Multiple Regression Model-based Analysis of the Impact of Chinese Energy Consumption on Economic Growth

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Abstract. Aiming at improving China’s energy consumption and making it have a greater effect on economic growth, from the perspective of promoting China’s economic growth, this paper use the multiple regression model to analyzes the specific long-term and short-term effect of energy consumption and its composition on economic growth with examples, and corresponding policy recommendations about China’s energy consumption are put forward combined with analysis result.

Introduction

At present, China is at the critical stage of building a moderately prosperous society in all respects, it’s a critical period for China to achieve industrialization and urbanization, economic structure, urbanization level, and resident consumption structure also change obviously in this phrase, all these need to be guaranteed by sustainable growth of energy supply. As the world's largest developing country, China has become the world's second largest energy consumer[1]. While due to extensive economic growth mode, high input, high consumption, low output, unreasonable industrial structure, and low efficiency of energy utilization as well as other factors, the development of human society is restricted to some extent, ecological environment is also damaged, and even the survival of mankind itself is threatened. While human beings are aware of the importance of energy industry, they also gradually realize the stark reality of unreasonable energy consumption structure, serious environmental overdraft, crisis that persistent existence and prospect of human are facing. Therefore, it’s very necessary to study the relationship between China's energy consumption and economic growth for readjusting the industrial set-up and building a energy-saving, environment-friendly society.

Theoretical Analysis

Energy Consumption Promotes the Expansion of Economic Scale

When other invested elements are available, many factories must have energy to provide power for their normal operation, and the scale and extent of operation are also constrained by energy supply. Therefore, energy makes inputs dynamic, and inputs is the prerequisite of economic growth. In addition, energy promotes the birth and development of new industries. Energy products, especially mineral energy products are also important industrial raw materials, the rise of coal chemical industry, petrochemical industry which use mineral energy as raw materials not only makes themselves become industry sectors with decisive position, but also drives a number of new industries to develop rapidly, at the same time, it creates conditions for transforming traditional industries and promotes the expansion of economic scale.

Energy Consumption Can Drive the Improvement of People's Living Standards

It is well known that the development of energy pushes the human society into civilization, and the increases of total energy consumption and types also promote the the progress of human society. In the process of economic and social development, used in industrial and agricultural production as fuel and chemical raw materials, energy creates progressively increasing material products for the promotion of life, making a contribution to promoting economic growth; On the other hand, energy is also widely applied in people’s daily life, it guarantees people's basic necessities of life and various
daily activities. Production and energy are inseparable, and the higher the living standard is, the
greater the dependence on energy is, the more important role of energy consumption in the factors
that influence economic growth plays, as a result, energy becomes one of the important material bases
of improving people's living standard.

Empirical Analysis

Data and Processing

In order to make a clearer analysis on the contribution of energy consumption to economic growth,
this paper chooses to ignore the factors except capital and labor input. This paper chooses five
variables: gross domestic product GDP(0.1 billion yuan), oil consumption S (10 thousand tons of
standard coal), total coal consumption M (10 thousand tons of standard coal), total investment in
fixed assets G (0.1 billion yuan), number of urban employment C (10 thousand people). All data are
derived from annual data of State Statistics Bureau, selected from 1989 to 2015, and analyzed by
Eviews7.2.

Table 1. Original data.

