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Dynamic Analysis between Urbanization and Shanxi Power Consumption

Lina Xu [1,2,3], Xiaofeng Yang [2], Hang Liu [4,5], Li Zhang [2], Yandong Zhang [6*]

[1] Energy Economics and Environmental Policy Research Centre, Datong University, Datong 037009, CHINA

[2] Business School, Datong University, Datong 037009, CHINA

[3] Datong Macroeconomic Research Center, Datong 037009, CHINA

[4] Regional Economic Teaching and Research Department, Sichuan Administration College, Chengdu 610071, CHINA

[5] School of Environment, Tsinghua University, Beijing 100084, CHINA

[6] College of Economics, North China University of Science and Technology, Tangshan 063000, CHINA

[*] Corresponding author: 314108476@qq.com

Abstract

The paper analysis the dynamic relationship between energy consumption and urbanization using SVAR model with Impulse response functions and variance decomposition based on time series data of 1990-2010 in Shanxi Province. The results show that: urbanization accelerates energy consumption in the short term and decreases energy consumption in the long run, but the contribution is smaller. Therefore, it is an important way for the balance between urbanization and energy consumption to improve energy efficiency, to promote energy-saving technology, to use scientific and technological innovation, and to enhance residents awareness of energy saving.

Keywords: urbanization, energy consumption, SVAR model, impulse response function, variance decomposition

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INTRODUCTION

Urbanization promotes the rural population to urban, the development of urbanization has important practical significance in China (Xu and Li 2011). According to the data of National Bureau of Statistics, the number of China's urban population surpassed the rural areas for the first time at the end of 2011 and the ratio of urban population has jumped from 17.92% in 1978 to 51.27%. At the same time, China's total energy consumption reached 3.48 billion tons of standard coal, ranked first in the world for three consecutive years. The increasing speed of energy consumption and the process of urbanization are synchronous, so the paper studies the inherent dependence between urbanization and energy consumption in order to provide theoretical reference for reasonable energy policy formulation, guarantee the steady growth urbanization and the energy security and the, and to promote coordinated development of energy and urbanization.

LITERATURE REVIEW

The relationship between urbanization and energy consumption was studied by scholars, using different models, different samples, different time interval, different testing methods of the parameters and assumptions, without the same conclusion. Part of the study thought that urbanization will increase energy consumption. Such as Jones (1991) pointed out that in a certain extent, in the process of economic development, the impact of urbanization on energy use was independent. The biggest single energy change was from individual traffic. Passenger traffic increased fuel consumption in cities. Parikh and Shukla (1995) pointed out that the impact from urbanization in the developing countries on energy consumption was through the change of fuel consumption style, food and service demand, housing and transportation. And increased 1% of the city population would result in increased 0.47% of the per capita energy consumption. Liu (2007) analyzed the process of resource consumption in Jiangxi, finding that the urbanization

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level was the Grainger reason to per capita energy consumption growth, and the improvement of urbanization level would bring a positive impact on energy consumption per capita. Peng and Lei (2010) got the long-run equilibrium equation between urbanization and energy demand, based on the Verhulst model in grey system.

Some scholars put forward that there were regional differences in the effect on energy consumption from urbanization. With balance panel data of 99 countries during 1975 and 2005, Poumanyvong and Kaneko (2010) studied the influence of urbanization on energy use in different development stages, using STIRPAT model. The results showed that urbanization had negative effect on per capita energy consumption in low income countries, and positive in modest and high income group of countries. Cheng and Cheng (2009) pointed out that the decreasing trend from East, Middle to West in the impact from urbanization on energy consumption was because of the stock of human capital, the advantages of technological innovation, industrial structure level and market level. With the provincial panel data during 1995 to 2010 in China, Zhang and Xia (2013) analyzed empirically that there was obviously regional difference of the effect on energy consumption from urbanization in China. The urbanization in western region would reduce energy consumption, and promote it in the central and eastern region.

