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The Relationship between Electricity Consumption and Economic Growth in China

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Abstract

This paper exam sal relationship between electricity consumption and real GDP in China through ve h can avoid the false causal relationship. The results of the VECM reveal the co-integration relationship between real GDP and electricity consumption and the presence of unidirectional causality from electricity consumption to economic growth in the short-run and long-run, which is subsequently verified in two different sub-phases. And then we come up with some suggestions that China should modulate the supply structure of electric power and pick up speed to adjust industry structures.

*Keywords:*causal relationship;vector error correction model; electricity consumption

1. Introduction and Literature Review

Although economic theories do not set forth the relationship between energy consumption, especially electricity consumption and economic growth, many studies have argued that electricity consumption is not only related to the creation of fortune but also one of important indexes of economic social development. Electricity consumption can promote economic growth, through which electricity consumption can to some extent enhance the production of capital, labor and technique; economic growth can in turn increase the demand for electricity consumption, which indicates the inherent relationship between them.

The study of causal relationship between electricity consumption and economic growth started with seminal work of Kraft and Kraft(1978), in which causality was found to run from GNP to energy consumption from 1947-1974 in the United states. But when using the shorter sample period and same time series data, Akarca and Long(1980) could not reach similar conclusion. Yu and Hwang(1984), however, did not find causal relationship between energy consumption and economic growth when updating Kraft and Kraft's data from 1947 to 1979. empirical studies were later extended to cover other

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developed and developping countries like the United Kingdom, Germany, Italy, Canada, France, Japan, Greece and China.(Yu and Choi,1985;Erol and Yu 1987;Hondroyiannis et al.,2002).Han Zhi Yong(2004)found that there exist bidirectional causal relationship between energy consumption and economic growth in China, but long-term co-integration was not found. Zhu Ya Xing(2006) analyze long term equilibrium and short term dynamic relationship between electricity consumption and economic growth by applying co-integration and vector error correction model and find there exist long-term equilibrium relationship between them. Liu Xiao Li(2007)found that there exist not only bidirectional causal relationship between energy consumption and economic growth but also long term co-integration by using Granger causal test and error correction model.

According to existing literatures, the relationship between electricity consumption and economic growth can be classified into three categories: firstly, if there exists a causal relationship from electricity consumption to economic growth, which means that electricity consumption can stimulate economic growth and economic growth is the energy dependence. Therefore, electricity shortages will hinder economic growth (see Galip Altinay（2005），Paresh Kumar and Narayan（2007）). Secondly, if there exists a causal relationship from economic growth to electricity consumption, which means that economic growth has low dependence on electricity consumption and the effect of electricity rationing on economic will of small. (see Cheng and Lai(1993)). Thirdly, there may be bidirectional causal relationship between electricity consumption and economic growth.

From the perspective of existing literature on the relationship between electricity consumption and economic growth, the following problem can be found. Firstly, most of the researching methods are relying on causality test, co-integration analysis and error correction model. But it should be payed attention that Granger causal analysis is sensitive to minor change in model structure, such as adding linear trend term in the co-integrated equation or changing lag periods from 2 to 3. We consider the above controversy results between Kraft and Kraft（1978）and Yu and Hwang（1984）to be not only different sample period selected but also lag periods of Granger causal test. Secondly, Han Zhi Yong (2004) use annual GDP and aggregate energy consumption to examine Granger causal relationship. But they do not adopt logarithmic transformation on original data so as to eliminate the effect of hetero-skedasticity on results, nor make difference to eliminate the effect of non-stationary data on regression. Therefore their testing result can not be fully convinced. The data applied by Ma Chao Qun(2004) is annual data from 1954 to 2003, although they make logarithmic transformation on original data in order to eliminate the affection of hetero-skedasticity on results, the logarithmic data remain one order non-stationary, which make their regression equation exist some doubt for false regression. This can to some extent reduce the convincing power of their result. Although the data about GDP and electricity consumption applied by Zhu Ya Xing(2006) are made logarithmic transformation, they do not make price deflator on GDP data. As we know that price can be affect by many factors, the co-integration analysis between GDP containing price factor and electricity consumption is full of doubt.

