which means that for the more developed eastern provinces, economic growth is not entirely energy-dependent mode. In addition to energy input, other factors promote economic growth, such as the increase of labor force, capital investment, and technological progress. At the same time, it is also possible that in recent years, the eastern provinces have done an excellent job in advocating economic transformation and industrial restructuring, and the government has established an effective mechanism for the improvement and perfection of energy policies, which has improved the efficiency of energy utilization. The results show that energy consumption is a one-way Granger causality of economic growth in Western China, which indicates that the economic development of these provinces is mostly driven by energy consumption. The implementation of energy-saving policies may affect economic growth. Compared with other regions, energy consumption in the western areas (Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, etc.) has always been characterized by high intensity, low utilization rate, and massive energy-saving task. With economic growth, energy consumption will continue to increase, and energy supply shortage and environmental pollution will become a problem that cannot be ignored. In the future, the western region must coordinate the contradiction between economic development and energy consumption and ensure that economic growth will not be affected while promoting energy conservation and emission reduction policies. Also, the test results of the central region and the northeast region are similar, indicating that economic growth is the one-way Granger cause of energy consumption. That is, energy consumption is not the direct cause of economic growth. This shows that in recent years, the plan for the rise of central China and the revitalization of Northeast China has achieved

preliminary results. The increase of income level and capital intensity will gradually become the factors affecting the interprovincial energy intensity.

#### 4. CONCLUSIONS

Conclusion: (1) there is at least one long-term equilibrium relationship among GDP, capital stock, human labor capital, and energy consumption through the cointegration test. (2) There is a two-way causal relationship between economic growth and energy consumption in eastern provinces. The energy consumption of central and northeast regions is the one-way Granger cause of economic growth. Still, economic growth is not the Granger cause of economic growth. That is, the economic growth of these provinces is driven by energy consumption. The western provinces conclude that economic growth is the one-way Granger cause of energy consumption. Economic growth will affect energy consumption, and there is a long-term equilibrium relationship between the two.

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