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ANALYSIS ON THE MAJOR INFLUENCE FACTORS OF ENERGY INTENSITY CHANGING

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ABSTRACT

Based on the energy intensity data of period 1990-2008, this paper uses impulse response function and variance decomposition model to empirical analysis the main influencing factors and effects of energy intensity,. The empirical results show that: the energy intensity of itself, and the proportion of secondary industry have a larger impact on energy intensity; the change of energy price and technological progress also play a certain impact on energy intensity; and the link with the internal relations and interaction mechanisms, which can play an active role in improving energy efficiency .

Keywords: *Energy Intensity, Cointegration Theory, Impulse Response, Variance Decomposition*

1. INTRODUCTION

The level of energy intensity not only directly affects the supply and demand of energy, but also influences the efficiency of energy use. Despite some fluctuation in the nearly two decades, China's energy intensity has been declining overall. From 1990 to 2007, energy intensity dropped from 5.29 tons of standard coal/million to 1.16 tons of standard coal/million. In China, there is a rapid growth during 2003 to 2004,and the energy intensity rebounded along with the increasing demand of energy-intensive production factors and energy market price fluctuations. The elasticity of energy consumption is up to 1.53 and to 1.59.By the state macro-control, at the beginning of 2006, energy intensity was again to be down, but was still far higher than the world average. The problem of energy efficiency has aggravated the imbalance situation that the energy demand and supply[1]. For the purpose of solving the problem of energy efficiency under the rapid economic development, we should clear the characters of influence factors, which leading to energy intensity changing and its influence.

Scholars of various countries, from different angles, use different methods to study the influence factor problems of energy intensive changing. The Literature[2,3,4,5]research from the angle of energy price which shows that the relative energy prices rising has made positive contributions to lower total energy intensity, oil intensity, electricity intensity and coal intensity. The literature [6,7,8,9,10]research from the technical progress angle which argues that the improvement of energy efficiency is the decisive factor of the decline of energy intensity. The literature[11, 12, 13, 14] research from the industrial structure angle .The literature[15] based on Industry sectors hierarchical division, the literature[15] has studied how the changes of industrial structure and technological progress to impact energy intensity.The literature[16] use index decomposition method to analyze the relationship between the energy intensity changing and the effects of technological progress, the effects of structural change and the effects of economic of the scale. Moreover, there are more researches which focus on energy intensity rebound[17] and energy intensity convergence[18]. As can be seen from the literature, all of the studies of the factors which cause energy intensity changing, mostly are the single factor static analysis, lacking integrated dynamic study of impact factors of energy intensity changing. Therefore, this paper adopts pulse response function and variance analysis to observe the dynamic functional system among the energy price, technique progress, industrial structure and energy intensity, as well as the energy intensity response models which are created by various factors impacts.

2. DATA SELECTION AND COINTEGRATION TEST

2.1 Variable Selection and Data Sources

We Select energy prices, technological progress and industrial structure as indicators of energy intensity changing to build a VAR model. As the secondary industry of national economy energy

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consumption has got a high proportion in the total energy consumption in China, which is a certain representativeness, we choose the proportion of the second industry in GDP to measure the industrial structure. In order to eliminate the influence of price factors, we use energy consumption per unit of GDP as energy intensity, and adjust it used 1990s' base period. Even though china's energy price reform has begun in the period of double-track pricing, it had obviously lagged behind other goods price reform during the whole 1980s, and the situation had not changed until the 1990s. Therefore, this paper chooses fuel price and energy-impetus price from 1990 to 2011 as energy price, and converse it into the pricing index based on the year of 1990. Key performance indicator of technology progress use the index which comes from the total factor productivity index calculated by the Solow Residual method . The whole statistics are from the *China Statistical Yearbook* and the *China Energy Statistic Yearbook*.

2.2 Time Series Stationary Test

To determine the single integration order, this paper does unit root test of the original sequence of the energy prices, technical progress and industrial structure. Prefers to the energy prices, EN stands for the energy intensity.EI represents the industrial structure and T refers to the technical progress. Considering comparability of the variable, this paper has taken all economic time series logarithm before using the related data which can effectively eliminate heteroscedasticity and remove dimension. Having these variables taken logarithm:

$$\ln EN = \ln(EN_T), \ln P = \ln(P_T), \ln T = \ln(T_T), \ln EI = \ln(EI_T)$$

whose corresponding differential sequence are:

$$\Delta \ln EN, \Delta \ln P, \Delta \ln T, \Delta \ln EI$$

.The test results are shown in table 1.

