Examining the Relationship between Industrial Output and Electricity Sales in the Philippines: A Time Series Analysis

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Abstract: Economic growth has always been associated with the increase in energy consumption. While mainstream growth theory does not incorporate energy as a factor of production, a large number of economists argue that economic growth and energy use are strongly related. The relationship between energy and production can be viewed from the perspective of thermodynamics. No physical transformation or movement can be achieved without the use of energy, thus making energy use essential in the production and distribution of goods and services. While the Philippine economy is growing at a pace faster than 5 percent over the last four years, constraints in electricity supply raise questions on whether the economic expansion is sustainable. This paper looks into the degree of the relationship between the value-added in the industry sector, one of the key drivers of economic growth today, and electricity sales using time series analysis. In particular, the study utilizes dynamic regression to assess the elasticity of electricity sales to industry sector value added. If the elasticity is equal to or greater than one (1), then it is suggests that expansion in power supply should rise at the same pace of manufacturing industry growth. On the other hand, if the elasticity is less than one (1), then it suggests that a rapid rise in industry sector output would not necessarily require electricity supply to grow at same pace. The analysis shows that electricity sales is inelastic to industrial output, implying that electricity supply does not need to grow as fast as industrial output.

Keywords: Economy; Electricity; Time Series; Transfer Function;

1. INTRODUCTION

1.1. The Problem and its background

Economic growth has always been associated with the increase in energy consumption. While mainstream growth theory does not incorporate energy as a factor of production, a large number of economists argue that economic growth and energy use is strongly related. This relationship between energy and production can be viewed from the perspective of thermodynamics. No physical transformation or movement can be achieved without the use of energy, thus making energy use essential in the production and distribution of goods and services (Stern, 2004). Some theories go as far as suggesting that energy is the only primary input to production. Since all production processes require labor and capital, and both labor and capital require energy to engage in production, it is argued that the two are only vehicles of energy in the production process (Stern, 2004; Hannon 1973). Laborers require energy to in order to execute their work. Likewise, machines and other equipment require some form of energy input to operate. The energy-economy nexus could also be viewed from the perspective of the demand. Economic growth requires energy, thus this expansion signals investors and governments to put up the necessary infrastructure to supply the demand for energy.

If such relationship exist between the economy and energy, then it could prove difficult, if not impossible, to enforce energy conservation efforts without hampering economic growth. Energy conservation is often aimed at reducing carbon emission and environmental degradation.

The energy industry generally produce a lot of residuals that result to environmental degradation. Conventional coal-fed and diesel-fed power plants are among the major sources of carbon emissions. The extraction of fuels is also known to have hazardous impact on the environment. Coal mining have been traced as a major cause of deforestation and the reshaping of landscapes. Likewise, accidents in offshore oil extraction activities, such as oil spills and rig explosion, has been known to cause major disruption of marine ecosystems. Assuming that economic expansion requires the increase of energy use in order to be sustainable, this would imply that if a country would want its economy to continue growing, then it is inevitable for that country to increase its energy use. In some cases, energy use is even used as a proxy for environmental impact of human activity (Common, 1995).

Developing nations in Asia, Africa, and Eastern Europe have been experiencing rapid industrialization in the past few decades. China, for instance, has grown to become the second largest economy in the world in terms of GDP. It has consistently been identified as the fastest growing economy in Asia, expanding above five percent per year in more than a decade. An essential question is that, could this growth be sustained without resulting to negative externalities to the environment? Health issues due to air pollution are currently plaguing the Chinese population in its major cities.

The relationship between economic growth and energy consumption has been the subject of many studies in the past. However, there is no consensus on the direction of the relationship between the two. The direction of the causality is of primary importance to policy makers since they are becoming more and more particular with the effects of economic growth on environmental degradation. A unidirectional causality from energy consumption to GDP would mean that economic growth cannot be achieved without increasing energy use. This becomes a concern since energy is a major source of greenhouse gas emissions. A unidirectional causality from GDP to energy consumption is just as concerning since it means that as economies expand, energy consumption would inevitably expand with it. A bidirectional causality between economic growth and energy consumption has also been theorized by some economists. This conclusion suggests that as the economy grows, energy consumption grows with it, allowing the economy to grow even further. For energy conservation policies to succeed without hampering economic growth, such causalities, of any direction must not exist.

Though it is desirable, in the point of view of policy, to conclude that there is no causality between energy use and economic growth, the results of past studies points to the contrary. Most research conclude that causality between the economy and energy use does exist. This study would assume a unidirectional causality from economic output to energy use.

