ELECTRICITY CONSUMPTION AND INDUSTRIAL PRODUCTION IN NIGERIA

Theophilus I. Ugwoke, Dr Christopher K. Dike and Paul O. Elekwa
Department of Economics, Madonna University, Okija, Nigeria

Abstract
This study examines the impact of electricity supply on industrial output in Nigeria. Data for the period 1980 to 2014 were obtained from CBN and WDI and analysed using a double-log linear formulation. The results show that electricity supply and trade openness impact industrial production negatively in Nigeria. They were also not statistically significant. It was recommended that, having failed to provide electricity even for the present level of industrial production, government should immediately provide tax relief for all privately generated power for industrial output. Doing so will not erode the gains of petroleum products subsidy removal but will improve the macroeconomy by effectively checking the excessive production cost which hinders industrial progress in Nigeria. It was also recommended that future trade treaties should take into account the actual state of Nigeria’s industrial sector, in order to obviate the increasing platform for products of other economies which our economy is fast becoming while we ourselves produce and export little.

Keywords: Electricity consumption, Industrial output, industrial tax relief

Introduction
Electricity is central to industrialization of any nation. That the world is now a global village is mostly dependent on access to information which in turn is only possible with efficient and constant supply of electricity. The reliable and adequate electricity supply produces a multiplier effect which goes a long way in tackling the problem of poverty, unemployment and prevalent absence of technological and structural changes that are commonly seen in many developing countries like Nigeria.

Industrialization as explained by Udah (2010) is a deliberate and sustained application, combination of an appropriate technology, infrastructure, managerial experts and other important resources. He further went to explain that industrialization has attracted considerable interest in development economics in recent time, that industrial production of a country accelerates the pace of structural transformation and also brings about diversification of economies, enables a country to fully utilize its factor endowment and depend less on foreign supply of finished goods.

Nigerian industrial development over the years has been bedevilled by a plethora of problems top among them is the epileptic nature of electricity supply. In recognition of the benefits of high industrial productivity as a veritable tool to industrialization, successive governments in the country since independence have adopted various polices, schemes and incentives towards realization of this all important objective. Some of these policies include the import
substitution/indigenization policy (1972), the Structural Adjustment Programme (SAP) of (1986),
the Bank of Industry and Small and Medium Equity Investment Scheme (2000), the Electricity
Power Sector Reform Act (EPSRA) of (2005) and the National Integrated Industrial Development
(NIID) blueprint (2007).

Despite these policies, available statistics indicate that the industrial sector is experiencing
slow growth and one of the factors responsible for this to a considerable extent is the poor energy
consumption. The survey by the Manufacturing Association of Nigeria (MAN) carried out in the
first quarter of 2006 painted a gloomy picture of the crisis in the Nigerian industrial sector.
According to the survey, only 10 percent of manufacturing concerns in Nigeria could operate at
48.8% of installed capacity, 60 percent of the companies operating were barely able to cover their
average variable costs while 30 percent had to completely shut down due to inadequate supply of

Oke (2006) attributed the non-competitiveness of Nigeria’s export goods to infrastructural
inadequacy especially electricity supply which drives the running cost of firms.

Odell (1965) in his study on the role of electricity in a rapidly developing economy observed that
electricity is very important for industrialization which leads to economic growth and
development. One of the potential contributors to the large productivity gap between the developed
and developing countries is low quality infrastructures of which electricity occupies the centre-
stage. The cost of electricity failures to the Nigerian manufacturing sector is quite high as firms
incur costs both on the provision and maintenance of expensive back-up to minimize the expected
outage costs.

From the reports of the extensive empirical studies reviewed, the direction of causality as well as
the correct estimates of the relationship between energy consumption and industrial productivity
remained empirically inconclusive. This is one of the gaps this work intends to fill by adequately
estimating the relationships between electricity consumption and industrial productivity in Nigeria
which will help policy makers in addressing squarely problems of unemployment, poverty,
productivity, etc. To the best of our knowledge and going by the numerous empirical studies
reviewed, earlier studies on this topic failed to include institutional quality as one of the
explanatory variables. However, an attempt made by Olarinde and Omojolaibi (2014) to include
this variable in their study covered the period (1980-2011) thereby omitting the crucial period of
the unbundling of the power sector (2013). This work is therefore intended to fill this gap by
inclusion of institutional quality as one of the variables, and also to cover the period of unbundling
of the electricity power sector in Nigeria. The rest of the paper is organised as follows: section 2
addresses current literature. Section 3 outlines research method while section 4 focuses on analysis
of data and discussion of results. Policy recommendations are taken up in section 5, which also
concludes the paper.