Our study contain the following features relative to others': firstly, GDP data is made deflator, namely real GDP, and then real GDP and electricity consumption are made logarithmic transformation in order to eliminate the effect of hetero-skedasticity on result. Secondly, Vector error correction model is applied to deeply analyze Granger causal relationship, which can not only rule out false causal relationship but also derive stable conclusion on causal relationship by determining suitable lags. Thirdly, exogenous dummy variable is added in the vector correction model in order to catch the right relationship between real GDP and electricity consumption through fully consideration on time series features of real GDP and electricity consumption datum.

This paper is organized as follows. Section2 describes data and methodology. Section 3 provides the empirical results of the research. Section 4 presents the stable test on results and the last section concludes the study.

2. data and methodology

2.1 Datum and Its Processing

Our empirical study uses the times data of GDP and electricity consumption for the 1953-2009 period of China. Nominal GDP and electricity consumption data for China are obtained from the National Bureau of Statistics (2009), China electricity statistics yearbook and statistical data collection on New China for 50 years. Firstly, the real GDP data is obtained by making deflator on Nominal GDP for 1953-2009 based on price index of 1952. Secondly, the real GDP and electricity consumption datum are made logarithmic transformation in order to eliminate the effect of hetero-skedasticity on results, which are represented respectively by $LnGDP_t, LnE_t$. The figures of logarithmic of GDP , real GDP and electricity consumption, represented by $LnGDP_t, LnE_t$ respectively .are given as follow:

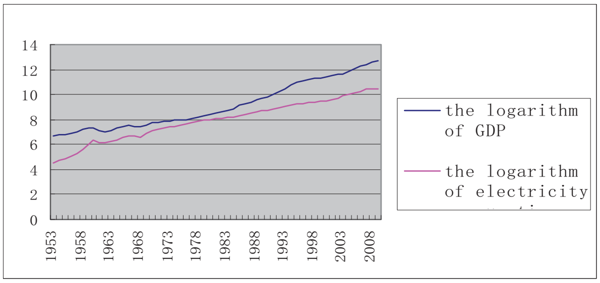

Figure 1 GDP and electricity consumption from 1953-2009 in China

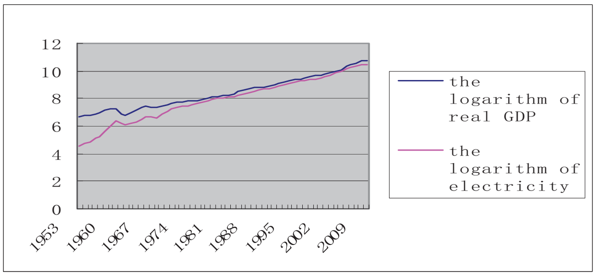

Figure 2 real GDP and electricity consumption from 1953-2009 in China

According the above two figures, the relationship between GDP deflated and electricity consumption is closer than that of GDP un-deflated and electricity consumption, which indicates GDP contain more price factors than electricity consumption. And it is found that the time series data of real GDP and electricity consumption have certain inertia and some tendency and all contain to some degree auto-regression.

2.2 Econometric Method

1) cointegration test

If time series $y_{1t}, y_{2t}, ..., y_{nt}$ are proved to be integration of order d , namely $I(d)$, then there exist a co-integration vector $\alpha = (\alpha_1, \alpha_2, ..., \alpha_n)$, which makes $\alpha y_t' \sim I(d-b)$ .where $y_t = (y_{1t}, y_{2t}, ..., y_{nt})$,d≥b≥0. then $y_{1t}, y_{2t}, ..., y_{nt}$ is called to be co-integration of order (d,b) , represented by $y_t \sim CI(d,b)$, α is co-integration vector. Two methods are used to test co-integration relationship between variables. First is E-G tow steps based on regression residuals. Second is Johansen co-integration test based on regression coefficient, which uses maximum likelihood estimation to estimate co-integration between variables tested under VAR system and it is testified to be more efficient than the former'. The maximum eigen-value statistics and trace statistics are given as follow:

$$LR_{\max} = -T\ln(1-\lambda_{T+1}), \quad LR_{trace} = -T\sum_{i=r+1}^{n-1}\ln(1-\lambda_i), \quad r = 0,1,2.....n-1 \tag{1}$$

If two time series are proved to be co-integration, there exists at least one direction of causal relationship.

