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The relationship of energy consumption, economic growth and foreign direct investment in Shanghai

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ABSTRACT: This paper investigates the existence and direction of Granger causality between energy consumption, economic growth and foreign direct investment in China, applying a multivariate VAR model of energy use, economic growth, carbon emissions based on data for Shanghai over the period 1985–2010.The result suggests a unidirectional Granger causality running from GDP to energy use and foreign direct investment, and a unidirectional Granger causality running from energy consumption to FDI. Further analysis reveals that the increase in foreign direct investment has good energy saving effect. So, to achieve the sustainable development of the economy, Shanghai should develop effective policies of guiding the internal and external capital flows, technological innovation, industrial structure optimization to achieve energy saving and sustainable economic growth.

Key words: energy consumption; economic growth; foreign direct investment

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1. Introduction

Following the trend of economic globalization, international capital flows have become increasingly strengthened, foreign direct investment (FDI) is also welcomed by the countries. In 2002, China's actual use of foreign direct investment reached $ 52.7 billion, more than that of United States and China has become the largest country to attract international direct investment. The inflow of FDI, not only brings capital to the production activities, but also promotes China's economic development through technology spillovers and industrial restructuring effects. The relationship between foreign direct investment and economic growth is also a hot topic of the academic research. Borensztein, Gregorio, and Lee (1995) used the data of 1970 – 1989 of 69 developing countries, to test the impact of FDI on economic growth in the OECD countries, and found that FDI can promote economic growth and make more contribution to economic growth than domestic investment. De Mellon (1999) believed that foreign direct investment sped up economic growth of the host country through the enhancement of skills and knowledge spillovers, depending on the extent of complementarity or Extrusion between foreign direct investment and domestic investment. Kunrong Shen, Qiang Geng (2001) put foreign direct investment and human capital into endogenous growth model, using1987 - 1998 provincial panel data of China and made regression analysis, the study concluded that FDI growth would make economic growth rate increase, and the degree of FDI's Technology spillover effects was closely linked to human capital. Bin Zhang (2011) used panel data from 1990 - 2009 of east China to measure the relationship of foreign direct investment and the host country's economic growth, and analyzed the internal mechanism of promotion of FDI to the economic growth of the host country.

Energy is the material basis of human progress and social development, economic growth requires energy for power. On a certain level of technological development, the greater economies of scale, the more energy demand. China's rapid economic growth has led to the continued growth in demand for energy. Since the total amount of energy resources is limited, following the strategy of sustainable development, energy conservation and improving the efficiency of energy use has become an inherent requirement to achieve sustained economic development. China has received a large number of FDI. In 2003, FDI got a proportion of gross domestic fixed asset investment as 8%, which was presenting a growing trend. While FDI is affecting a country's economic development, it is affecting a country's energy consumption and utilization as well. Alfaro (2010) concluded that it is depending on the host country's own economic development levels, commonly referred to as the absorptive capacity of the host country that whether FDI can improve the energy utilization efficiency of the host country by restructuring of production, technology transfer, and other ways. Puyang Sun(2011) made an empirical test by using global data between 1985 and 2008 of 74 high-income and low-and middle-income countries. The results proved that FDI can improve energy efficiency, reduce energy consumption intensity, while there was "the inverted U-shaped "relationship between per capita income and energy consumption intensity.

Most studies focus on the nexus of FDI-output or FDI-energy. Very few investigate the inter-temporal links between energy consumption, economic growth and FDI. Shanghai, as a bridgehead to the forefront of China's reform and opening up, with its unique comprehensive advantages, has become one of the cities which attract the largest number of foreign direct investment and built a stable environment for foreign investment. Shanghai is a densely populated, highly developed city and a great energy consumer. In 2009 the city's GDP reached 1.5trillion yuan, with a per capita GDP reached 79 thousand yuan, which is four times of the national average, and city's total energy consumption was more than one hundred milliontons of standard coal. Since Shanghai is a prominent city in economic take-off, energy consumption and utilization of FDI, to study the interaction between energy consumption, economic growth and FDI is quite representative. More than providing theoretical support for Shanghai's fast and healthy economic growth, we can give important reference and inspiration to other parts of China for energy saving , utilization of foreign investment and sustainable economic development. The remainder of this paper is to study the relationship between foreign direct investment, energy consumption and economic growth in Shanghai, and to make policy recommendations by

analyzing the results.

