http://doi.org/10.1051/e3sconf/202018501007

Electricity Consumption and Secondary Industry Structure: Case Analysis of Shandong

Zhiwei Zhang[1*], Bing Li[2]

[1] Department of Public Relations, State Grid Shandong Electric Power Company, Jinan, Shandong, 250001, P. R. China
[2] School of International Economics and Trade, Shandong University of Finance and Economics, Jinan, Shandong, 250014, P.R. China

Abstract. This paper analyses the relationship of electricity consumption and secondary industry structure with GDP as control variable. Cointegration analysis indicates that there is a long run relationship between the electricity consumption and the secondary industry structure. Granger causality test indicates that variables all have one-directional Granger causality relationship. Increased electricity consumption could explain the development of GDP in Shandong in the period under study. Secondary industry structure played a significant role in the explanation of the increased electricity demand. And secondary industry structure helps explain the growth of GDP in Shandong province. Although tertiary industry is developing very fast but the secondary industry is still very important in the electricity consumption.

1 Introduction

Shandong is a province with big electricity consumption in China with annual growth rate at about 9 per cent. Meanwhile, Shandong is also a big industrial province with GDP reaching 7647 billion RMB in 2018. Figure 1 shows that secondary industry plays a significant role in the growth of Shandong GDP with ratio reaching the highest point of nearly 60% in the year of 2006. After 2006, the ratio of secondary industry gradually decreases and the ratio of tertiary industry begins to increase. The ratio of tertiary industry overlaps that of the secondary industry in 2016. This paper will explore the causes of Shandong annually increased electricity consumption. We want to find out whether secondary industry structure helps accelerate the increased electricity consumption or not.

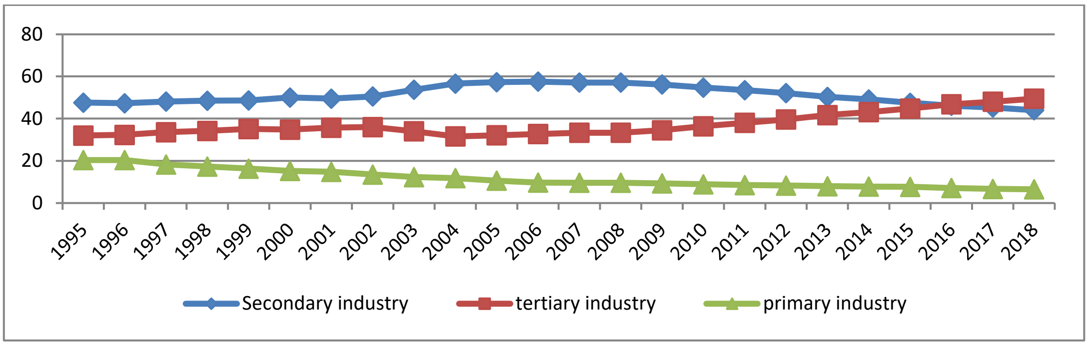

Figure 1 Ratio of Three industries in Shandong

2 Literature Review

Some research paper examined the significance of changes in industrial structure and in the intensity of electricity use within major industries using empirical procedure. The conclusion reached was that many factors had a major influence on trends in industrial electricity consumption [1]. Some other paper examined the contradiction that electricity consumption declination accompanied with GDP growth occurred in 2008 global outbreak of financial crisis. The authors examined characteristics of cyclical fluctuation of the electricity industry, the relationship between the electricity industry cycle and macroeconomic cycle, and factors affecting changes in electricity consumption [2].

Many paper found that the industrial structure and the layout in China is important in the electricity consumption studies. Some paper made a quantitative analysis of the new influencing factors, and establishes the quantitative relationship based on econometrics [3].

*Corresponding author e-mail: libingchina@sina.com

With the help of Data Envelopment Analysis(DEA) approach, the total factor electricity consumption efficiency of China's industry in 33 industrial sectors from 1998 to 2007 was measured and the influence factors of the efficiency is explored by using Tobit model [4]. Some study employed the threshold regression model analysed the difference effects of economic growth, industry structure, total factor electricity efficiency and electricity price on electricity consumption in the different range of economic growth, it also demonstrated the asymmetry effects between electricity consumption and economic growth in 1980-2008.Research result shows that the roles of variables on electricity consumption are different in the different range of economic growth [5].

Research found that energy, especially the electricity, is the basis of a country's economic development. It was of great significance for a country to develop the economy. Meanwhile, this also can illustrate the mechanism and change trend of electricity consumption [6]. Other study focused on the relationship between economic growth and electricity consumption of the secondary and tertiary industry in China. This study had a great significance to reveal the relationship between industrial electricity consumption and the pattern of economic development [7].

In this paper, after the econometric methodology and data are briefly explained, we will do unit root test, cointegration test and Granger causality test to estimate the possible relationship between the electricity consumption and industry structure upgrading with GDP as the control variable.

