Empirical Analysis on Shandong Industrial Electricity Consumption, GDP, Industrial Goods Export and FDI in Industrial Sector

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Abstract. This work is to analyse relations which exist among the consumption in industrial electricity, GDP, industrial goods export and the FDI in industrial sector in Shandong. From the coefficients of VAR model, we can see once there is one per cent growth in GDP in the previous year or two will increase industrial electricity by 0.03%, and a 1 per cent growth in industrial goods export in the previous year or two will increase industrial electricity consumption by 0.2%, and a 1 per cent growth in FDI in industrial sector will increase industrial electricity consumption by 0.2%. As the Granger Causality test shows that increased industrial electricity consumption can be explained as the causes of GDP growth in Shandong. And increased FDI in industrial section can be explained as the causes by industrial electricity consumption growth. While industrial goods export and industrial electricity consumption could not be explained as the causes to the growth of each other under the study significance.

1. Introduction
Shandong, one of the most important industrial provinces in China, has an increased industrial electricity demand year by year. While at the same time, gross domestic product (GDP) growth in Shandong is accelerating to a new stage, industrial goods export is keeping a steady pace in both the quantity and quality aspects. Shandong is an excellent place for foreign investors to build their plants and factories due to the friendly business atmosphere and fair competition environment. In this paper, we will perform empirical analysis on Shandong industrial electricity consumption, GDP, industrial goods export and foreign direct investment (FDI) in industrial sector to find the relationship among those variables.

2. Literature Review
Some researchers have done studies about the relations of electricity demand and GDP. Those studies foster a good concept about the role of electricity which accelerated the growth of economics in a region. Methods in the study include causality tests to suggest the electricity policies for the future. The conclusions are that the higher the economic development, the more electricity demand [1]. Some studies have been done upon the relationship of GDP in different industry sectors and energy consumption in different types. Those studies are conducted in different emerging industrial countries, too. The results showed that the cointegrated relationship did exist in the study period. And the Granger causality test indicated that there were a bidirectional relationship existed too [2]. Other
papers found that in the Middle East countries and Southeast European countries and Asian countries, electricity consumption, export and GDP all had feedback effects with statistically significance upon each variable [3-6].

Some investigations studied the energy demand, urbanization development and economic growth speed in some New Industrialized-Market states. The results showed that there existed panel Granger causality relationship among these variables. Economic growth was Granger caused by the energy consumption and urbanization [7-8].

This paper will explain first the model and data collection, then test the unit root among variables. Cointegration and Granger causality will be tested to find the relationship between consumption in industrial electricity, GDP, export in industrial goods and FDI in industrial sector in Shandong in the long run.

3. Model and Data

We use the vector auto-regression (VAR) model to find the dynamic impact by random disturbance in a economic system so that the predictions could be made. The VAR model has many different written forms, here we present the form with 1 lag as follows:

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

If we write it in a Vector Moving Average (VMA) form, it goes like this:

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

In this paper, Granger causality test method as a common approach is taken to test the possible link between the variables under our research. The idea of the test is to set up information set with at least 2 variables, for example Xt and Yt. We want to see that whether Yt could be explained by more past Xt and Yt. If this is successful, we call it Xt Granger causes Yt. In doing test of Granger causality, first we have to test the variables sequences’ stationarity. Because the non-stationarity of the sequences is one of the important factors which might lead to a false causal relationship. If the sequence is found non-stationary, we will difference it one or several times to make it a stationary sequence so that the Granger causality could be tested. A typical non-stationary series is the random walk just like the following equation:

\[ y_t = y_{t-1} + \varepsilon_t \]  

Of which \( \varepsilon_t \) is a term of stationary random disturbance, and series \( y_t \) is increasing over time.

\[ y_t - y_{t-1} = (1 - L)y_t = \varepsilon_t \]  

The integrated difference stationary series is often marked as I(d), of which d is the indication of unit roots number existing. If there is no unit root, we call it an I(0). If one unit root exists, we call it an I(1). Before we apply it into regression test, we have to check the series stationary or not.