2. Methodology and Data

2.1 Vector autoregression (VAR)

Traditional regression models are generally based on economic theory, appropriately describe the behavior of economic subject and then analyze how the exogenous variables affect the endogenous variable. This kind of model has some shortcomings, one of which is that it makes a variable exogenous or endogenous, such decisions are often subjective, for two variables may be cause and effect of each other. The other disadvantage is that the model lays down certain variables in order to make the model identifiable. The core idea is to focus on direct relationship between time variables instead of economic theory.

The general form of VAR is as follows:

$$Y_t = \alpha + \sum_{i=1}^{p} \beta_i Y_{t-i} + \varepsilon_t \quad (1)$$

where $E(\varepsilon_t)=0$, $E(\varepsilon_t, Y_{t-i})=0$, $i=1, 2, \ldots p$; α is a vector of constant, β_i is coefficient matrix, and ε_t is white noise residuals. Y_t is Smooth linear random process of same variance constructed by (n×1) vector.

2.2 Variable selected and data sources

We use annual data on real GDP(Y) and real FDI (DI) (both in constant 1990,local currency yuan),energy consumption(E)(10kt of standard coal equivalent). All data covering the period 1985-2010 were obtained from the Statistical Yearbook of Shanghai.

3. Modeling and Analysis

3.1 Unit root tests

Firstly, we conduct natural logarithmic transformation so that we can eliminate heteroscedasticity which may exist in the series. We get LY, LE, LDI.

Unit root tests are required before proceeding VAR model to avoid spurious regression. We conduct Dickey-Fuller (ADF) by Eviews6.0. The results are reported in Table1:

Table1 The result of Dickey-Fuller (ADF)

variables	test types (c, T, d)	ADF statistics	critical value(5%)	Probability P	conclusion
LY	(c, 0, 1)	0.040186	-2.991878	0.9536	not stationary
ΔLY	(c, 0, 5)	-6.163036	-3.029970	0.0001	stationary
LE	(c ,0, 0)	1.171005	-2.986225	0.9970	not stationary
ΔLE	(c, 0, 0)	-3.531615	-2.991878	0.0159	stationary
LDI	(c, 0, 0)	-2.388580	-2.986225	0.1548	not stationary
ΔLDI	(c, 0, 0)	-3.826320	-2.991878	0.0082	stationary

Note: (c, T, d)are orderly represent intercept, trend and lag lengths. Lag lengths are determined via SC. ΔX means first order differential of X.

3.2 The VAR

The main purpose of this paper is to analyze the relationship of energy consumption, economic growth and foreign direct investment in Shanghai. We use stationary series ΔLE, ΔLY, ΔLDI for modeling.

$$\Delta X_t = A_1 \Delta X_{t-1} + \cdots + A_p \Delta X_{t-p} + \varepsilon_t \quad (2)$$

Where, p stands for lag lengths. It is required that p is large enough to completely reflect dynamic characteristics of the constructed model, but the longer the lag period, the more parameters to be estimated and the fewer degrees of freedom. Therefore, the state should seek a balance between the lag and freedom. In order to determine the optimum lag period, we apply model lag structure identification criteria of Eviews6.0, and get the following result (maximum lag of 4):