2. Review of Related Literature
The relationship between energy consumption and industrial productivity has been a very serious
and ongoing discussion especially in the developing nations of the world where electricity
production has been problematic. This discussion has been on since middle of the 19th century.
The interest in the relationship was later fuelled by the energy crisis of 1970s that saw the increase
of the study of energy and industrial productivity process and subsequent effects on the economy
as a whole (Jiang, Chen and Zhou, 2011). Presently, energy still holds a decisive significance for
economic activity because economic growth is determined by the energy resource of the country
(Velasquez and Pichler, 2010). Electricity is the dominant source of energy in the manufacturing
sector, comprising more than 40% of primary energy consumption in the sector while coal is
approximately 25%. As a result, the manufacturing sector is extremely vulnerable to shortages in electricity supply. Depending upon a firm’s ability to substitute to alternative forms of energy, this reliance on electricity may result in manufacturing firms taking the full brunt of electricity shortages.

Several empirical literatures exist on electricity and its effect on economic performance. Yu and Choi (1985) studied the Philippines and found a positive relationship between energy consumption and economic growth. They went further to define that relationship as a unidirectional one where economic growth served as the dependent variable and energy consumption was the independent variable. Asafu-Adjaye (2000) carried out the same research on Singapore and Indonesia respectively and found out the same unidirectional causality effect of Energy consumption and Economic growth.

Lee and Anas (1992) reported that manufacturing sub-sector in Nigeria spends an average of 90% of their variable cost on infrastructure, with electric power accounting for half of the share. The duo studied 179 manufacturing firms in Nigeria and reported that the impact of electricity deficiency of all types was consistently higher in small firms. Ageel and Mohammad (2001) ran a co-integration on energy and its relationship with economic growth in Pakistan, a developing nation like Nigeria and found that increase in electricity consumption leads to economic growth. Sanchis (2007) stated that electricity as an industry is responsible for a great deal of output.

A study by Soytas and Sari (2003) obtained mixed results for the countries they studied. While they found bi-directional causality in Argentina, there was causality running from Gross Domestic Product to energy consumption in Italy and Korea and from energy consumption to gross domestic product in Turkey, France, Germany and Japan. Ghosh (2002) carried out a study for India using annual data for the period 1950 to 1997. He found no co-integration but argued that there is unidirectional causality from economic growth to electricity consumption. However, the results contradicted Granger’s (1986) postulation that there cannot be causality between non-stationarity variables that are not co-integrated. Sica (2007) investigated the possibility of energy demand-led growth and growth-driven energy demand hypothesis in Italy, using the error correction model. The result of the study did not reveal any causality linkage. Though, the standard Granger test found evidence of unidirectional causality running from energy to Gross Domestic Product.

Adenikinju (2005) in his study analyzed the cost of power outages to the business sector of the Nigerian economy using both a survey technique and revealed preference approach and the result shows that the poor state of electricity supply in Nigeria has imposed significant costs on the business sector. Alam (2006) agrees that there is a departure from neoclassical economics which include only capital, labour and technology as factors of production to one which now includes energy as a factor of production. He went further to say that energy drives the work that converts raw materials into finished products in the manufacturing process.

Sanchis (2007) added that increase in the electricity production will avoid the paralysation of the industrial production. Increased industrial production will eventually increase output. Thus, this implies that electricity production should become an economic policy high-priority objective which should be urgently responded to. Ultimately, energy efficiency contributes to wealth. (Oviemuno 2006). Alper and Atilla (2007) used the wavelet analysis and found that in the short-run, there is feedback relationship between gross national product and energy consumption. However, in the long-run, gross national product led to energy consumption. Masih and Masih (2007) studied the causality
between energy consumption and GDP in Asian countries using vector error correction model (VECM) and VAR analysis. They used annual data over 1955 to 1999 periods. They drew the conclusion that there was no causal relationship between energy consumption and GDP in Malaysia, Singapore and Philippine. They also found that there was bidirectional causality between energy consumption and GDP in Pakistan, unidirectional causality from energy consumption to GDP in India and unidirectional causality from GDP to energy consumption in Indonesia. Ciarreta, et al (2010) used panel data from 1970 to 2007 to analyze the causality relationship between electricity consumption, real GDP and energy price. They revealed the long-run equilibrium relationship between variables. The causal relationship running from electricity consumption to GDP was revealed. Also they found a bidirectional relationship between electricity consumption and growth in the short-run and long-run. Hondroyiannis et al (2002) studied the link between energy consumption, gross domestic product and the consumer price index (CPI) for Greece. They used annual data over the period 1960 to 1996 and found evidence of long-run bidirectional causality between energy consumption (total and industrial) gross domestic product. On the other hand, there was no causality between residential use of energy and gross domestic product.