Table1: The Results Of Unit Root Test

Variable	ADF test value	Inspection type	Critical value	Conclusion
LnEN	*-2.354*	*(c，t，1)*	*-3.887**	*unstable*
lnP	*-1.923*	*(c，t，1)*	*-3.887**	*unstable*
lnT	*-2.528*	*(c，t，1)*	*-3.887**	*unstable*
lnEI	*-1.419*	*(c，t，1)*	*-3.887**	*unstable*
△lnEN	*-2.256*	*(c，0，1)*	*-1.967***	*stable*
△lnP	*-2.696*	*(c，t，1)*	*-2.7745****	*stable*
△lnT	*-3.458*	*(c，t，1)*	*-3.3286****	*stable*
△lnEI	*-2.276*	*(c，0，1)*	*-1.9754***	*stable*

*Note: (1) The type of （c, t, k）, c and t represents a constant term and trend term. K represents the number of lags used; (2) The critical values in chart are calculated from the data given by the statistical yearbook. *stand for the critical value of which are blow 1% significant level, **stand for the critical value of which are blow 5% significant level, *** stand for the critical value of which are blow 10% significant level.*

We can see that the ADF values of $\ln EN, \ln P$, $\ln T$ and $\ln EI$ are -2.354、-1.923、-2.528 and -1.419 ,which are more than the critical value at 1% level.That is to say, the energy intensity and influence factors of sample under which are less than 1% critical value are non-stationary series. After the first-order differential, the four sequences become stationary series. That is, the four sequences are Single integration order which can be used to make impulse response function analysis in VAR model.

2.3. Co-integration Test

This paper takes the co-integration test of four variables with method of Johansen maximum likelihood estimate. Table 2 is the test analysis results.

Table 2 : Johansen Co-Integration Test Results

Cyclomatic number	Eigen value	Trace test statistic	The critical value of 5% level	The critical value of 1% level
None **	0.769	57.842	47.21	54.46
At most 1	0.651	33.469	29.68	35.65

We can be known from the test results of Table2, trace test statistic is 57.842.when cyclomatic number is 0, which is lager than the critical value of 5% and 1%, therefore, we should reject the null hypothesis that there is no co-integration relation ,cyclomatic number should be greater than 0, four variables exist co-integration relationship. Further, Trace test statistic is 33.469,when cyclomatic number is 1, which is greater than the critical value of 5% and less than that of 1%, so we receive the null hypothesis that there is existing cointegration relation at 5% significance level, and the four variables have a co-integration relationship.

3. THE INFLUENCE PATH OF CHANGES OF ENERGY INTENSITY INFLUENCE FACTORS

3.1 The Setting And Testing Of the VAR Model

The VAR model is established by $\ln EN, \ln P$, $\ln T$ and $\ln EI$, according to maximum likelihood

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value, AIC information criterion and SC criterion, the lag order of VAR model is 2. Estimating the model with the method of Ordinary Least Squares(OLS) and the results are shown in table 3.

Table 3: VAR Model Estimation Results

	regression coefficient	standard deviation	T statistics
LnEN(-1)	1.481345	0.31126	4.43792
LnEN(-2)	-0.739523	0.30251	-1.78347
LnP(-1)	0.023581	0.19188	0.10726
LnP(-2)	0.276786	0.13675	1.80459
LnT(-1)	2.319718	5.31387	1.43466
LnT(-2)	-1.192811	5.24171	-0.20848
LnEI(-1)	-1.295073	0.64712	-1.99975
LnEI(-2)	0.456349	0.78553	0.58133
C	-2.923478	1.12954	-2.75362
VAR model system test value：R-squared： 0.988649			
Akaike AIC ： -5.869467			
Schwarz SC： -5.518354			

As shown in the table above, most of the estimated coefficients in the model are statistically significant except for a small part, which can be caused by the multicollinearity problems which generated by the multiple lag value presenting in the same variable in the equation. From the overall testing of the model, the fitting degree of equation is relatively high, AIC value and SC value are smaller. The characteristic root of the equation is all located in the unit circle, which illustrates that the model is stable and the whole explanatory is strong. Therefore, the regression result is more reliable and can be used as the basis for the further analysis.