1.2. *Research question*

While it is generally accepted in literature that there exist a significant correlation between economic output and electricity sales, the magnitude of such relationship is not standard. This study seeks to quantify such relationship in terms of elasticities in the Philippine context. In economics, elasticity is a measure of the responsiveness of a dependent variable to an independent variable. The research shall answer the question, to what degree would electricity sales increase for every increase in industrial output in the Philippines?

1.3. Significance of the study

Determining the elasticity of electricity sales to industrial output is imperative for policy making, considering the rate of growth in industrial output in relation to constraints in electricity supply. Power supply in the Philippines is relatively tight as of the writing of this paper. Mindanao is experiencing rotating power outages. The Department of Energy announced that reserves in Luzon would be tight during the summer months of 2015. Meanwhile, the national government, banks, multilateral institutions, and think tanks see the Philippine economy growing between 5 to 7 percent annually until 2016 and industry is expected to play a key role in the economic expansion. It would be of interest for policy makers to know the degree to how much would power demand increase given the pace of growth in industrial sector output, in order to avert future supply shortages.

2. METHODOLOGY

This paper aims to examine the magnitude of the relationship between industrial output in terms of gross value added (in million Pesos) and energy sales (in gigawatt hours). Annual data from 1986 to 2012 was used in the analysis. In order to answer the research question, this study employs two methods: the descriptive analysis and dynamic regression.

The first part of the study would be dedicated to descriptive analysis. The time plot of both electricity sales and gross value added, as a measure of GDP would be examined for trend, correlation, and structural change.

The second part of the analysis would involve the estimation the elasticity of total electricity sales to industrial output. For this section, dynamic regression would be used to determine the elasticity of electricity sales to manufacturing value added. Dynamic regression models such as the ARIMA transfer function model is commonly used to determine the effect of the variations of one or more independent variables (called the input variable) to dependent variables (output variable) using time series data. This paper would not specify in detail the procedure but readers would instead be referred to Pankratz (1991) and Wei (2006).

The first step in the procedure would be the pre-whitening stage, where in the specific ARIMA model for the input variable would be identified and fitted. The step involves a visual analysis of the autocorrelation function (ACF) and the partial autocorrelation function (PACF) to determine the appropriate ARMA structure of the input series. Once the ARIMA model for the input series is known, cross-correlation would be applied to the pre-whited input series and dependent variable to identify the specification of the transfer function. For this analysis, both industry value-added and electricity sales would be expressed in natural logarithms so that the parameters for the numerator of the transfer function can be interpreted as elasticities. The regression model would be specified as follows:

$$Ln(TS_t) = \frac{(\omega_0 B^b - \cdots \omega_s B^{b+s})}{(1 + \delta_1 B - \cdots \delta_r B^r)} Ln(Ind_t) + N_t$$

(Eq 1)

Where:

Ln(TS) = Natural Log of the Total Electricity Sales;
Ln(Ind) = Natural Log of the Industrial Sector GVA;
$\omega_0 \ldots \omega_s$, and $\delta_1 \ldots \delta_r$ = parameter of the transfer function, and;
N_t = ARIMA Noise model

If the elasticity is equal to or greater than one (1), then it is suggests that expansion in power sales should rise at the same pace of industry growth. On the other hand, if the elasticity is less than one (1), then it suggests that a rapid rise in the industry sector output would not necessarily require electricity supply to grow at same pace. SAS Analytics would be used in the analysis.

It would also be the interest of this research to identify the elasticity of industrial electricity sales, which is sales to the industrial sector, to industrial output. The second regression equation would be specified as follows:

$$Ln(IS_t) = \frac{(\omega_0 B^b - \cdots \omega_s B^{b+s})}{(1 + \delta_1 B - \cdots \delta_r B^r)} Ln(Ind_t) + N_t$$

(Eq 2)

where:
Ln(IS) = Natural Log of the Industrial Electricity Sales;
Ln(Ind) = Natural Log of the Industrial Sector GVA;

$\omega_0 \ldots \omega_s$, and $\delta_1 \ldots \delta_r$ = parameter of the transfer function, and;
N_t = ARIMA Noise model

