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On the relationship between energy intensity and industrial structure in China

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Abstract

This paper use cointegration analysis and causality research to analyze the relationship between energy intensity and industrial structure in China. By observation, we find the proportion of secondary industry change not too much in the past decade. So, we are studying the relationship between energy intensity and tertiary industry instead of studying energy intensity and industrial structure. Indirectly, the purpose of the paper is to re-examine a statement that secondary industry is the main factor that caused over-consumption in energy in China. Our finding is that tertiary industry has positive impact on energy intensity in China. It proves that tertiary industry Granger-causes energy intensity.

Keywords: energy intensity; industrial structure; tietiary industry

1. Introduction: problem description

Nowadays, energy problem is emerging as a hot issue in the world as well as in China. In 2009, global climate change conference was hold in Copenhagen. Chinese Premier Wen Jiabao and delegates attended the conference and vowed to reduce carbon intensity by 50% in 2020 from 2005 levels. All these promises become signals that China will take measures to reduce gas emission in the future.

In current China reducing energy consumption and gas emission is becoming a difficult works. According to the studies of western and China's scholars, factors such as economic structure, technique level, large-scale manufacturing sector, a rapid economic growth, energy consumption structure are working together or separately on energy consumption in a certain country. Let us take a brief look on some of these factors.

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For a large-scale manufacturing industry, Now China has become world factory with magnitude of powerful manufacturing sector. China's statistics shows that the added value of the manufacturing industry has accounted for 34% of the GDP and 95% of China's total export sales in recent years. The number of Chinese worker engaged in manufacturing has reached up to 29% of the total number of employees(Sun, 2008). Also we know that China's world manufacturing factory was fuelled by huge amount of energy consumption. Some articles indicated that china's manufacturing sector accounted for 58% of energy consumption in China .(Feng et al.2009).

For the energy consumption structure, China's coal consumption has accounted for 70% of the total primary energy consumption in past 20 years. Clean energy, such as hydroelectric power, nuclear power and wind power, is only about 7% the energy consumption.

For the economic structure, many scholars have studied the relationship between energy consumption and economic structure. A law observed by them is that where there is the upgrade industrial structure, where there is lower energy consumption and advanced industrial structure. Exactly, so called optimal and upgrade economic structure is referred to a large part of tertiary sector, and comparable lower secondary industry and primary industry as western states have.

Compared China's industrial structure with many other countries in the world, we find the proportion of primary industry in developed states less than 3%, while in China that was 14.8%, China's secondary industry was 45.9%, 13% higher than that of Japan which was once the largest manufacturing country in the world. For the tertiary industry, in developed states it is more than 65% of the total, while in China it is only 40% of the total. (see table 1)

Table 1: GDP composition of selected states in 2000. (unit:%)

State	Primary industry	Secondary industry	Tertiary industry
China	14.8	45.9	39.3
Japan	1.8	32.4	65.8
Canada	2.3	33.2	64.5
American	1.2	24.2	74.6
France	2.8	22.9	74.3
German	1.3	30.3	68.5
Britain	1.0	28.2	70.7

Source: national statistic bureau 2000.

Since some scholars has proved that secondary industry is associated with the higher energy intensity among three major industries. The purpose of our paper is trying to reveal if the change in industrial structure is the main reason for China's soaring energy consumption. In order to prove it, we need to start our analysis from change in China's industrial structure in the history.

2. China's industrial structure and its problem

By observing 2010 China statistic yearbook, we find primary industry has low down to 10.6% from 16.4% in 1999. And secondary sector has been keeping around 45% since 1999 to 2009. The tertiary industry rose up to 42.6% in 2009 from 37.6% in 1999. A surprising fact from date observation is the proportion of second industry did not change much among three major industries from 1999 to 2009. While tertiary industry rose up 5% to 42.6% from 37.67%. 5% rising comes from 5% decreasing in primary industry. (see table 2)

So, past academic research on China's industrial structure and its results shows that secondary industry is the main factor contributes to energy over-consumption in China needs to be re-examined. Owning to the proportion of secondary industry change not too much during 1999-2009, so in this paper

we choose a new vision to examine the relationship between the change in energy consumption and industrial structure. The change in tertiary industry will be selected as a variable and try to reveal if this variable has some relationship with high energy consumption in China.

Table 2: GDP composition of 3 major industries

Year	Primary industry	Secondary industry	Tertiary industry
1999	16.4	45.7	37.6
2000	15.0	45.9	39.0
2001	14.3	45.0	40.4
2002	13.7	44.7	41.4
2003	12.7	45.9	41.2
2004	13.3	46.2	40.3
2005	12.2	47.7	40.1
2006	11.3	48.7	40.0
2007	11.3	48.6	40.1
2008	10.7	47.5	41.8
2009	10.6	44.4	42.6

Source: China statistic yearbook 2010.

3. Variables selected and interpretation

We mean to study the relationship between energy consumption and industrial structure. Here energy consumption represent by energy intensity (EI) which is being a popular index used for indicating the degree of energy consumption and energy efficiency in a certain country. It calculated energy consumption for each unit of GDP. Normally, we reflect it with consumed standard coal or crude oil (t) / GDP per 10,000 U.S dollar in one year. China's energy intensity decrease year by year in the past. From 2000 to 2006, energy intensity decreased from 9.22 to 7.65. The trend of China's energy intensity will be lower and lower as China's government try our best to eliminate outdated production capacity.