3.2 Pulse Response Analysis

In order to eliminate the problem of related in the same period in the random error term of VAR model, this paper takes Chol-Esky decomposition method to get the impulse response function. Figure 1 is Impulse response function curve which based on VAR (2) and progressive analytic method (Analtic). In figure 1, Solid line for impulse function response value which stands for the reaction of energy intensity bears influencing factors impact. Dotted line for positive and negative two times the standard deviation confidence band. The horizontal axis shows tracking periods which are set as 10 years.

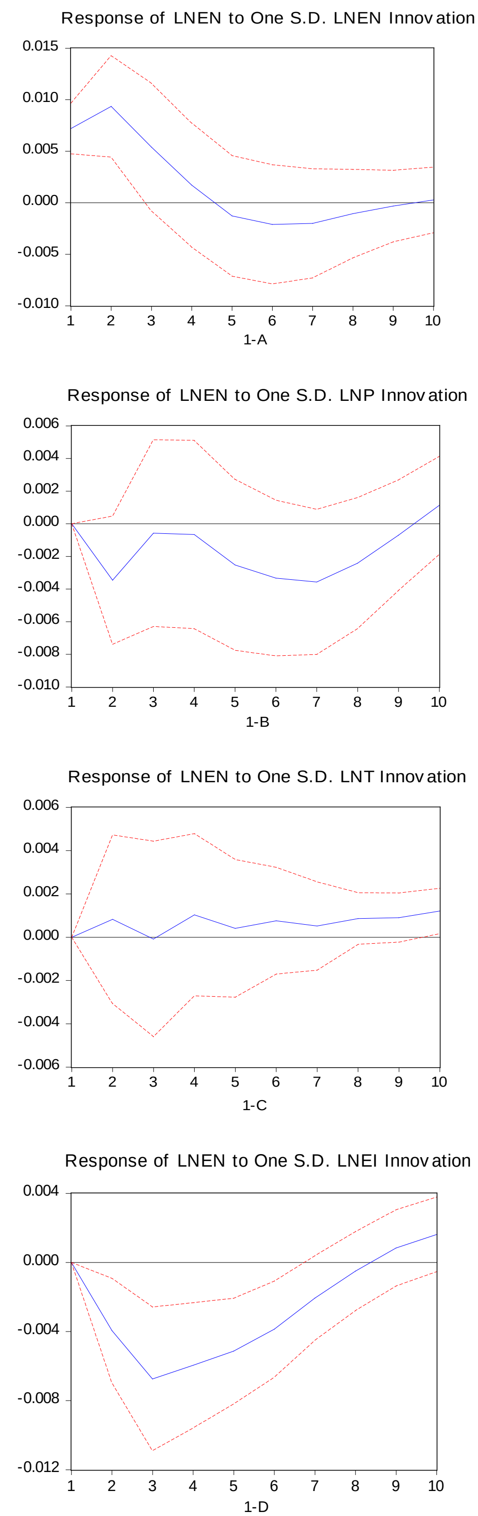

Figure 1 Impulse Response Function Curve Of The Influence Factors Of The Change Of Energy Intensive

From figure 1-A, we can get the impulse response to energy intensity itself impact behaving

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prominently in the former 2, the most positive response appeared in the second period , and the most negative response appeared in the sixth period . Due to being gradually influenced by other variables, the steady convergence sign began to appear from eighth period.

Figure 1-B shows that the response of energy price that one standard deviation of the impact on energy intensity in the first 10 years, and the impact is negative from the first stage to the ninth stage, especially in the second stage ,this negative response has reached the maximum, and transformed into positive response after the middle period of ninth stage. This reflects the energy price signal influence China's change of energy intensity significantly, high energy consumption and operation led to energy dependence excessively, once the energy price fluctuations significantly, will have a huge impact on the use of energy.

Figure 1-C shows that energy intensity has a clear positive reflection on the impact of a standard deviation unit of technological progress. The positive reflection has a small-scope fluctuation, which shows that China technical progress on the improvement of energy use efficiency in the sample period has not been effectively improved. The" return effect" of technical progress is not obvious.

Figure 1 - D displays the proportion of the secondary industry as a negative response to energy intensity changing, whose impact reached the maximum in the first three years, but had no effect in the 8th year. It illustrates that actually the level of efficiency of energy use in the secondary industry will automatically lead to energy intensity changes. And this reaction will continue in the long term. This conclusion just coincides with the reality that rapid development of economy China whereas energy intensity has been on a downward trend. That is, long-term implementing economic developing strategy --“changing methods, adjusting structure”, constantly optimize industrial structure and reduce the industrial energy intensity.