3. RESULTS AND DISCUSSIONS

3.1. Trend and structure of electricity sales and industry value added

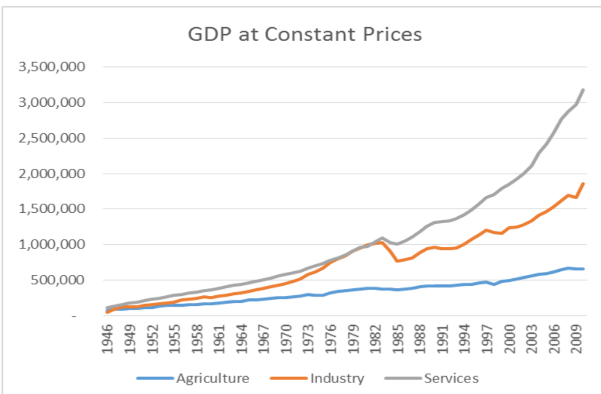


Figure 1.1: GDP Industrial Sectors

It can be seen from Figure 1 that in recent years, the services sector has been growing faster than industry and agriculture sectors. It is important to note that services tend to be less electricity-intensive than industries such as manufacturing and construction. The share of the services sector to GDP has grown from 42.0 percent in 1980 to 55.8 percent in 2010. The share of the industry sector to GDP, meanwhile, dropped from 41.6 percent in 1980 to 32.6 percent in 2010. The time plot shows that value added for both and industry and services sector sectors are growing in an exponential rate. The services sector, in particular, appears to be moving faster than both industry and agriculture sectors.

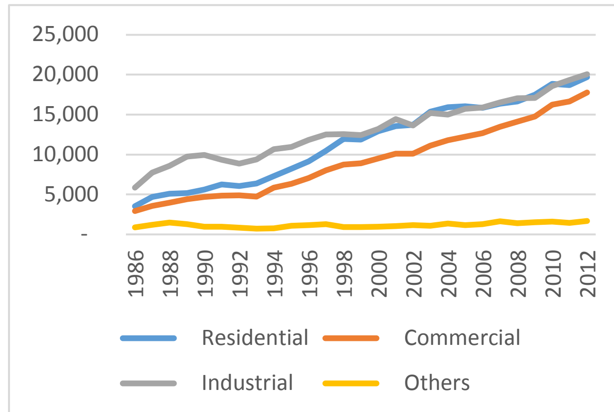
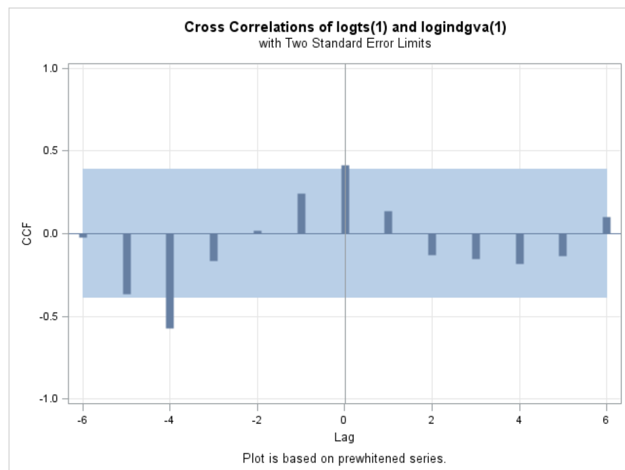


Figure 1.2: Electricity Sale by Sectoral Use



As shown in figure 2, growth in the major components of electricity sales is generally following a linear trend. This suggest that electricity sales is growing slower than economic output in terms of value added.

It can also be noticed from figure 2 electricity sales to residential users been growing at the same level as electricity sales to industrial users starting 2000. This suggests some structural change in the consumption pattern of energy users in the Philippines. Either industrial users has started to become more efficient or greater access to electricity was provided to more households.

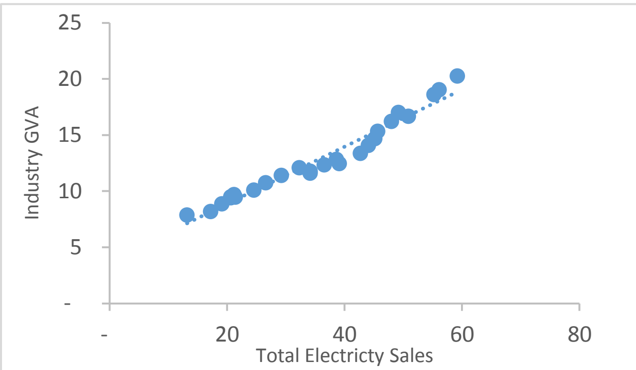


Figure 2: Scatter plot between Electricity Sales and Industry Value Added

The scatter diagram in figure 3 suggests that there is indeed a linear relationship between electricity sales and industry sector value added. This implies expansion of the industry sector would correspond to an increase in energy sales. The goal of this paper, however, would be to measure the strength of this relationship in terms of elasticity.

3.2. Elasticity of industry value added and electricity sales

SAS Analytics was used to analyze the data and to obtain sensible parameterizations of the noise process. An examination of the ACF and PACF suggest the series of the natural logarithm of total electricity sales, electricity sales to the industrial sector, and the gross value added in the industry sector do not follow a white noise process. Since the time plots also show that all three series are not stationary in mean, the three variables were differenced at order 1. Both ACF and PACF show no significant spikes in all three series after differencing.