2) error correction model

Error correction model is initially used to make short term dynamic model on order to compensate the drawback of long term static equilibrium. It can not only reflect long term equilibrium between time series but also reflect feedback mechanism of short deviation to long term equilibrium. According Engle theorem if there exist co-integration relationship between non-stable variables, error correction model can be made using the following (1,1) auto-regression distribution lag model:

$$Y_t = \beta_0 + \beta_1 X_t + \beta_2 Y_{t-1} + \beta_3 X_{t-1} + \varepsilon_t \tag{2}$$

Supposing that all variables are stable, there don't exist autocorrelation and hetero-skedasticity in stochastic error. Equition (2) can be made parameter transformation and rearranged as follow:

$$\Delta Y_t = \beta_0 + \beta_1 \Delta X_t + (\beta_2 - 1)(Y - \frac{\beta_1 + \beta_3}{1-\beta_2} X)_{t-1} + \varepsilon_t \tag{3}$$

Equition (3) is error correction model, where error correction term is $(Y - \frac{\beta_1 + \beta_3}{1-\beta_2} X)$, from which we can not only make a distinction between long term equilibrium and short term dynamic but also avoid false regression. And Wald test can be used to test the direction of causal relationship and has strong economic significance.

3. Empirical Results

3.1 Unit Root Test

TABLE I UNIT ROOT TEST RESULT

	Original series		Differentiated series	
	$LnGDP$	LnE	$\Delta LnGDP$	ΔLnE
ADF	-0.647	-1.25	-3.67[a]	-5.1[a]

Where：a，b，c represent respectively significant level of1%，5%，10%. $LnGDP$ and LnE represent respectively logarithmic of real GDP and electricity consumption. Δ represents diffenrence of order 1.

Table 1 shows that although the logarithm series of real

GDP and electricity consumption are non-stationary in level, after differencing the variables once, the two variables are confirmed to be stationary, which indicates that the logarithm series of real GDP and electricity consumption are $I(1)$, next we will analyze long term equilibrium relationship between real GDP and electricity consumption through co-integration.

3.2 Cointegration Test

TABLE II MAXIMUM LIKELIHOOD AND TRACE CO-INTEGRATION TEST

Hypothesis	eigen value	Trace statistics	Critical value at 5%	proba bility	Maximum eigenvalue statistics	Critical value at 5%	proba bility
Non cointegration	0.322	33.68	25.87	0.004	21.38	19.39	0.025
One cointegration art most	0.2	12.3	12.52	0.054	12.3	12.52	0.054

Table 2 shows that one co-integration relationship can be accepted at 5% significant level from trace and maximum eigen-value statistics, which indicates there exists long term co-integration relationship between electricity consumption and economic growth and Granger causal relationship of one direction at least. And next the results of vector error correction model and causal test are given as follow.