From the effect of the influencing factors impact on energy intensity, the impact from energy intensity itself comes to the first most. However, with the comprehensive influence of other economic variable, the response mode gradually reaches stable. Energy prices, technological progress and the proportion of the second industry all have obvious effects on the energy intensity impact. Viewing from the impact influencing cycle, various factors have long-lasting effects on energy intensity. Therefore, promoting economic intensive growth, readjusting industrial structure, speeding up technological progress and strengthening the management of energy prices should be considered as the national long-term measures in order to reduce energy intensity.

3.3 Variance Decomposition Analysis

Different from Impulse response function tracking system, variance decomposition evaluate thee the importance of different structure impact by analysis analysis, the contribution of each structure impact caused by y endogenous variable change. The results of variance decomposition of LNEN are in figure 2

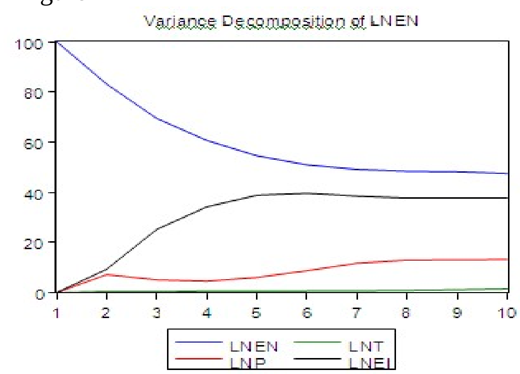

Figure 2: Decomposition Analysis Of Energy Intensity Forecast Variance

The Variance decomposition results show that the order of the impact factors of energy intensity changing, which according to the importance. The order degree of the impact factors of energy intensity changing which according to the importance is that: energy intensity＞the proportion of the second industry＞ energy price＞technical progress. In the short term, the contribution of energy intensity itself to energy intensity changing is more than 70%, the secondary industry is in about 23%, energy piece is in about 4% and technical progress is in about 0.3%.

4. CONCLUSIONS AND SUGGESTIONS

In this paper, the data analysis from 1990 to 2011 shows that, regardless of price of the sources of energy, technological progress or industrial structure, any one of them has the long-term stable co-integration relationship with energy intensity. But different factors have different importance and different effects on energy intensity. Since 1990, changes of energy intensity have been mostly influenced by itself, and later by other economic

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variables. The effect of inertia energy intensity decreased significantly and tended to be stable, proportion of the second industry, the price of energy, and technological progress on the energy intensity of the shock effect are more obvious and the effect is in a longer cycle. The influence factors on energy intensity are ordered as: the influence of energy intensity itself is the strongest, followed by the proportion of the second industry, energy price and technical progress.

According to the conclusion above, for achieving the strategic objectives of the "11th Five-Year Plan" which proposed unit GDP energy consumption reduced by 20%, we should give full consideration to the effect of the long-term impact of the energy intensity itself and the proportion of secondary industry, strict control of the second industry, the speed and the scale of the development of heavy industry, continuing to change the mode of economic development, promoting the upgrading of the industrial structure optimization; for the access of new projects , we should strictly control high energy consumption projects, improve energy conservation and environmental protection market access threshold; positive to eliminate the exit barriers of production capacity out, gradually clean up and rectify preferential policies for high-energy-consuming industries; strengthening audit the compliance standards of high energy-consuming enterprises; actively explore a new industrialization road, and accelerate the construction of energy-efficient industrial system, improving the efficiency of energy usage in order to Reduce energy intensity.

Improving the price adjustment system of energy market, and gradually establish a energy prices system of which can really reflection the full social costs of energy development, the supply and demand of energy market , the environmental costs. To achieve full compensation for the energy use, to further deepen coal price reform, and gradually perfect the oil and natural gas pricing mechanism, in order to optimize the energy structure, and make the energy price could guide energy consumers to reduce energy consumption or alternative consumer. Make prices mechanism to achieve energy conservation and efficiency, declining energy intensity.

In conclusion, the technological innovation should be push forward energetically; Research and development of the state energy-saving investment and extension intensity should be increased. And make good use of financial subsidies and tax policy; promote the development and utilization of clean production technology energy-saving technologies, new energy and energy efficiency technologies. Improve the technical level of energy use positive, explore the incentives of technology innovation in enterprise, and rely on technological progress to promote the energy efficiency.

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