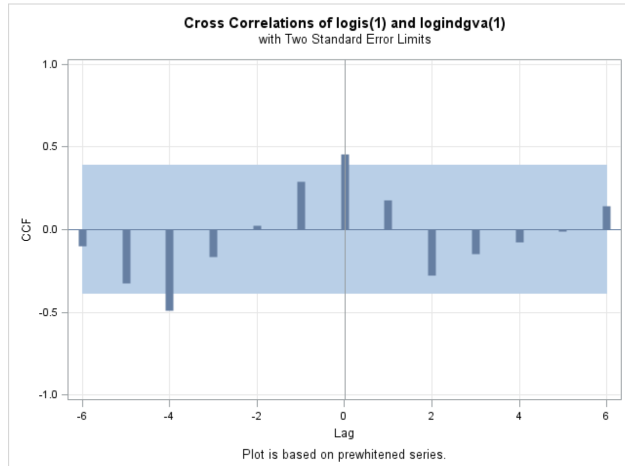


Figure 3.1: Cross Correlation plot of Total Electricity Sales to Industry GVA

Figure 3.2: Cross Correlation plot of Industrial Electricity Sales to Industry GVA

Cross correlation was then used to identify the specification of the transfer functions. As seen in figure 3.1, industry value added is significantly correlated to total electricity sales only at lag zero. Likewise, industry value added is also significantly correlated to electricity sales to the industrial sector at lag zero (figure 3.2). Equation 1 would be re-specified as:

$$(1-B)Ln(TS_t) = \omega_0(1-B)Ln(Ind_t) + a_t \quad \text{(Eq 3)}$$

Where:
a_t = white noise
$(1-B)$ = difference operator

While Equation 2 would be re-specified as:

$$(1-B)Ln(IS_t) = \omega_0(1-B)Ln(Ind_t) + a_t \quad \text{(Eq 4)}$$

Where:
a_t = white noise
$(1-B)$ = difference operator

Table 1 shows that parameter estimate for ω_0 in equation 3 is 0.83, which is less than one. This indicates that total electricity sales is inelastic to industry sector output, meaning a one percent change in industrial output would cause electricity sales to change by less than one percent.

Table 1: Conditional Least Squares for Equation 3

Parameter		S.E.	tstat		prob
ω_0	0.8341	0.20865	4		0.00
Variance Estimate	0.002627			AIC	-76.6
Std Error Estimate	0.051249			SBC	-75.4

Likewise, as shown in table 2, electricity sales to the industrial sector is also inelastic. This means that one percent change in industrial output would cause electricity sales to change by less than one percent.

Table 2: Conditional Least Squares for Equation 4

Parameter		S.E.	tstat		prob
ω_0	0.7332	0.22525	3.3		0.003
Variance Estimate	0.003061			AIC	-72.8
Std Error Estimate	0.055326			SBC	-71.6

The results from the conditional regression is consistent with what can be seen from the visual representation of the data. The time plots show that value added appears to be increasing in an exponential rate, while the increase in electricity sales to the major sectors are seems to only following a linear trend. This suggests that while electricity sales is indeed responsive to changes in output in terms of value added, it is inelastic. Even sales to the industrial sector, a sector, known to be energy intensive, is inelastic, according to the estimates.

Many reasons could contribute to how industrial output could grow at faster rate than electricity sales. First, the industries that are driving the growth may not be dependent on electricity. Certain industries like the manufacture of chemical products does not require substantial electricity as their input. The rise in the contribution of the services sector to GDP could play a part on why total electricity sales does not respond strongly to changes in industrial output. The rise in the contribution of residential electricity sales may also explain why total electricity sales is inelastic to industry output.

4. CONCLUSIONS AND RECOMMENDATIONS

This paper extends the literature by measuring the responsiveness of electricity sales to industrial output in terms of value added. The industry sector is expected to play a key role in economic growth in the coming years. Constraints in the electricity supply could pose a problem to growth considering the correlation between the two, as stated by earlier research. The findings of this study suggest that economic growth can continue while having less pressure to expand electricity supply by as much.

In the perspective of environmental economics, we can say that since electricity sales is inelastic of industry output, economic growth can continue without having a proportional level externalities to the environment as a result of energy production.

The researcher cautions about the interpretation of the results of this paper. The study suggest that electricity sales responds weakly to changes in industrial output, however, the hypothesis test show that industry output is still a significant driver of electricity sales and a positive linear relationship between the two variables can still be assumed.

Future research can seek to empirically identify the reason why the electricity sales responds weakly to changes in industry value added. Future researchers could also try to identify if there are changes in the elasticity over time, implying structural changes in the economy.

5. ACKNOWLEDGMENTS

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