Table2, VAR lag order selection criteria

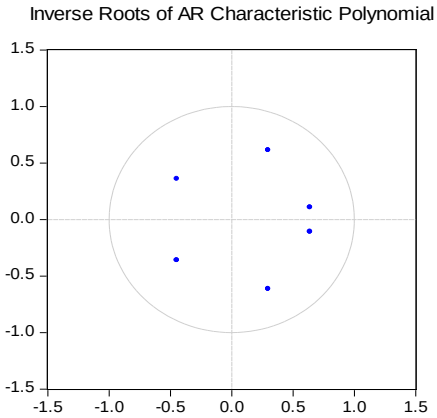
Lag	LogL	LR	FPE	AIC	SC	HQ
0	87.00248	NA	6.73e-08	-8.000236	-7.851019	-7.967852
1	101.3071	23.15987	4.12e-08	-8.505439	-7.908569	-8.375903
2	117.8651	22.07736*	2.14e-08*	-9.225250	-8.180728*	-8.998562
3	127.1290	9.704985	2.48e-08	-9.250379	-7.758204	-8.926538
4	139.6028	9.503902	2.59e-08	-9.581223*	-7.641396	-9.160231*

According to the result of Table2, the optimum lag period should be 2, thus modeling VAR(2).

$$\begin{Bmatrix} \triangle LDI \\ \triangle LE \\ \triangle LY \end{Bmatrix} = \begin{Bmatrix} 0.090 & 9.242 & 5.429 \\ -0.018 & 0.247 & 0.400 \\ 0.001 & 0.232 & 0.638 \end{Bmatrix} \begin{Bmatrix} \triangle LDI_{-1} \\ \triangle LE_{-1} \\ \triangle LY_{-1} \end{Bmatrix} + \begin{Bmatrix} -0.080 & -5.477 & -9.824 \\ -0.000 & 0.286 & -0.491 \\ -0.012 & 0.145 & -0.196 \end{Bmatrix} \begin{Bmatrix} \triangle LDI_{-2} \\ \triangle LE_{-2} \\ \triangle LY_{-2} \end{Bmatrix} + \begin{Bmatrix} 0.377 \\ 0.040 \\ 0.039 \end{Bmatrix} \quad (3)$$

The empirical results show that all unit roots are in the unit circle, the model structure is stable and fitting well:

Fig.1. inverse roots of characteristic polynomial



3.3 The causality tests

Table3, the result of Granger causality test

Null Hypothesis	df	Chi-sq	Prob.
Δ LE does not Granger Cause Δ LDI	2	6.129353	0.0467
Δ LY does not Granger Cause Δ LDI	2	8.021072	0.0181
Δ LE、Δ LY does not Granger Cause Δ LDI	4	16.76113	0.0022
Δ LDI does not Granger Cause Δ LE	2	1.929806	0.3810
Δ LY does not Granger Cause Δ LE	2	5.141133	0.0765
Δ LDI、Δ LY does not Granger Cause Δ LE	4	5.611916	0.2301
Δ LDI does not Granger Cause Δ LY	2	0.955416	0.6202
Δ LE does not Granger Cause Δ LY	2	1.468418	0.4799
Δ LDI 、Δ LE does not Granger Cause Δ LY	4	2.835460	0.5857

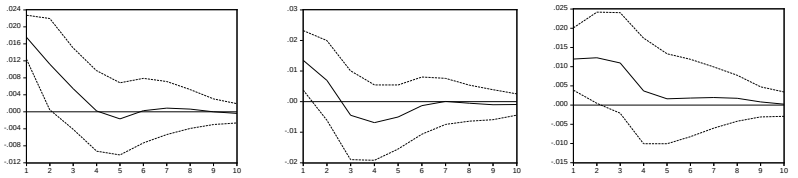
As the result, in the 5% significance level, the increase in economic growth and energy consumption in Shanghai Granger cause the growth of foreign direct investment in Shanghai. It also suggests a unidirectional Granger causality running from output increase to energy consumption increase in the 10% significance level. Both

the increase of energy consumption and FDI are not Granger cause of economic growth.

