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The Study of Relationship between China's Energy Consumption and Economic Development

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Abstract. The paper, under the working of modern economic growth theory, introduced the energy as a new factor of production into Cobb-Douglas production function, used the two stages of different levels about economic development in the period of 1985-2000 and 2001-2009, during which the time series data are weighted least squares analysis, and by conducted the comparison two empirical results and the estimated analysis of the Granger causality test on variables of 1985-2009 time series. It showed that energy consumption was playing different roles on economic growth at different stages of economic development. The trend was from the weak to strong performance sequentially, but the increase of energy consumption is not the main drivers of economic growth.

Keywords: Economic Growth, Energy Consumption, Granger Test

1. Introduction

At present, China's economic growth has been along with the great cost of resources. after 2001, China's energy intensity did a continued rise, the average annual increase of 4.15%, so it is increasingly apparent that a large amount of energy consumption constrained on economic growth. Since 2006, the government has begun to strengthen the specific emission reduction, while many domestic areas has started to perform the energy reduction of industrial structure in order to further improve efficiency of utilizing energy. The past two sessions in 2010 stressed that GDP growth of 8% in the 2010 ,obviously appears to prevent the overheating of the economy, meanwhile, it means that the our nation switch the importance of economic construction from improving speed to ensuring the quality, which promotes industrial upgrading, makes the structure change and creates green GDP. Saving resources and improving energy efficiency are always locked in a stalemate with economic development .empirical analysis of energy consumption and economic growth in this paper make a practical significance on the long-term plan of social economy and formulation of energy development strategy.

Meanwhile, after the oil crisis of 1970s, the action of energy for economic growth had been begun to study extensively, As a basic factor of production, energy is the same as the labor and capital, making an obvious influence on economic growth. Rashe and Tatom (1977), who was advanced to introduce the energy into consumption of Cobb-Douglas production function, tried to seek the basic law of the actual process between energy use and economic growth and quantitatively described the relationship between energy and economic development. With the impact of energy on economic development gradually expanding ,The method of study from new classical economists (such as Renshaw, 1981) was to exam effects of relative prices on world energy on potential GNP, income distribution, capital formation and economic welfare, etc on the basis of a priori theory. Yun Liu fluttering of flag (2009) also used energy as a new factor of production into Cobb-Douglas production function, who studied the relationship between energy and Shanghai's

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economic development during the period 1985-2007 by supplying the vector autoregressive (VAR) Model Research. Research shows that energy is very necessary for china's economic growth.

Research findings on the relationship between energy consumption and economic growth included three aspects: non-causal relationship, one-way causality, bi-directional causality. Cheng (1997) found that there is no causal relationship between China Taiwan's energy consumption and GDP by using the analysis of binary variables; Kraft and Kraft unfolded that economic growth is the major cause of energy consumption via studying the relationship between energy consumption of 1947-1974 at the United States and economic growth; Zhiyong Han and Yi-Ming Wei (2004) found that China's energy consumption and economic growth had a two-way causal relationship China's energy consumption and economic growth by studying the causal relationship between economic growth and energy consumption in China 1978-2000.

The common study of above scholars is based on a time series empirical analysis, not compare a regional or national economic development at different times, then explored in-depth relationship between energy use and economic growth. Given that energy intensity continued to rise after 2001, this paper builds Cobb-Douglas production function model, respectively conducting the test of single integer and cointegration, Granger causality and finally uses weighted least squares method to analyze the 2001-2009 1985-2000 period of two Cobb-Douglas production function and the relationship between economic growth and energy consumption based onthe data of the total national energy consumption, GDP, labor, and capital.

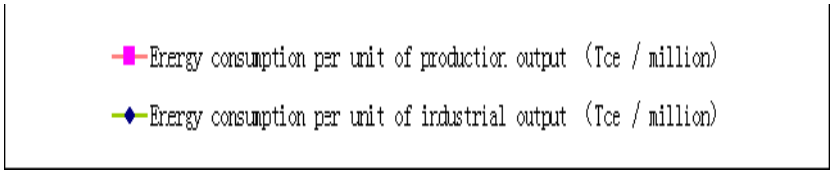
It concluded that there is a strong correlation between the energy consumption and economic growth and the difference between energy consumption and economic growth at two stages trends from weakness to strength, but the increase of energy consumption is not the critical driver of economic growth and policy recommendations will be put forward at final.