The most significant effect of electricity supply on industrial outfits and their productivity is cost. Cost is a variable input in the measurement of profit. Profit is only realisable where cost of production is less than revenue. As a fixed cost therefore access to sufficient and affordable supply of electricity is a crucial determinant of productivity and growth. It is observable that industries suffer operation and maintenance costs arising out of power fluctuations (Lai et al., 2008). In the views of Odularu and Okonkwo (2009), only 40% of Nigerians have access to electricity (Energy Information Administration, 2007). However, majority of the electricity is supplied to the urban areas. According to the encyclopaedia on energy (2006), energy is a vital ingredient to economic and industrial growth and that this has been discovered for as long as economic data has been compiled. According to Krizanic (2007), one importance of power supply is the fact that it has become equally indispensable as food supply. Energy is a necessary condition for an industrial and economic survival. In other words, what Krizanic is saying is that what food is to a hungry man, energy is to economic growth of a nation. In both situations, consumption will increase productivity and therefore growth is achieved.

Abosedra et al (2009) investigated the direction of causality between electricity consumption and industrial growth for Lebanon, using monthly data covering the period 1995 to 2005. The outcome of the study substantiates the absence of a long-term equilibrium relationship between electricity consumption and industrial growth but existence of a unidirectional causality without feedback running from electricity consumption to industrial growth. They therefore called on the policy makers to place more emphasis on reconstruction and building of additional capacity and infrastructural development in the electricity sector which would drive industrial growth of the country.

Velasquez and Pichler (2010) reiterated that sufficient and affordable supply of energy (in this case, electricity) has had a decisive significance for industrial productivity and economic growth. Since a country’s economic growth is a composite of economic activities of enterprises, the less cost they have to tolerate, the better a country’s chance at harnessing their input towards greater levels of gross domestic product and growth. Okpara (2011) consents that industrial productivity can contribute immensely towards economic growth and poverty reduction.

Rud (2012a, 2012b) investigate the effects of electricity provision on firms in India. Rud (2012a) finds that an increase in rural electrification in Indian States starting in the mid 1960s led to an
increase in aggregate manufacturing output in the affected states. On the other hand, Rud (2012b) shows that more productive firms are able to adopt captive power generators to cope with unreliable electricity provision. Similarly, Alby, Dethier and Straub (2013) find that in developing countries with a high frequency of power outages, electricity-intensive sectors have a low proportion of small firms since only large firms are able to invest in generators to mitigate the effects of outages.

Zuberi (2012) estimates a dynamic model of manufacturing production using data from Pakistan, showing how firms reallocate production to non-shortage periods. Alam (2013) studies how India’s steel industries and rice milling industries respond differently to blackouts. Bloom et al. (2013) gathered data on the severity of shortages across Indian states, and an instrument that addresses the endogeneity of blackouts with respect to growth. A natural response to outages is to self-generate electricity. According to Fisher-Vanden, Mansur and Wang (2014) Resource availability and input factor reliability are important for firm productivity, and are especially problematic in developing countries like Nigeria.

Olarinde and Omojolaibi (2014) examined electricity consumption, institutions and economic growth in Nigeria for the period 1980-2011. They tested for causality using the ARDL and WALD test approach, and found a positive direct relationship between institutions, electricity consumption and economic growth.

In this study the focus is on the relationship electricity consumption has with Industrial production.

3. Research method

Annual Time series data were used for this analysis, sourced from Central Bank of Nigeria Statistical Bulletin and World Bank’s World Development Indicators. The study covered the period 1980 to 2014.

In view of the objectives of the study, the long term estimates were used to determine the impact of electricity consumption on industrial production in Nigeria. These were extracted in elasticity form using natural log of the variables and the Johansen co-integration procedure. From the relationship:

\[ \text{INDP} = (ELEC, IQ, GFCF, HCD, TOP, TGAP) \]  

the following functional form was estimated:

\[ \ln \text{indp} = \beta_0 + \beta_1 \ln \text{elec} + \beta_2 \ln \text{iq} + \beta_3 \ln \text{gfcf} + \beta_4 \ln \text{hcd} + \beta_5 \ln \text{top} + \beta_6 \ln \text{tgap} + \mu \]  

where \( \ln \) = natural log; \( \text{INDP} \) = industrial output, \( \text{ELEC} \) = electricity consumption, \( \text{IQ} \) = institutional quality, \( \text{GFCF} \) = gross fixed capital formation, \( \text{HCD} \) = human capital development, \( \text{TOP} \) = trade openness, and \( \text{TGAP} \) = technological gap. \( \beta_0 \) = intercept, \( \beta_i \) (where \( i = 1, 2...5 \)) = parameters to be estimated, and \( \mu \) = stochastic error term.