Along with the deepening of the research, some scholars believed that there was dynamic relationship between urbanization and the energy consumption. Liu (2007) established the vector auto regression model (Vector Autoregression, VAR), and analyzed the short and long term relationship between urbanization and energy consumption in China, by Granger effect analysis and cointegration analysis. The results showed that the level of urbanization was the Granger reason to energy consumption growth, and there was long-term equilibrium cointegration between them.

To sum up, the vast majority of existing literature used the static analysis of the unilateral relationship between urbanization and energy consumption, with small part of scholars to study the dynamic analysis by the VAR model without constraints that was unable to examine the variables influence over the same period. At the same time, owing to Chinese vast territory, the relationship between urbanization and energy consumption may not follow the same rules, because of the different regional resource endowments, industrial structure difference and economic development. In this paper, the perspective is specific to the regional level. Take the power consumption in Shanxi Province as an example to analyze the dynamic relationship between urbanization and energy consumption. With the structural vector autoregressive model (Structural Vector Autoregression, SVAR), which considers both economic theories and short and long time constraints of variables, and based on time series data from 1990 to 2012, the dynamic relationship between them is to be analyzed, combined with the impulse response function (Impulse Response Function, IRF) and variance decomposition technique.

THE MODEL SETTING AND VARIABLE SELECTION

The Model Setting

Compared with the traditional VAR model, the relationship between variables over the same period is considered in the SVAR model, avoiding the model errors that can't be explained. Considering both theory and reality constraint, the prior information provided by economic theories is used to impose on endogenous relationship between variables, resulting in that there is more logical and explanatory in analyzing the random disturbance term by the impulse response function (Impulse Response, Function, IRF) (Liu and Yang 2011). The expression SVAR is:

$$B_0 \cdot y_t = d + \sum_{i=1}^{p} \Gamma_i y_{t-1} + \delta_i \quad (1)$$

Considering the lagged impact from urbanization on energy consumption, the lag operator model is introduced:

$$B(L) \cdot y_t = k + \delta_t \, E(\mu_t, \mu_t') = l \quad (2)$$

Among them, B_0 respects the coefficient matrix variables; y_t respects the variable matrix; $i = 1,2, \dots, p$ respects the lag order; Γ_i respects variable coefficient matrix with the lag of order i; k respects the deterministic trend after the conversion; $B(L)$ respects polynomial matrix of lag operator; δ_t respects the residual vector of structure, including non-interaction structural impulse information, with the identity matrix as variance.

Variable Selection and Data Sources

In the existing literature, there are two ways to measure the urbanization level: one is the proportion of urban population to the total population, and the other is that non agricultural population to the total population (Lin and Liu 2010). Due to the shift from

Table 1. The results of ADF test

series	ADF test	test critical value			P-value	conclusion
		1%	5%	10%		
lnep	-2.194390	-4.616209	-3.710482	-3.297799	0.4626	nonstationary
lnu	-0.607870	-3.808546	-3.020686	-2.650413	0.8479	nonstationary
$\Delta \ln ep$	-4.022048	-3.831511	-3.029970	-2.655194	0.0067	stationary
$\Delta \ln u$	-3.311260	-4.532598	-3.673616	-3.277364	0.0945	nonstationary

Note: D respects the first-order difference sequence.

rural population to the city, and the Chinese household registration system, the statistical data of the agricultural population and non-agricultural population is easy to get. In view of this, this paper takes the proportion of non agriculture population to the total as indicator to measure the level of urbanization, with the unit for %.

Rather than the total energy consumption, this paper takes the electric power consumption as an indicator to respect the total energy consumption. As a resource-based province, Shanxi has rich mineral resources of coal. Driven by interests, there has always been a private mining digging phenomenon, although the government has taken action to mean to clean up it. Because of but the reality of medium and small coal mines, energy production and consumption may be underestimated. The data of power consumption of is read directly by a computer, with high accuracy (Liu 2007), and the conclusion will be more persuasive. This paper will analyze electricity consumption data, with the unit of 10^4 tons of standard coal.

The data of electricity consumption, the total population and non-agricultural population is from Shanxi Statistical Yearbook. In order to eliminate the effects of inflation, data involving the value in this paper will be parity changed, with 1952 as the base year. Before the 1990, the economy of Shanxi province was backward, with large difference from the situation after 1990. The data from 1990 to 2012 will be analyzed to study the relationship between energy consumption and urbanization.