As for the variable of the industrial structure, we use IS to represent industrial structure which we define as the percentage of the added value of tertiary industry in GDP.

What we are going to study is trying to figure out if there are some relationship between two variables that is energy intensity and industrial structure which we defined as the percentage of the added value of tertiary industry in GDP.

4. Analysis model and conditions of its applications

We adopt Granger causality test to analyze the relationship between energy intensity and industrial structure. In 1969, Granger showed that causality analysis was a useful statistical technique to investigate the relationship between two and more variables.

But before using this model, the property of selecting variables need to be verified which is called unit root test.

4.1 Stationary series and unit root test

Unit root test was initially introduced by Dickey and Fuller(1979,1981). And it was used for identifying if the variables belong to stationary series. In order to conduct the unit root test, the following form of the Augumented Dickey-Fuller(ADF) test will be used:

$$\Delta x_t = (p-1)x_{t-1} + \sum_{j=1}^{p} \lambda_j \Delta x_{t-j} + \varepsilon_t$$

4.2 Cointegration analysis and testing method

If a series variables test is non-stationary, while its first order difference is stationary, we denoted by $I(1)$ that represent it is integrated of order 1. Similarly, if a series is stationary after dth difference, it is integrated of order d, denoted by $I(d)$. According to integration theory proposed by Engle and Granger in 1978, for two variables belonging to series of random walk, if a liner combination of two series are proved to be stable, we will say that the variables with this property are cointegrated. If the variables are cointegrated, there may be long term equilibrium among those variables.

Now supposed two series Xt and Yt are non-stationary and integrated of order d. Use ordinary least squares (OLS) significance tests to perform the cointergrated test. The equation could be expressed as followed:

$$x_t = \alpha + \beta y_t + \varepsilon_t$$

The residual ε_t should be test and must have the property of stationary. Then we say x_t and y_t are cointegrated.

4.3 Causality analysis and testing method

The core of Granger causality test is that supposed X and Y are two economic variables, if the prediction of the current value of Y is improved by using past values of X. Then X is said to Granger-cause Y. Granger model apply based on the following bivariate vestor autoregressive (VAR) models:

$$y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i y_{t-i} + \sum_{i=1}^{m} \beta x_{t-i} + \varepsilon t$$

$$x_t = \alpha_0 + \sum_{j=1}^{n} \alpha_j x_{t-j} + \sum_{j=1}^{n} \beta_j y_{t-j} + \varepsilon_t$$

The null hypothesis is β_i （i =1,2,…,m） =0, equal to “X does not Granger-cause Y”. if β_i （i =1,2,…,m） =0 is rejected, we can conclude that X Granger-causes Y. In the same way to test β_j （j=1,2,…,n） =0 and determine if Y Granger-causes X.

5. Test results

All date in this paper are from the China Statistical Yearbook. Two kind of test will be conducted. One is for examining the relationship between added value of tertiary industry and energy intensity in China. The other is to study if there is Granger causality between the selected variables.

The results of unit root test reported in table 3. Since ADF estimates are sensitive to the time length of variables. So we use AIC criterion to select lag structure. According to the AIC criterion, the lag length of EI was determined to be 2, the lag length of IS was 1, then original equation change corresponding as follows:

$$\Delta EI_t = (p-1)EI_{t-1} + \sum_{j=1}^{2} \lambda_j \Delta EI_{t-j} + \varepsilon_t$$

$$\Delta IS_t = (p-1)IS_{t-1} + \lambda_1 \Delta IS_{t-1} + \varepsilon_t$$

We find two variables are non-stationary in level forms. And the results of the first difference variables show that all of the variables are stationary after differencing once which indicate variables are integrated of order I(1) which mean there are one and more cointegration relationship between them.

Then use OLS to perform the cointegration test, we get equation as follows:

$$IS = 0.2361483409\ EI - 1090427427 + \varepsilon_t$$

The equation indicates that tertiary industry has positive impact on energy intensity. It shows if 1% increase of tertiary industry will push up energy intensity increased by 0.236%. The reasons for this result is that some of tertiary industry are heavy energy consumption sector. Therefore, save energy and reduce emission should not just copy economic structure of developed countries. We should not confine us to increase the proportion of tertiary industry among 3 industrial sector, we should adjust inner structure of tertiary industry further.

Use VECM model to test ε_t which go through stationary test. That is to say, there are cointegration between variables.

Table 3: Results of unit root test

Variables	ADF value	critical value			stationary/non-stationary
		1% level	5% level	10% level	
IS	-2.308	-4.374	-3.603	-3.238	non-stationary
EI	-0.640	-4.394	-3.612	-3.243	non-stationary
DIS	-3.334	-4.374	-3.603	-3.238	stationary
DEI	-3.698	-4.374	-3.603	-3.238	stationary

6. Granger causality tests

Here we just want to test the relationship between change in industrial structure and energy intensity. Therefore, null hypothesis is proposed that EI does not cause IS and IS does not cause EI. The result of the test as follows:

Table 4: Granger causality test

Null hypothesis	F-statistic	P-value	conclusion
EI does not cause IS	0.790	0.563	fail to reject
IS does not cause EI	0.354	0.087	reject

Test result shows a unidirectional causality exist in the relationship of the energy intensity and industrial structure. It imply that IS granger-causes EI.

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