To fully explore the data generating process, we first examined the time series properties of the variables using the Augmented Dickey-Fuller test.

The ADF test regression equations with constant are:

\[ \Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \sum_{j=1}^{k} a_j \Delta Y_{t-j} + \varepsilon_t \]  

where \( \Delta \) is the first difference operator \( \varepsilon_t \) is random error term that is iid \( k = \) no of lagged differences \( Y = \) the variable. The unit root test is then carried out under the null hypothesis \( \alpha = 0 \) against the alternative hypothesis of \( \alpha < 0 \). Once a value for the test statistics

\[ ADF_t = \frac{\alpha}{SE(\alpha)} \]  

is computed we shall compare it with the relevant critical value for
the Dickey-Fuller Test. If the test statistic is greater (in absolute value) than the critical value at 5% or 1% level of significance, then the null hypothesis of $\alpha = 0$ is rejected and no unit root is present. If the variables are non-stationary at level form but nevertheless integrated, we would explore the existence of stable long run relationships among the variables. If such exist we may then extract the parameter estimates using the Johansen co-integration procedure. The co-integration equation is stated in equation 5 as:

**Co-integrated equation**

$$
indp_t = \alpha_t + \sum_{i=1}^{p} \alpha_i \eta_i Z_i - \left[ \eta_i indp_t - \sum_{i=1}^{n} \beta_i X_{t-i} + v_{2t} \right] \tag{5}
$$

Where

$$
[\eta_i indp_t - \sum_{i=1}^{n} \beta_i X_{t-i}] \text{ is the linear combination of the non co integrated vectors,}
$$

$X$ is a vector of the non co integration variables. The individual influence of the co integrated variables can only be separated with an error correction mechanism through an error correction model as shown below.

The Error Correction Model *Equation*

$$
\eta_i indp_t = \alpha_t + \sum_{i=1}^{p} \alpha_i \eta_i Z_i - \left( \lambda ECM_{t-i} + v_{4i} \right) \tag{6}
$$

Where $-\lambda ECM$ is the error correction mechanism, $-\lambda$ is the magnitude of error corrected each period specified in its a priori form so as to restore $\eta_i log KF_t$ to equilibrium.

Also the optimum lag length of the model was determined using the multivariate versions of information criteria of Akaike’s Information Criteria (AIC) and Schwarz’s Bayesian Information Criteria (SBIC).

4. **Data Analysis and Discussions.**

**Unit Roots Test Result**

Augmented Dickey Fuller (ADF) unit roots test was employed to test the time series properties of model variables. The null hypothesis is that the variable under investigation has a unit root. The choice of lag length was based on Akaike and Schwartz-Bayesian information criteria. Thus, the optimum lag length was 1. The null hypothesis was rejected if the ADF statistic value exceeded the critical value at a chosen level of significance (in absolute term). The results show that all the variables are integrated of order one, I (1) (Appendix 1)

**Long Run Test Results**

Given the unit root properties of the variables, we implemented the Johansen co-integration procedure. This revealed one co-integrating equation at 5% level of significance (see Appendix). This lone equation was accordingly estimated with the result shown below (Table 1)

**Table 1: JOHANSEN COINTEGRATION TEST RESULT**

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>COEFFICIENT</th>
<th>STD ERROR</th>
<th>t STAT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lnelec</td>
<td>-1.032794</td>
<td>0.87877</td>
<td>1.17527</td>
</tr>
<tr>
<td>Iq</td>
<td>0.140658</td>
<td>0.04918</td>
<td>2.86006*</td>
</tr>
<tr>
<td>Lngfcf</td>
<td>1.943043</td>
<td>0.64657</td>
<td>3.00515*</td>
</tr>
<tr>
<td>Lnhcd</td>
<td>0.333856</td>
<td>0.14814</td>
<td>2.25365*</td>
</tr>
<tr>
<td>Lntop</td>
<td>-0.348344</td>
<td>0.44600</td>
<td>0.78104</td>
</tr>
<tr>
<td>Lntgap</td>
<td>1.536471</td>
<td>0.71049</td>
<td>3.04373*</td>
</tr>
<tr>
<td>C</td>
<td>29.31056</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
In equation form, the estimated model can be stated as:

\[ \text{INDP} = 29.3 - 1.03\ln\text{ELEC} + 0.14\text{IQ} + 0.1943\ln\text{GFCF} + 0.333\ln\text{HCD} - 0.348\ln\text{TOP} + 1.536\ln\text{TGAP} \]  

\[(7)\]