Electricity consumption is a physical indicator, and urbanization proportion of indicator. Energy consumption and urbanization is logarithmic, in order to eliminate heteroscedasticity, noted as lnep and lnu respectively.

DATA TESTING AND MODEL ESTIMATION

Series Stationarity Testing

In SVAR model, the time series should be stationary time series, meaning that the mean, variance and covariance does not change with time, and that covariance of every order just have relationship with the lag order. With nonstationary data, pseudo regression will appear. The stationarity test is necessary for lnep and lnu. The stationary testing method commonly used was DF unit root test presented by Dickey and Fuller. DF test was extended to ADF (Augmented Dickey-Fuller test) to solve the issues related to high lagged correlation (Dickey and Fuller 1979, 1981). The ADF test results as shown in **Table 1**, with the optimal lag order 2 from SIC criterion.

From **Table 1**, at the 10% significance level, the test values are greater than the critical value of lnep and lnu, meaning not rejecting the unit root null hypothesis. The original series are not stationary ones. At 1% significant level, the test value is less than the critical value of Dlnep. At 10% significant level, the test value of Dlnu is -3.311260, less than the critical value of -3.277364. So the two series both are stationary. Urbanization and power consumption series both are nonstationary I (1) process.

AR Test

The AR test is to test whether VAR model is stable. When the VAR model is stable, the relationships between variables could be measured accurately. If not, errors will be produced. When all the models of reciprocal eigenvalues of VAR model are less than 1, meaning in the unit circle, the model is stable. The test results as shown in **Fig. 1**.

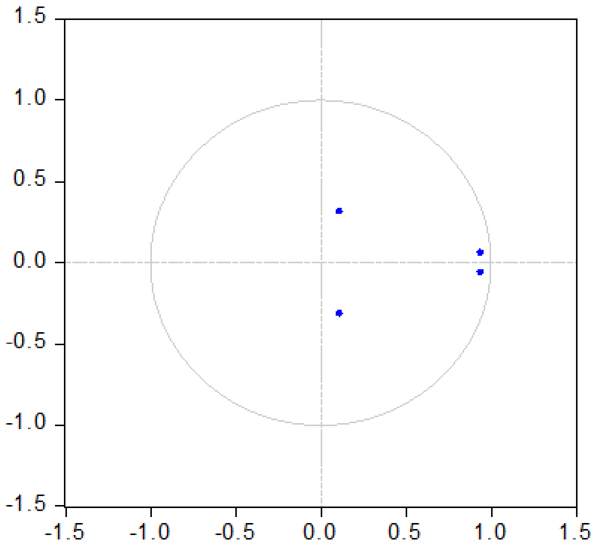

Fig. 1. Inverse Roots of AR Characteristic Polynomial

In this paper, there are 2 variables, with lagged order of 2. So there are four eigenvalues. As seen from **Fig. 1**, the four models of reciprocal eigenvalues all are in the unit circle. Then the VAR model established in this paper is stable through the stability. The next step analysis can be done.

Identification of SVAR Model

After several times of simulation analysis by Eviews, the most reliable SVAR model constraint can be obtained in this paper. Matrix X is lower triangular matrix, with 1 as the member on diagonal. Matrix Y is diagonal matrix. The formula is:

$$Xe_t = Yu_t \tag{3}$$

With the help of Eviews6.0, parameter estimation of matrix X is:

$$\begin{vmatrix} 1 & 0 \\ C(2) & 1 \end{vmatrix} = \begin{vmatrix} 1 & 0 \\ 0.069121 & 1 \end{vmatrix}$$

The same to that, parameter estimation of matrix Y is:

$$\begin{vmatrix} C(1) & 0 \\ 0 & C(3) \end{vmatrix} = \begin{vmatrix} 0.073634 & 0 \\ 0 & 0.020404 \end{vmatrix}$$

From the results, the SVAR model can be identified. Further analysis of the impulse response function and variance decomposition can be done to determine the structural impact of urbanization variable on electricity consumption (Liu and Yang 2011).