In this paper, the statistical data information are adopted in "Shandong Statistical Yearbook" and "China Energy Statistical Yearbook". Due to data shortage, we select the sample period as among the years of 1995-2018. Model variables include the Industrial electricity consumption (IEC), Gross domestic product (GDP), Industrial goods export (IEX), Foreign direct investment in industrial sector (IFDI). Variables are taken in the natural log form, that is, LNIEC, LNGDP, LNIEX and LNIFDI. From Figure 1, we can see that all the four variables have a upward trend under study period. We use the Eviews 9.0 to do this research.
4. Results of Tests & Discussion

4.1. Test of Unit Root

Unit root in group is tested to find the stationarity of variables under study. The variables in levels are firstly tested. Table one has the results. The first null hypothesis assumes there is a unit root in common and test result shows that the probability is 0.0594 far higher than the 0.01 significance level. From this test, we can say that LNIEC, LNGDP, LNIEX and LNIFDI have unit root in common and they are non-stationary. Second null hypothesis is to find unit root individually and we use different methods such as Im Pesaran methods, etc. to test the variables. The Shin, ADF, PP results are also showing that the LNIEC, LNGDP, LNIEX and LNIFDI in level do have unit root too. So that we can say that those variables are non-stationary.

Table 1. Test Results for Level LN***

| Method                                    | Statistic | Prob.** |
|-------------------------------------------|-----------|---------|
| Null: Unit root (assumes common unit root process) |           |         |
| Levin, Lin & Chu t*                       | -1.55990  | 0.0594  |
| Null: Unit root (assumes individual unit root process) |           |         |
| Im, Pesaran and Shin W-stat               | 0.56579   | 0.7142  |
| ADF - Fisher Chi-square                   | 3.84967   | 0.8704  |
| PP - Fisher Chi-square                    | 3.40771   | 0.9062  |

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

So we have to test the 1st-degree difference so as to find out whether they are stationary or not. Table 2 shows that results of tests according to the same methods as in level. The results are showing that the variables in 1st difference do not have any unit root. So that we can say that LNIEC, LNGDP, LNIEX and LNIFDI are stationary.

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

| Method                                    | Statistic | Prob.** |
|-------------------------------------------|-----------|---------|
| Null: Unit root (assumes common unit root process) |           |         |
| Levin, Lin & Chu t*                       | -9.59348  | 0.0000  |
| Null: Unit root (assumes individual unit root process) |           |         |
| Im, Pesaran and Shin W-stat               | -8.20011  | 0.0000  |
| ADF - Fisher Chi-square                   | 63.5271   | 0.0000  |
| PP - Fisher Chi-square                    | 265.954   | 0.0000  |

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

4.2. Lag Number

We try to find the appropriate lag number for the test by selecting the choices provided by the following criteria as shown in Table 3.
Table 3. Lag Number Results for LN*** in 1st Difference

| Lag | LogL  | LR   | FPE    | AIC    | SC     | HQ      |
|-----|-------|------|--------|--------|--------|---------|
| 0   | -15.89034 | NA   | 7.17e-05 | 1.808213 | 2.006584 | 1.854943 |
| 1   | 61.96821  | 120.3269* | 2.67e-07 | -3.815292 | -2.823435* | -3.581641 |
| 2   | 80.29651  | 21.66071  | 2.57e-07* | -4.026955* | -2.241613 | -3.606382* |

* indicates lag order selected by the criterion.
LR: sequential modified LR test statistic (each test at 5% level)  FPE: Final prediction error  
AIC: Akaike information criterion SC: Schwarz information criterion HQ: Hannan-Quinn information criterion

The statistical tests reveal that choices selected by the three criteria including FPE, AIC and HQ are for a lag number p = 2, which is appropriate for the test next.

4.3. Cointegration Test

In the VAR model, the stationarity test shows that variable of LNIEC, LNGDP, LNIEX and LNIFDI all satisfy the I(1) stationary requirements. We try the cointegration analysis to do the study. The cointegration test is used to find out the possible long run stable relation that may have in variables under study. The Trace statistics test result indicates there is 1 cointegration equation which exists at the 0.05 level. Table 4 lists the test results.