3 3 Econometric methodology and data

The equation of VAR model of one lag is written as follows:

$$Y_t = \alpha + \Phi Y_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim IID(0,\Omega) \tag{1}$$

So the Vector Moving Average (VMA) form as follows:

$$Y_t = (I - \Phi)^{-1}\alpha + \sum_{i=0}^{\infty} \Phi^i \varepsilon_{t-i} \tag{2}$$

It could be stated in the following matrix form:

$$\begin{pmatrix} x_t \\ y_t \end{pmatrix} = \begin{pmatrix} 1-\phi_{22} & \phi_{12} \\ \phi_{21} & 1-\phi_{11} \end{pmatrix}\begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} + \sum_{i=0}^{\infty}\begin{pmatrix} \varphi_{11}(i) & \varphi_{12}(i) \\ \varphi_{21}(i) & \varphi_{22}(i) \end{pmatrix}\begin{pmatrix} \varepsilon_{xt-i} \\ \varepsilon_{yt-1} \end{pmatrix} \tag{3}$$

We know that Granger causality test is used to test the relationship of electricity consumption and the industry structure upgrading. The test idea was put forward by J. Granger in 1969 and then developed by Henry and Richard in 1970s. The Granger causality test uses the following two equations to do the test:

$$y_t = \sum_{i-1}^{q} a_i x_{t-i} + \sum_{j-1}^{q} \beta_j y_{t-j} + u_{1t} \tag{4}$$

$$x_t = \sum_{i-1}^{s} \lambda_i x_{t-i} + \sum_{j-1}^{s} \delta_j y_{t-j} + u_{2t} \tag{5}$$

We know that the stationarity of the variable series is critical in the Granger causality test. The reason is that the non-stationary sequences might lead to a false causal relationship. If the sequence is found not stationary, the solution is to have variables differenced one or more times to become stationary, and only then the Granger test can be done accordingly. Usually a differenced stationary series is said to be integrated and is denoted as I(d) where d is the order of integration. The order of integration is the number of unit roots contained in the series, or the number of differencing operations it takes to make the series stationary.

All the variables analysed in this paper have been expressed in a logarithmic scale. The empirical study uses time-series data for electricity consumption (LNEEC), secondary industry structure (LNRAS) and gross domestic product (LNGDP) for the period of 1995 – 2018 in Shandong province, P. R. China. Data are obtained from the Shandong Statistical Yearbook annul edition. In this paper electricity consumption is expressed in terms of GW/h, secondary industry structure is expressed in the ratio of secondary industry in the three industries. GDP is in constant RMB. The choice of the starting period is constrained by data availability on electricity consumption. The Eviews 9.0 is used as the software for analysis.

4 Tests results and discussion

4.1 Unit root test

Stationarity of the variables is critical in the analysis. In this section, we first use Group unit root test to investigate the variables are stationary or not in level. Table 1 lists the results of the test in which the Levin, Lin & Chu statistics is -1.35667 with a probability of 0.0874. If we take the 5% significance, we cannot reject the Null hypothesis that assumes common unit root existing. Then Im Pesaran and Shin W statistics, ADF-Fisher Chi-square and PP-Fisher Chi square statistics are all showing that the probabilities are all bigger than the 5% significance. So we cannot reject the Null hypothesis that assumes individual unit root.

Table 1. Group Unit Root Test Results for LN*** in Level

Group unit root test: Summary Series: LNEEC, LNGDP, LNRAS in level		
Method	Statistic	Prob.**
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-1.35667	0.0874
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	0.58227	0.7198
ADF - Fisher Chi-square	2.77860	0.8361
PP - Fisher Chi-square	2.53142	0.8649

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Next, we take the variables in 1st order differences to test the stationarity. As table 2 indicates that the statistics of the Levn, Lin & Chu in common unit root process is 0.0215 in probability which is smaller than the 5% significance. So we can reject the null hypothesis which assumes common unit root. The Im Pesarn and Shin W statistics and ADF-Fisher Chi-square and PP-Fisher Chi-square statistics all indicate that we can reject the null hypothesis which assumes individual unit root. So the test result is the variables under study are all stationary in their 1st order differences.

Table 2. Group Unit Root Test Results for LN*** in 1st Difference

Group unit root test: Summary Series: LNEEC, LNGDP, LNRAS in 1st Difference		
Method	Statistic	Prob.**
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-2.02423	0.0215
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	-1.68939	0.0456
ADF - Fisher Chi-square	13.0883	0.0417
PP - Fisher Chi-square	13.0344	0.0425

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

4.2 Cointegration test

With stationary variables of I(1) conditions, the cointegration test could be conducted. Tables 3 lists the settings of the test: we assume trend is linear deterministic, with LR, AIC and SC criteria, we set the lag interval from 1 to 1. Trace statistics indicates that there is 1 cointegrating equation at the 0.05 level and this is tested according to MacKinnon-Haug-Michelis (1999) p-values.