Impulse Response Function Analyses

According to the variables, the paper selected 20 lag times (1-year for1 lag) for analysis, the impulse response of each variable shows in **Fig. 2** and **3**. The solid line shows the shock trend of the variables, the dotted line represents twice the standard error of the trend in the figures.

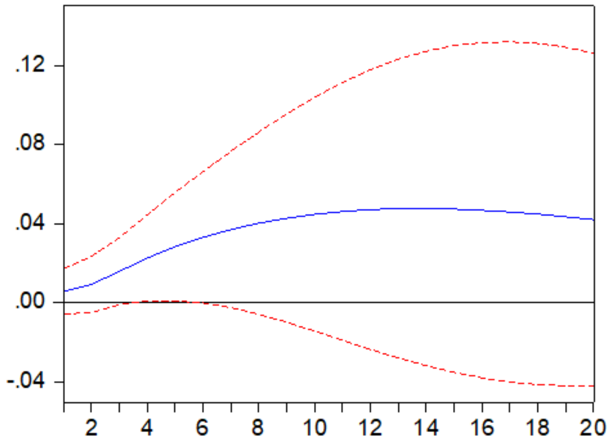

Fig. 2. The response of lnep to lnu

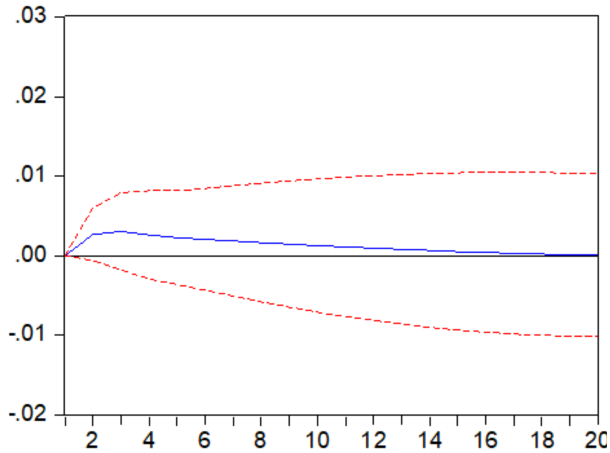

Fig. 3. The response of lnu to lnep

Fig. 2 shows that the electricity consumption shocked by a positive impact of urbanization, the electricity consumption raised in the 1 lag time, and reached a peak in the 10, the trend remained stable until 16 lag, then shocked impact dropped, the shock value is less than 0.05%. The results indicate that in the short term urbanization accelerates the power consumption, energy consumption is inhibited in the long term as energy intensive action. The analysis is according with the results of Wei et al. (2003). The process of urbanization, means not only an increase in the urban population but also means lifestyle changes, especially the energy consumption patterns changes. In the short term, energy demand structure will not change much, so raising the level of urbanization will lead to increased energy consumption; But in the long-term raising the level of urbanization will promote industrial structure adjustment, improve energy use efficiency, promote technological structural reform, Thus cause profound