3.3 Error Correction and Causal Test

1) result of error correction

TABLE Ⅲ ERROR CORRECTION MODEL AND CAUSAL TEST

Dependent variable	C	C_1	**Error correction term**	ΔLnG_{t-1}	TABLE I	ΔLnG_{t-3}	ΔLnG_{t-4}	ΔLnE_{t-1}	ΔLnE_{t-2}	ΔLnE_{t-3}	ΔLnE_{t-4}	$\overline{R}^2$	F
ΔLnG	0.11 (4.54)	0.22 (3.78)	-0.04 (-1.76)	0.33 (1.77)	0.14 (0.73)	-0.06 (-0.32)	-0.29 (-1.72)	-0.3 (-2.29)	-0.28 (-1.89)	-0.18 (-1.22)	0.24 (1.64)	0.55	7.4
ΔLnE	0.1 (3.47)	0.28 (3.95)	0.05 (1.49)	-0.004 (-0.02)	0.61 (1.53)	-0.63 (-2.58)	0.24 (1.16)	0.2 (1.29)	-0.53 (-2.93)	0.19 (1.04)	-0.12 (-0.66)	0.56	3.74

where ΔLnG 、 ΔLnE represent respectively difference of logarithm transformation of real GDP and electricity consumption., C_1 is a exogenesis dummy variable, datum in parentheses are t-statistics.

As we know that error correction model is considered to be a special VAR model, to which a long term condition is restricted. According to the changing characteristics of the real GDP and electricity consumption before and after 1960 in selected sample period, an exogenesis dummy variable is added in error correction model, which can size the true relationship between them. Because it is very important to select suitable lags in VAR model, we determine the lags according to AIC and SC rules. And the lag order is confirmed to four.The empirical results reported in table 3 show that there exist a unidirectional causality from electricity consumption to economic growth. The long-term causality from electricity consumption to economic growth is supported by the coefficient of the lagged error-correction term, which is negative and statistically significant. The short-run causality from electricity consumption to economic growth is, however supported by the F-test and the coefficient of the electricity consumption variable in the economic growth function, which are both statistically significant. The reverse long-term and short-run causalities from economic growth to electricity consumption can not be supported by coefficient of the lagged error-correction term and the F-test, which are both insignificant.

4. Robust Test

Table 3 report that there exists an unidirectional causality from electricity consumption to economic growth. According to the literature review, the selected sample period may affect causality relationship. We reselect two different sample periods within 1953-2009 time period in order not only to give a robust test on above result but also to testify causality relationship consistency in the full period. As we know reform openness in China is put into practice in 1978, from which Chinese economy system transform from planned economy to planned commodity economy. In 1992, Deng Xiao ping inspect the southern of China and make a speech on Chinese economy, which make Chinese economy soft landing, therefore we divide the above sample period into two sub-stages, namely 1953-1978 and 1953-1993 and carry through causal test.

Table Ⅳ CAUSAL TEST BASED ON VECM

independent variable / **Dependent variable**	**First period（1953-1978）**		**Second period（1953-1993）**		**Third period（1953-2009）**	
	$\Delta LnGDP$	ΔLnE	$\Delta LnGDP$	ΔLnE	$\Delta LnGDP$	ΔLnE
$\Delta LnGDP$		16.1[a]		29.24[a]		19.81[a]
ΔLnE	7.13		6.37		8.1	

Where $\Delta LnGDP$、ΔLnE represent respectively the difference of logarithm series of real GDP and electricity consumption. Datum are χ^2-statistics. the lags are determined by AIC and SC criteria.

Table 4 show that at the three periods there all exists unidirectional causality from electricity consumption to economic growth, which indicate that our results are robust and consistency.

5. Conclusion and Suggestions

This study examine the causal relationship between electricity consumption and economic growth using Chinese data and find there exists unidirectional causality from electricity consumption to economic growth, which indicates that electric power supply can to some extent become the restricting factor to economic growth and the shortage of electric power can hinder economic growth in China.

Electric power is a special energy and do not easily keep in reserve. Therefore China must keep regular growth of electricity supply in order to boost the growth of output and to some degree avoid unnecessary waste. Firstly China should modulate the supply structure of electric power, increasing supply of wing energy, solar energy and nuclear power. Secondly China should pick up speed to adjust industry structures, reducing the proportion of energy-hungry heavy and low value-added industry, increasing the proportion of output value of service industry, especially modern service industry in economic growth. Thirdly China should popularize the usage of energy-saving products through several routes, enhancing the consciousness of consumers to save energy.

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