2. The Core Indicators's Analysis of Energy Consumption and Economic Growth

2.1. Energy Consumption Intensity

Energy consumption intensity, is the amount of energy consumed per unit of output within a certain period of time from a country, region, sector or industry, usually be represented by tonnes (or kg) of oil equivalent (or coal equivalent) / million. The energy consumption per unit of output for acountry or region is usually balanced by the units of energy consumption to gross national product, which reflects how the degree about economy relying on the energy and the efficiency of using energy. The industrial development around the world experienced the process from traditional agriculture to industry ,then to service industry. Traditional agriculture consumed less energy and energy intensity is little ,so it had slow development. But the energy intensity had turn to rise since the industrialization and urbanization. After the completion of industrialization and urbanization, the third industries had been developed. Energy intensity gradually decreased and stabilized along with the progress of science, technology and management improvement.

China's overall energy intensity trend is downward. In addition, total energy intensity of industrial units appeared down in addition to a slight rebound in 1990. The path of changes in energy consumption per unit industrial output value was the same as total output value. Industrial output value of unit energy consumption per unit was higher than GDP energy consumption, especially in the 80s and early 90s, there was significant difference. However, due to the current industrial energy equipment, and improvements in technology, in recent years, the gap between them has been shrinking.



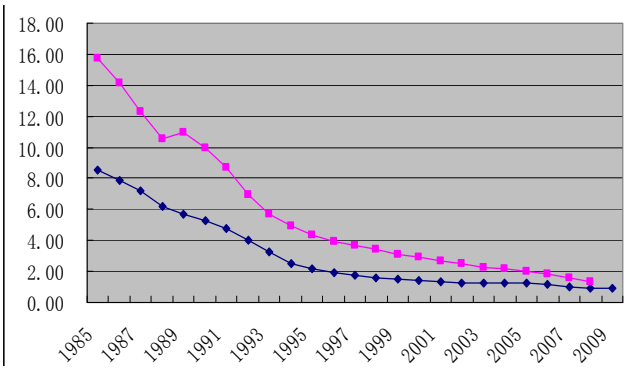


Fig. 1.1985-2009 energy consumption per unit of GDP energy consumption and unit industrial output value (at 1985 constant prices) primary data sources: CEInet Statistics Database.

2.2. Energy Consumption Elasticity

Energy consumption elasticity is a indicator reflecting a certain percentage of relations between a country or region's energy consumption and economic growth over the same period and a ratio of average growth speed of energy consumption and national economy . China's energy consumption elasticity coefficient fluctuated considerably (Figure 2-2) in the period 1985-2009.See from three time periods as Table (2-2) showed, we can find that the overall elasticity of energy consumption is on the rise. Changes in elasticity of energy consumption is small in 1990s ,but since 2001, individual coefficientsare relatively large and directly impact the overall elasticity of energy consumption in this century. 10 years of the 21st century is China's fastest economic growth in 10 years. It has stimulated the higher demand for energy, but energy consumption growth rate is much higher than the rate of economic growth, so the elastic coefficient should remove the increase.

Comparison of GDP and energy consumption growth, we can see that energy consumption growth and GDP growth is the same in the overall trend, but the GDP growth rate was slower than the growth rate of energy consumption. peaks or troughs of energy consumption are earlier than economic growth, indicating that stimulated the growth of GDP energy consumption growth,indicating that energy consumption growth stimulated the growth of GDP.

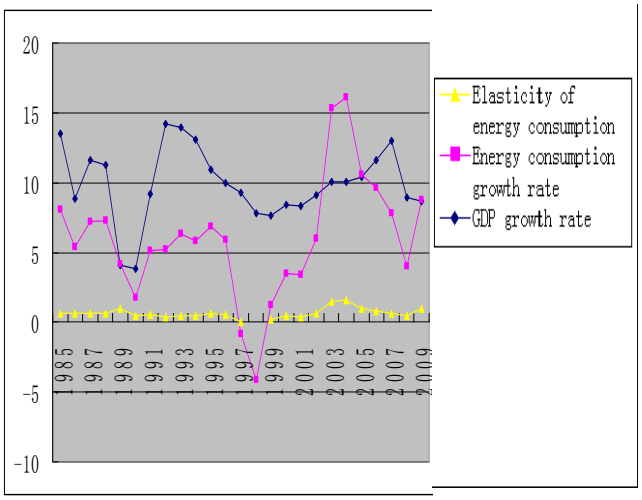


Fig. 2.1985-2009 index of China's energy consumption elasticity Raw Data Source: Statistics Database CEInet