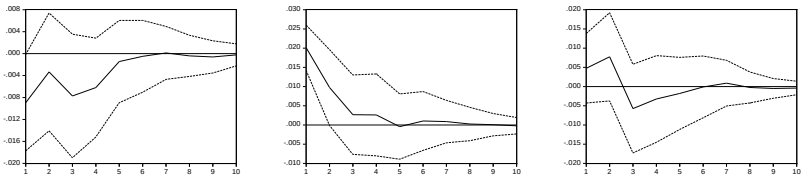
3.4 Generalized impulse response

VAR Model is a non-theoretical model, in practical application, it is difficult to interpret its coefficient. In the analysis of the VAR model, we often do not analyze the influence of one variable to another variable, but with a pulse response function, we utilize generalized impulse response which overcomes the orthogonality problem in traditional out-of-sample Granger tests.

Fig.2, generalized impulse responses of Y, E to variables.



Response of Y to Y Response of Y to DI Response of Y to E



Response of E to DI Response of E to E Response of E to Y

It is clear from Fig.2, a shock in E or DI has positive initial impacts on Y. It is worth noting that the initial impact of energy use on output not only is slightly higher, but it also lasts longer than FDI. Another importing finding is that the impact of FDI shocks on energy consumption is negative, and lasts for almost six years, and a shock in output has fluctuate impact on energy consumption, although initial impact is positive and more significant.

4. Conclusions and Policy implications

Appling the VAR model, this paper investigate the temporal linkages among GDP, energy consumption, and FDI for Shanghai of China during the period 1985-2010. The empirical finding of unidirectional Granger causality from real GDP to energy consumption implies that it not feasible to rely on energy consumption alone to promote economic growth and the government can implement stronger energy conservative policy without compromising economic growth in the long run. The empirical finding of unidirectional Granger causality from real GDP to FDI suggests that continued economic growth of Shanghai will lead to the increase of foreign direct investment, but on the contrary, both from Granger causality analysis or impulse response analysis, we find that the increase in foreign direct investment can not be continued momentum of economic growth in Shanghai. It is domestic investment that supports long-term economic growth in Shanghai.

From the impulse response analysis, we conclude that in the short term, the increase in foreign direct investment will lead to reduced energy consumption. Based on the analysis results, I believe that the reason why the increase in FDI has the effect of reducing the energy consumption of the reasons lies in two aspects. First, FDI leads to the improvement of energy efficiency through technology effects. Furthermore, from the industry distribution of FDI in Shanghai, FDI appears to promote the upgrading of industrial structure. According to the Statistical Yearbook of Shanghai, in 2000, the amount of actual foreign direct investment in secondary industry Shanghai absorbed was $ 2 billion, $ 1.15 billion (36% of total FDI) in the tertiary industry. The proportion of the total amount of foreign capital invested in the tertiary industry increased year by year, which reached 79%($8.831 billion)in 2010. Increase of foreign investment in the tertiary industry accelerated Shanghai's industrial structure upgrading and optimization.

The analysis result in some suggests. First, In order

to provide a more efficient platform for attracting foreign direct investment and optimize the environment for FDI, it is important for he local government to improve laws and statutes and make reasonable industrial policy to guide the industry distribution of FDI, which will be helpful for the local government to play a positive role in upgrading the industrial structure, reducing energy consumption, and establishing an energy-saving city. Further more, Domestic investment is the long-term motivation which supports the economic growth of Shanghai. It is necessary to create a favorable investing environment, make efficient use of private capital and guide its flow direction to serve for the industrial and regional structure adjustment of Shanghai. Besides that, to keep sustainable economic growth and protect the environment requires building a resource-saving society. It will be useful for the government to utilize innovative technologies and more intensive management, improve the efficiency of the use of coal, oil, natural gas and other energy and lead aggressive research and development of new technologies, energy use technology so that a resource-saving and environment-friendly society will be built.

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