Table3 VAR model variables cointegration test

Included observations: 22 after adjustments
Trend assumption: Linear deterministic trend
Series: LNEEC LNGDP LNRAS
Lags interval (in first differences): 1 to 1
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.679376	37.73177	29.79707	0.0050
At most 1	0.386381	12.70709	15.49471	0.1260
At most 2	0.085351	1.962726	3.841466	0.1612

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

So the normalized 1 cointegrating equation is shown in Table 4.

Table4 Normalized cointegration coefficients

1 Cointegrating Equation(s):	Log likelihood	159.7029
Normalized cointegrating coefficients (standard error in parentheses)		
LNEEC	LNGDP	LNRAS
1.000000	-1.280599	-7.101763
	(0.14105)	(1.83154)

4.3 Granger Causality Tests and other residual tests

Table 5 lists the results of the Granger causality test. At the lagging order 2 and 5% significant level, we can see the LNEEC, LNGDP and LNRAS are all one-directional Granger causes existing in their pairwise Granger causality relationship. That is, LNEEC Granger causes LNGDP, LNRAS Granger causes LNEEC and LNRAS Granger causes LNGDP. That LNEEC Granger causes LNGDP means that electricity consumption could explain the development of GDP in Shandong in the period under study. And that LNRAS Granger causes LNEEC means that the secondary industry structure in the three industries played a significant role in the explanation of the increased electricity demand. That LNRAS Granger causes LNGDP means secondary industry structure in the three industries help explain the development of GDP in Shandong province, too.

Table 5 Pairwise Granger causality tests

Sample: 1995 2018

Null Hypothesis:	Obs	F-Statistic	Prob.	Conclusion
LNGDP does not Granger Cause LNEEC	22	0.24556	0.7850	Accept
LNEEC does not Granger Cause LNGDP		5.98241	0.0108	Reject
LNRAS does not Granger Cause LNEEC	22	4.25486	0.0318	Reject
LNEEC does not Granger Cause LNRAS		2.32294	0.1283	Accept
LNRAS does not Granger Cause LNGDP	22	6.40484	0.0084	Reject
LNGDP does not Granger Cause LNRAS		2.74066	0.0930	Accept

5 Conclusion

This paper analyses the relationship of electricity consumption and secondary industry structure with GDP as control variable. First we test the unit root in level and then in 1st difference and the results show that variables are stationary in the 1st difference. Then we perform the cointegration test and find that there is 1 cointegration equation existing. This means that there is a long run relationship between the electricity consumption and the secondary industry structure.

Granger causality test indicates that variables all have one-directional Granger causality relationship. LNEEC Granger causes LNGDP, LNRAS Granger causes LNEEC and LNRAS Granger causes LNGDP. That LNEEC Granger causes LNGDP means that electricity consumption could explain the development of GDP in Shandong in the period under study. And that LNRAS Granger causes LNEEC means that secondary industry structure in the three industries played a significant role in the explanation of the increased electricity demand. That LNRAS Granger causes LNGDP means secondary industry structure in the three industries help explain the development of GDP in Shandong province, too.

The policy indication of the analysis is that increased electricity consumption in Shandong is to a great extent due to the development of secondary industry in the period of 1995-2018. Although tertiary industry is developing very fast, the secondary industry is still very important in the electricity consumption.

Acknowledgments

Shandong social science planning research project: Research on dynamic collaborative development of Shandong manufacturing industry and producer services industry (19CDNJ31).

References

1. Hankinson, G. A., & Rhys, J. M. W. (1983). Electricity consumption, electricity intensity and industrial structure. Energy Economics, 5(3), 146-152.
2. Chang, L., & Tiemei, G. (2011). Characteristics of electricity industry cycle fluctuation and influential factors of electricity demand based on business analysis and the error correction model. Resources Science, 33(1), 169-177.
3. He, Y., Jiao, J., Chen, Q., Ge, S., Chang, Y., & Xu, Y. (2017). Urban long term electricity demand forecast method based on system dynamics of the new economic normal: the case of tianjin. Energy, 133(15), 9-22.
4. WANG Xi-ping, & QIU Le. (2011). Industrial electricity consumption efficiency and its determinants. Electric Power, 44(7), 71-76.
5. Ke, L. I. (2012). Relationship between electricity consumption and economic growth of china based on threshold regression model. Systems Engineering-Theory & Practice, 32(8), 1704-1711.
6. Niu, D. & Gu, Z. (2011). An empirical analysis of electricity consumption intensity based on structure factor and efficiency factor. International Journal of Information Technology & Management, 10(1), 94-104.
7. Zhang, C., Zhou, K., Yang, S., & Shao, Z. (2017). Exploring the transformation and upgrading of china's economy using electricity consumption data: a var–vec based model. Physica A: Statal Mechanics and its Applications, 473, 144-155.