3. Empirical Analysis Energy Consumption and Economic Growth Based on Energy Consumption and Economic Growth

3.1. Building Model

Above theory explained how the variables effects the dependent variable from an empirical point of view of model. Production function is a mathematical equations describing the mutual relations between the factors of production inputs and output the maximum possible, so the use of Cobb - Douglas production function, namely, C-D production function: Gi = AKiαLiβ Gi, A, Ki, Li respectively mean,the level of annual output

in this section i, different from the amount of physical capital and labor factors, fixed capital investment and labor inputs. α and β are the output elasticity of fixed capital and labor flexibility. Energy ,capital and labor are the endogenous factors of economic growth, this new production of energy as factors of production function was introduced: Gi = AKiαLiβTiKi is in the total social fixed assets investment in the i year; Li is the i year's labor input; Ti is the total amount of energy consumption; γ is the energy consumption elasticity. To eliminate the impact of heteroscedasticity for economic time series data, all variables are natural logarithm.The empirical model is also designed to model the three variables after logarithmic transformation for the linear model, is easy to verify, so the transformed model: LOGG = C + αLOGK + βLOGL + γLOGT + LOGμ , G said the level of inspection of the GDP, C as the base level of technology, K is the total social fixed assets investment, L is labor input; G representatives for the economic output of GDP, T is the total energy consumption, μ is random disturbance term.

3.2. Model 's Estimation and Analysis

3.2.1. Obtaining the data

This article uses series data over the years of 1985-2009 time at different stages of economic development for the period of estimated GDP growth of energy consumption and the relationship between the weighted least square method to estimate the Panel data models. Basic data derived from the "China Statistical Yearbook (2009)," and finishing CEInet statistical database, G said GDP, L expressed by the number of employees, K with the current total investment in fixed capital, said, T with Total energy consumption.. all the datas are in accordance with the conversion of 1985 constant prices. Due to space limitations, data tables omitted.

3.2.2. Single-variable integration and Cointegration Test of variables

To avoid the false return, must have a single integration and cointegration test to the explained variables variables LOG (G) and the explanatory variables LOG (L), LOG (K), LOG (T) , select a trend and intercept option in the unit root test, found that they satisfy the (1,2,2,2) one order in the 5% confidence of their level by stepwise selection differential comparison. Examine cointegration relationship between variables by using the Engle-Granger, EG has two steps, first create the whole association equation of LOG (T), LOG (L) and LOG (K) on LOG (G) of by Eviews3.1 software, and then test the residual series from which estimated equation parameters cointegrationis is stable of not. The result of the residual unit root test sequence is as follows:

Table 1. Unit root test on residuals table

		T-statistics	prosbilites
ADF Test statistics		-3.038999	0.021862
Test critical values	1% level	-2.9893	
	5% level	-1.8730	
	10%level	-1.3820	

In summary, there is a long-term stable equilibrium relationship between LOG (G) and the explanatory variables LOG (T), LOG (K), LOG (L) after a single integration and cointegration test, it does not produce a false return by the use of LOG (G), LOG (L), LOG (K), LOG (T) constructed regression model, can be a regression model of the real economic significance.

3.2.3. Granger causality test

Using Granger causality test of Eiews3.1 software test the causal relationship of economic growth and the energy consumption, the results are as follows:

Table 2.Granger causality test

Original Assuming	The Number Of Samples	F statistic	P Value	Conclusions
LOG (G) is not caused by LOG (T)	25	0.15137	0.86167	Accept the null hypothesis
LOG (T) is not caused by LOG (G)	25	1.01607	0.40006	Accept the null hypothesis

As can be seen from the table,the probability of the original assumption is 0.86167 and 0.40006 for the LOG (T) is not caused by LOG (G) and LOG (G) is not caused by LOG (T) , accept the null hypothesis that there is no causal relationship between both energy consumption and economic growth , GDP growth not the main motivation in total energy consumption growth, the improvement of total energy consumption is not the main reason for GDP growth, indicating that China's economic output increased at the same time,the waste of the energy the total consumption are quite serious.