Table 4. Test results of VAR model variables

Included observations: 21 after adjustments  
Trend assumption: No deterministic trend (restricted constant)  
Series: LNIEC LNGDP LNIEX LNIFDI  
Lags interval (in first differences): 1 to 2  
Unrestricted Cointegration Rank Test (Trace)

| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistical | 0.05 Critical Value | Prob.** |
|---------------------------|------------|-------------------|---------------------|---------|
| None *                    | 0.981179   | 117.8769          | 54.07904            | 0.0000  |
| At most 1                 | 0.653732   | 34.44865          | 35.19275            | 0.0600  |
| At most 2                 | 0.285000   | 12.17726          | 20.26184            | 0.4331  |
| At most 3                 | 0.216823   | 5.132322          | 9.164546            | 0.2692  |

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

The coefficients of VAR model estimation with a lag number p = 2 are listed as follows:

\[ \text{LNIEC} = 0.65*\text{LNIEC}(-1) + 0.25*\text{LNIEC}(-2) - 0.025*\text{LNGDP}(-1) - 0.026*\text{LNGDP}(-2) + 0.24*\text{LNIEX}(-1) - 0.15*\text{LNIEX}(-2) + 0.21*\text{LNIFDI}(-1) - 0.20*\text{LNIFDI}(-2) + 0.68 \]  

4.4. Granger Causality Tests

Results of Granger Causality test are listed in Table 5. We perform this test at a lagging order 3 and with a 5% significance. The results indicate that LNGDP doesn’t Granger cause LNIEC, but LNIEC does Granger cause LNGDP. While results also indicate LNIEX doesn’t Granger cause LNIEX and
LNIEC doesn’t Granger cause LNIEX. LNIFDI does Granger cause LNIEC, but LNIEC does not Granger cause LNIFID. These test results mean there are only a one-directional Granger cause of LNGDP and LNIEC, LNIFDI and LNIEC. This shows that Shandong’s consumption in industrial electricity helps explain the GDP growth, and that foreign direct investment in industrial sector is accelerating the increasing demand in industrial electricity consumption.

### Table 5. Tests Results

| Null Hypothesis                              | Obs | F-Statistic | Prob. | Conclusion |
|----------------------------------------------|-----|-------------|-------|------------|
| LNGDP does not Granger Cause LNIEC          | 21  | 0.51619     | 0.6778| Accept     |
| LNIEC does not Granger Cause LNGDP           | 9.77471 | 0.0010    |       | Reject     |
| LNIEX does not Granger Cause LNIEC          | 21  | 1.05653     | 0.3987| Accept     |
| LNIEC does not Granger Cause LNIEX           | 0.68700 | 0.5748    |       | Accept     |
| LNIFDI does not Granger Cause LNIEC         | 21  | 3.43651     | 0.0464| Reject     |
| LNIEC does not Granger Cause LNIFDI          | 0.94917 | 0.4435    |       | Accept     |

## 5. Conclusion

This work aims at analysing the relationship among the industrial electricity consumption, GDP, industrial goods export and the FDI in industrial sector in Shandong. After unit root tests are given and the test results tell us that variables under study are of stationarity, lag number of equation is given, too. So the coefficients of VAR model can be estimated. From the coefficients of VAR model, we can see that once there is one per cent growth in GDP in the previous year or two will increase industrial electricity by 0.03%, and that a 1 per cent growth in industrial goods export in the previous year or two will increase industrial electricity consumption by 0.2%, and that a 1 per cent growth in FDI in industrial sector will increase industrial electricity consumption by 0.2% approximately.

As the Granger Causality test shows that increased industrial electricity consumption can be explained as the causes of GDP growth in Shandong. And increased FDI in industrial section can be explained as the causes by industrial electricity consumption growth. While industrial goods export and industrial electricity consumption could not be explained as the causes to the growth of each other under the study significance.

This study could provide suggestion and advices to officials of the local government and to help them make executive polices decisions. FDI actually is the most important influential factor affecting the increase of the consumption of industrial electricity. Industrial electricity demand will increase GDP. So FDI in industrial sector has a critical function in the GDP development in Shandong. Policies concerning foreign investment measures need to be well adopted to ensure the steady growth of the GDP.

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