| year | oil consumption S (10 thousand tons of standard coal) | total coal consumption M (10 thousand tons of standard coal) | gross domestic product GDP(0.1 billion yuan) | total investment in fixed assets G (0.1 billion yuan) | number of urban employment C (10 thousand people) |
|------|-----------------------------------------------------|-------------------------------------------------------------|---------------------------------------------|------------------------------------------------------|-----------------------------------------------|
| 2015 | 77830                                               | 275200                                                     | 685505.8                                   | 561999.83                                            | 7799.9                                         |
| 2014 | 74090.24                                           | 279328.74                                                 | 643974                                     | 512020.65                                            | 7009                                          |
| 2013 | 71292.12                                           | 280999.36                                                 | 595244.4                                   | 446294.09                                            | 6142                                          |
| 2012 | 68363.46                                           | 275464.53                                                 | 540367.4                                   | 374694.74                                            | 5643                                          |
| 2011 | 65023.22                                           | 271704.19                                                 | 489300.6                                   | 314851.13                                            | 5227                                          |
| 2010 | 62752.75                                           | 249568.42                                                 | 413030.3                                   | 251683.77                                            | 4467.5                                         |
| 2009 | 55124.66                                           | 240666.22                                                 | 349081.4                                   | 224598.77                                            | 4244.5                                         |
| 2008 | 53542.04                                           | 229236.87                                                 | 319515.5                                   | 172828.4                                            | 3609                                          |
| 2007 | 52945.14                                           | 225795.45                                                 | 270232.3                                   | 137323.94                                            | 3310                                          |
| 2006 | 50131.73                                           | 207402.11                                                 | 219438.5                                   | 109998.16                                            | 3012.5                                         |
| 2005 | 46523.68                                           | 189231.16                                                 | 184937.37                                  | 88773.61                                             | 2777.7                                         |
| 2004 | 45825.92                                           | 161657.26                                                 | 159878.34                                  | 70477.43                                             | 2521.2                                         |
| 2003 | 39613.68                                           | 138352.27                                                 | 135822.76                                  | 55566.61                                             | 2377                                          |
| 2002 | 35611.17                                           | 116160.25                                                 | 120332.69                                  | 43499.91                                             | 2268.8                                         |
| 2001 | 32975.96                                           | 105771.96                                                 | 109655.17                                  | 37213.49                                             | 2131.2                                         |
| 2000 | 32332.08                                           | 100670.34                                                 | 99214.55                                   | 32917.7                                             | 2136.1                                         |
| 1999 | 30187.608                                          | 88480.92                                                  | 89677.05                                   | 29854.7                                              | 2414.2                                         |
| 1998 | 26928                                              | 97376                                                      | 84402.28                                   | 28406.2                                              | 2259                                          |
| 1997 | 28187.292                                          | 98793.695                                                 | 78973.03                                   | 24941.1                                              | 1919                                          |
| 1996 | 25010.64                                           | 103794.156                                                | 71176.59                                   | 22913.5                                              | 1709                                          |
| 1995 | 22955.8                                            | 97857.296                                                 | 60783.73                                   | 20019.3                                              | 1560                                          |
| 1994 | 21356.238                                          | 92052.75                                                  | 48460                                      | 17042.1                                              | 1225                                          |
| 1993 | 21110.726                                          | 86646.771                                                 | 35524                                      | 13072.3                                              | 929.5                                         |
| 1992 | 19104.75                                           | 82641.69                                                  | 27068                                      | 8080.1                                               | 740.2                                         |
| 1991 | 17746.893                                          | 78978.863                                                 | 21896                                      | 5594.5                                               | 692                                           |
| 1990 | 16384.698                                          | 75211.686                                                 | 18547.9                                    | 4517                                                  | 614                                           |
| 1989 | 16575.714                                          | 73669.84                                                  | 16909.2                                    | 4410.4                                                | 648                                           |

Following table and logarithm sequence chart derive from natural logarithms of the original time
series of five variables S, M, GDP, G, C.
It can be seen from the above figure that time-dependent direction of lines of LNC, LNG, LNGDP, LNM and LNS sequences are very similar, they all show a relatively gentle growth trend. It shows a certain non-stationary feature among the five variables.

**ADF Test**

The principal use of time series analysis is to predict the future according to the past, therefore it’s necessary to make the statistical regularity do not change with time, that is the so-called stationarity. The method that can verify if there is stationarity in time series, method of ADF test is used in this article. The original sequences are not stationary, so ADF test on first-order difference is carried out.

From the above results, we can see that all the sequences after the first-order difference undergo the unit root test at the significant level of 5%, that is, these sequences have become stationary time series, denoted as: LNG~I(1), LNGDP~I(1), LNC~I(1), LNM~I(1), LNS~I(1).