3.2.4. Estimate the parameters by using the WLS method

Using weighted least squares (WLS) estimate the model coefficients can effectively eliminate the heteroscedasticity model, but alsoovercome the serial correlation to a certain extent,,so Eviews3.1 software is used for weighted least squares method in this paper, the weight is the countdown residual time, estimates as the following table:

Table 3. Weighted least squares estimation results

Dependent Variable: LOG(G)

Method: Least Squares

Sample: 1985 2000

Included observations: 16

Weight : 1/ABS(RE)

Variable	Coefficient	Standard error	T-statistic	. probability
C	-11.13674	1.758181	-6.334	0.0000
LOG(L)	0.842809	0.235726	3.575	0.0038
LOG(K)	0.713009	0.058117	12.268	0.0000
LOG(T)	0.486461	0.307449	1.582	0.0396

The estimation model result of two-stage of economic output and energy consumption in 1985 -2000 and 2001-2009 are as follows:

$$LOG(G) = -11.13674 + 0.842809*LOG(L) + 0.713009*LOG(K) + 0.486461*LOG(T) \quad (1)$$

(-6.334) (3.575) (12.268) (1.582)

R^2=0.999999 D.W= 1.000496 F=12470.13

$$LOG(G) = 79.34568 + 0.668*LOG(L) + 1.325*LOG(K) + 0.874*LOG(T) \quad (2)$$

(4.207) (3.554) (6.546) (20.989)

R^2=0.999999 D.W= 2.564737 F=10701.89

3.3. Test the WLS model

3.3.1. The economic significance test

The coefficients of the three explanatory variables are positive in model equation, in line with the positive correlation between the explained variables and explanatory variables, in line with the economic real of the growth of explained variable is caused by thegrowth of explanatory variables, in line with the real economic significance, so the model is through economic significance test.

3.3.2. The statistical test

- Fit test: R2 test. The goodness of fit of the three regions are 0.99999, indicating the equation has a
- better goodness of fit.
- Variable significance tests: t test. T test with all the coefficients are far less than 5% probability,

Therefore, the coefficient of explanatory variable significant is not zero, pass the significance test.

- Equation test of significance: F test. The F-value of the two equations are far greater than the F0.05

(3, Ni-4), which the Ni is the numbers of the sample two equations, respectively 16,9. And the associated probability of the equation of the overall test of significance is less than 0.001, the equation is remarkable establishment in the high confidence level , which has economic significance.

3.3.3. Heteroskedasticity test

Can be found that the pregnant specific variance test whether has the cross termsr or not, both accept the original hypothesis which not exist to heteroscedasticity in the high level of confidence in the equation, using weighted least squares method to estimate model parameters is almost completely eliminated the heteroskedasticity of initial equation .

4. Conclusions

The production function model is used in this paper, and an empirical study on differential impact between energy consumption and economic growth the first 14 years and after 9 years of the 21st century by the use of a single whole and Cointegration Test, Granger and weighted least squares econometric research methods it can be seen, first,energy consumption has great positive effect to promote economic growth in China from the the coefficient of LOG (T) in two time periods model. Second, by analyzing the economic significance of the model can be seen that among the explanatory variables LOG (T) coefficient of 0.874 during the later stage model of development, said for every 1% increase in the energy consumption, the GDP will increase 0.874%. Comparing the coefficient of the LOG (T) in the first equation found that other factors in certain circumstances, the existence of energy consumption on economic growth in the contribution of phase change. With economic development, changes in industrial structure and technological development, among other factors to improve energy efficiency, energy consumption in the 21st century in stimulating economic growth rate even more. China's economy is in the initial stage of development, agricultural economics stations dominate, the development of the industrial economy is not mature, the demand for energy far less than the more developed industrial economy is relatively dominant in the 21st century, while the relationship between energy consumption and economic growth is bigger than than the pre-degree, which meant that the relationship is affected by the level of economic development and operational mechanism of the economy. Third, although the energy consumption and economic growth has a long-term equilibrium relationship, but in the long run, energy consumption growth is not the main drivers of economic growth.

However, the energy consumption on economic growth has an irreplaceable contribution, energy shortages will be a bottleneck of economic development in the future , and based on promote long-term sustainable development of China's economy, the following three suggestions: (1)Adjust the industrial structure, promote energy conservation structures, development high value-added industries, and improve energy efficiency. (2)Promote diversification of energy, optimizing energy consumption structure, actively develop the tertiary industry with lower energy consumption, so that the light of the economic structure and energy development. (3) Develop new energy sources, clean energy and renewable energy.

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6. References

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