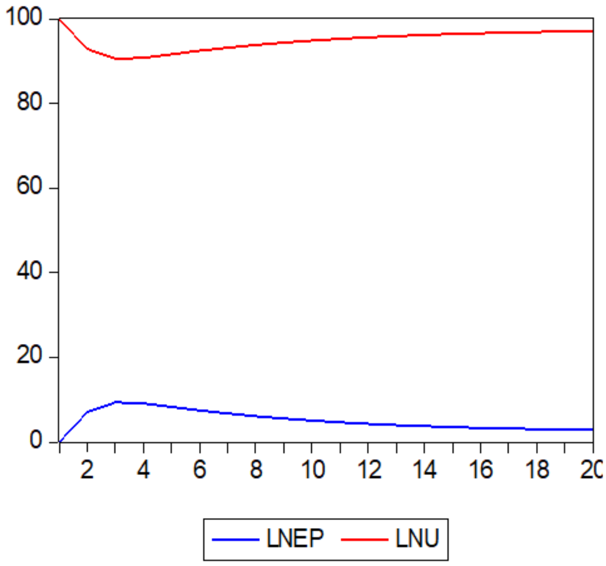

Fig. 4. Variance Decomposition of lnep

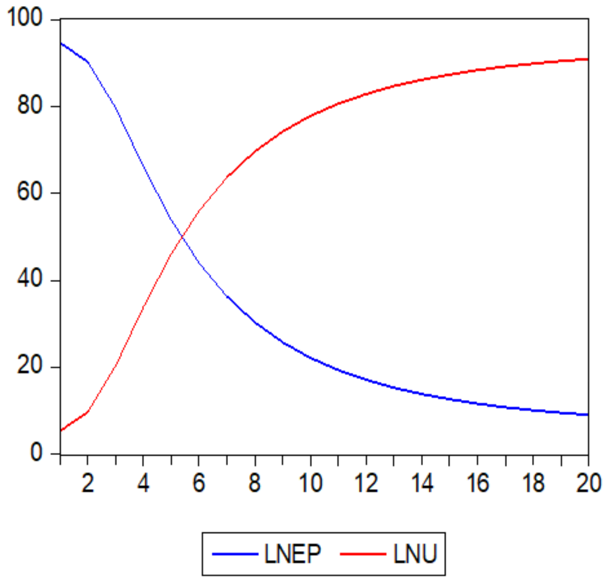

Fig. 5. Variance Decomposition of lnu

changes of energy consumption structure, so the process of urbanization will reduce power consumption in the long run. **Fig. 3** shows that the electricity consumption had a positive rising dynamic shock on urbanization of 1-2 lag time, impact values remained at around 0.007 in the period between 4-8, the impact trend began to decline after six lag time, and the impact of electricity consumption on urbanization was very weak.

Variance Decomposition

In the paper, the variance decomposition adopted Choleski method, results in **Figs. 4** and **5**.

As can be seen from **Fig. 4**, its own variance contribution of electricity consumption decreased in the period of 1-5, and variance contribution of urbanization gradually increased, variance contribution of urbanizations surpassed that of energy consumption at six period, stabilized at 19. The results show that the process of urbanization and early energy consumption makes a significant contribution to medium and long-term electricity consumption.

Fig. 5 showed variance decomposition of urbanization. The growth of urbanization was mainly due to its own disturbance. Variance contribution of urbanization gradually decreased in period1-4, stabilizing after 13 period and its contribution was maintained at about 90% in long term. In the period of 1-4, the variance contribution of electricity consumption on urbanization progressively increased, but the value was very small, did not exceed 10%, then began to decline, after 10 contribution was less than 5%. The analysis indicated that the effect of Electricity consumption on improving the rate of urbanization was very weak and rate changes of urbanization was mainly affected by its own.

CONCLUSIONS

The paper builds SVAR model, combined with structural shock effect function and variance decomposition to evaluate the dynamic relationship between urbanization and energy consumption based on time series data from 1990-2011 of Shanxi province. The conclusions are as follows:

(1) ADF stationary test shows that At the 10% significance level, the series of urbanization and electricity consumption are non-stationary sequence, the first difference sequence of the two factors are smooth sequence and the series of lnep, lnu are integrated of order I(1) process;

(2) AR root test and SVAR model identification test show that the model is stable and identifiable;

(3) Impulse response analysis showed that urbanization accelerated electricity consumption in the short term and energy consumption was inhibited in the long term;

(4) Variance decomposition shows that the process of urbanization has an important contribution to long-term electricity consumption, the contribution of electricity consumption to urbanization is very weak, and the variance contribution of urbanization is mainly from itself.

According to the above conclusion, the policy recommendations are as following: (1) Improve energy efficiency, promote the upgrading of the energy structure using science and technology innovation and optimize the allocation of resources; (2) promote energy-saving technologies, implement energy saving policies actively and take effective measures, such as levy energy consumption tax, offer subsidies for the energy-saving production and other methods to reduce energy consumption; (3) Strengthen energy saving awareness of urban residents' to promote energy saving lifestyle.

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