**JOHANSEN Co-integration Test**

JOHANSEN co-integration test first calculates the maximum likelihood method of dependent variable, followed by comparison of the positional relation between this value and confidence interval of different co-integration relationships, if the likelihood estimate of dependent variable is not in the confidence interval of co-integration relationships, it indicates that there is a long-term co-integration relationship among variables[2]; On the contrary, when the likelihood estimate of dependent variables is in the confidence interval of co integration relationships, accept its assumptions, it shows that there is no long-term co-integration relationship among variables. Process LNGDP and sequences by co-integration test. The tested null hypothesis is that the number of solutions of co-integration equation is zero, judge whether there is a co-integration relationship between the variables and GDP in the level of 5%, it shows that there is a long-term control relationship among GDP, oil consumption, coal consumption, total investment in fixed assets and the number of urban employment.

**Granger Causality Test**

The Granger causality test is proposed by Granger and Sims to test whether there is a causal relationship between variables. Its core idea is that there are two variables A and B, assume A is the Granger cause of B, but B is not the Granger cause of A, then current changes of B can be expressed by the past value of A, but the changing trend of A cannot be expressed by B. So what Granger causality tests is the extent that present value of B can be interpreted by past value of A. If the present value and past value of A can better simulate the trend of the value of B, if a number of A can better
simulate the value of B, we call A the Granger cause of B. The Granger causality test between GDP and sequences is mainly analyzed. The results are shown in the figure.

![Figure 3. Granger causality test.](image)

Accepted LNGDP is the Granger cause of LNC, accepted LNC is the Granger cause of LNGDP. Rejected LNG is the Granger cause of LNGDP, accepting LNGDP is the Granger cause of LNG. Accepting LNM is the Granger cause of LNGDP, rejecting LNGDP is the Granger cause of LNM. Accepting LNS is the Granger cause of LNGDP, rejecting LNGDP is the Granger cause of LNS. All in all, LNC, LNG, LNM, LNS have Granger cause of LNGDP.

**The Building of Regression Model**

Because multicollinearity may exist, the effect of multicollinearity should be taken into full consideration while building the regression equation, utilize successive regression to eliminate effects of multicollinearity. The regression result estimated by the least square method are shown in the figure.

![Figure 4. Regression model.](image)

Based on the adjusted goodness of fit, and sort the explanatory variables by their importance, the order is LNG, LNS, LNC, LNM, on the basis of regression equation of LNG and LNGDP, introduce LNS, LNC, LNM successively to carry out stepwise regression. First introduce LNS into the model. The goodness of fit is almost unchanged, but LNS is not prominent, P is greater than 0.05, and LNS is not retained. Then introduce LNC into the model. The goodness of fit increases, in all vectors, statistic of t vector is large, statistic of F model is 4118.357, P is less than 0.05, and the LNC can be retained. Then introduce LNM into the model.

The goodness of fit increases, in all vectors, statistic of t vector is large, statistic of F model is 4118.357, P is less than 0.05, and the LNC can be retained. Then introduce LNM into the model.

Its regression result is worse than the result that introduces LNC, therefore, in this stage, LNC should be retained. Then based on the regression model of LNG, LNC and LNG, introduce LNM, LNS in turn. The result is:
It shows that regression models of LNGDP, LNG, LNC, LNS are better.

**Autocorrelation Test and Correction**

According to the final conclusion of multicollinearity test and correction, DW = 0.90, for model with example size of 27 and 3 explanatory variables, consult DW statistical chart in the significant level of 5%, it shows that \( d_L = 1.14 \), \( d_U = 1.65 \), in the model, DW < \( d_L \), it is clear that there is a first order autocorrelation in the model.

For previously generated regression model, generate residual sequence and define residual sequence \( e = \text{resid} \). Input \( L_\text{resid}(-1) \) into the command bar of Eviews, use \( et \) to carry out 1 period lag autoregressive, then the regression results come out.

Autocorrelation coefficient \( = 1 - 0.5DW \), and DW=0.90665, so \( = 0.546675 \). Use generalized difference to process original model, input \( L_\text{lngdp} - 0.546675* L_\text{lngdp}(-1) \quad c \quad L_\text{lng} - 0.546675* L_\text{lng}(-1) \quad L_\text{ln} - 0.546675* L_\text{ln}(1) \quad L_\text{ln} - 0.546675* L_\text{ln}(-1) \), the result is:

\[
L_\text{NGDPt} - 0.546675 L_\text{NGDPt-1} = -0.2318 + 0.4047 (L_\text{NGt} - 0.546675 L_\text{NGt-1}) + 0.3475 (L_\text{NCT} - 0.546675 L_\text{NCT-1}) + 0.4928 (L_\text{NSt} - 0.546675 L_\text{NSt-1}) + et
\]

The adjusted goodness of fit is 0.992930, DW=1.758926, \( F=1029.929 \)

\( d_L=1.14 \), \( d_U=1.65 \), now \( d_L<\text{DW}<4 - d_U \), Therefore, there is no first-order serial correlation

It can be referred that the estimated original regression model is:

\[
L_\text{NGDP} = -0.51138 + 0.4047 L_\text{NG} + 0.3475 L_\text{NCT} + 0.4928 L_\text{NSt}
\]

**Result Analysis**

As the energy consumption is only one of the many factors that affect economic growth, this paper introduces oil consumption and the total coal consumption into the traditional two-factor production function model, and constructs the logarithmic production function model, so as to make specific analysis on the effect of energy consumption and its composition on economic growth from long-term and short-term. Through calculation analyses such as ADF test, johansen co integration test, Granger causality test, successive regression analysis, autocorrelation test and correction, the conclusion is drawn: The original natural logarithm sequences of above five elements are all non-stationary series, but they all change into stationary series after a difference, it indicates that there is cointegration in all variables. The relationship among coal consumption, oil consumption and economic growth is fluctuant in short term, and current short-term fluctuations in oil consumption have positive impact on current GDP. Change of 1% of total investment in fixed assets can promote
an increase of about 0.40% in GDP. Change of 1% of the number of urban employment changes will produce an increase of 0.3475% in GDP. If the total oil consumption increases by 1%, GDP will increase by 0.4928%. The goodness of fit after adjustment is 0.992930. The error term between oil consumption and the model of economic growth is relatively large, indicating that the long-term equilibrium between oil consumption and economic growth has great adjustment on the short-term fluctuations.

Countermeasures

Improve the Energy Development Strategy for National Energy Security

China's energy security issues includes not only the contradiction between the total amount of energy supply and the total demand, but also the structural problems caused by increasing rigid demand for clean energy while serious supply shortage, which is the principal contradiction in China's energy security issues[3]. And the shortage of oil is the main aspect of the principal contradiction of energy security in China. As the world's relatively large oil importer, in order to guarantee national energy security, we must implement the "go global" strategy, strengthen international cooperation with other oil-producing countries to strive to have diverse energy supplying countries and supply channels: keep improving the technology of oil exploration and development, a number of complex, relatively difficult overseas oilfield exploitation have been completed; endeavor for international pricing power of oil to break Western states’ monopoly on resource control, speed up the construction of efficient national strategic reserve system of energy to prevent the risks brought by energy interruption.

Improve the Energy Supervision System to Maintain the Stability of Energy Prices

First, perfect the energy market access mechanism. Reduce government administrative interference, break the industry monopoly, relax control over market entry, introduce competition mechanism, and encourage private enterprises to invest in the energy industry under the premise of perfect and effective modern supervision system; Reform current administrative approval system, build a new energy management system that separates government functions from enterprise management with fair competition, positive liberalization and healthy development under the supervision of the government. Second, strengthen the energy economy warning mechanism. Over the past few years, in most parts of China, coal, electricity, oil are lacking inordinately, this situation also shows that China currently lacks an effective mechanism for energy monitor, early warning and emergency. Therefore, we need to focus on the "source" of energy, and establish an early warning system of sustainable development of energy economy as soon as possible, which is responsible for energy forecasting and early warning, energy information distribution, involving in adjustment of energy coursing and emergency security, in order to timely discover the problems existing in energy economy, and take effective measures to nip them in the bud. Third, establish a reasonable energy price mechanism. In the market economy environment, establishing a reasonable energy price mechanism and price structure refers to reforming current energy price mechanism and the way of price regulation which are not suitable for market economy. In coal price and electricity price, coal price and electricity price linkage should be implemented, in electricity price two-part electricity price should be gradually implemented and improved. In addition, measures such as tax policy, environmental expenditure, price regulation should be used to form reasonable price relations between various energy products to promote the adjustment of energy structure; Establish a scientific price mechanism which protects low-income groups and guarantees people’s basic living requirement.

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