**Error correction model** was employed to determine the speed of adjustment between the variables. The error term was found to be significant and negatively signed. Other diagnostic tests appeared satisfactory (Appendix 3)

**Discussion.**

From the result in Table 1 and in equation 7, the estimated model shows that electricity consumption has a negative and insignificant impact on industrial production. This is inconsistent with *a priori* expectation and the findings of other scholars around the world. However, it is a more plausible empirical depiction of the relationship between electricity consumption/supply and industrial output in Nigeria, in that increases in industrial output have not come about through increased electricity supply. Instead public supply has dwindled as industrial output has risen. Increases in output, where such occurred, came about largely through private and off-grid power generation. Therefore, since growth of public supply of electricity (equivalent to consumption of electricity) has remained stagnant and even retrogressed, while in yielding to increasing domestic demand producers have struggled to grow production through off-grid power generation, the relationship between public electricity supply and industrial production is bound to be negative.

Trade openness was also not significant in its effect on industrial output. What effect it had was in the opposite direction to what liberalization theorists posit. However, the finding of this study to the effect that trade openness and industrial production have an inverse relationship appears closer to reality. For one, it has been observed that industrial production in Nigeria has slackened the more trade liberalization and openness got underway. Also, heightened importation of both consumer and industrial goods has been an immediate outcome of liberalization efforts. Ogu et al (2016) find that trade liberalization in fact hurts manufacturing activity in Nigeria. Institutional quality shows a positive and statistically significant effect. This is consistent with expectation and the findings of some researchers. For example, Olarinde and Omojolaibi (2014) examined and found a direct positive relationship between electricity consumption, institutions and economic growth in Nigeria in the period 1980-2011. The positive and significant effect appears to reflect the changing and somewhat improving institutional framework in the country.

**5. Conclusions and Policy Recommendations**

This paper investigated the impact of electricity supply on industrial output in Nigeria between the period 1980 and 2014. The estimated results showed that electricity supply has a negative and insignificant impact on industrial production in Nigeria.

The major recommendation is that, having failed to provide electricity even for the present level of industrial production, government should immediately provide tax relief for all privately generated power for industrial output. Doing so will not erode the gains of petroleum products subsidy removal but will improve the macroeconomy by effectively checking the excessive production cost which hinders industrial progress in Nigeria. It is also necessary for future trade treaties to take into account the actual state of Nigeria’s industrial sector, in order to obviate the increasing platform for products of other economies which our economy is fast becoming while
we ourselves produce and export little. Not much, unfortunately, can be done about the numerous existing bilateral and multilateral treaties which Nigeria has already exuberantly entered into.

References
http://dx.doi.org/10.1108/02632770810865014


Velasquez, J. R. C., & Pichler, B. (2010) China’s increasing economy and the impacts on its


### APPENDIX 1: Unit Root Test Result Summary

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF statistics - Level</th>
<th>Critical values</th>
<th>ADF statistics - 1st difference</th>
<th>Critical values</th>
<th>Lag length</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELEC</td>
<td>-0.158165</td>
<td>1% -3.639407</td>
<td>5% -2.951125</td>
<td>10% -2.614300</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-6.642931</td>
<td>5% -2.954021</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10% -2.615817</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INSQ</td>
<td>-1.90091</td>
<td>1% -3.646342</td>
<td>5% -2.954021</td>
<td>10% -2.615817</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-5.051137</td>
<td>5% -2.954021</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10% -2.615817</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INDP</td>
<td>-2.860618</td>
<td>1% -3.646342</td>
<td>5% -2.954021</td>
<td>10% -2.615817</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-6.554345</td>
<td>5% -2.953710</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10% -2.617434</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCD</td>
<td>-1.170746</td>
<td>1% -3.639407</td>
<td>5% -2.951125</td>
<td>10% -2.614300</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-5.913052</td>
<td>5% -2.954021</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10% -2.615817</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOP</td>
<td>-0.590219</td>
<td>1% -3.639407</td>
<td>5% -2.951125</td>
<td>10% -2.614300</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-6.181733</td>
<td>5% -2.954021</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10% -2.615817</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TGAP</td>
<td>-1.600335</td>
<td>1% -3.639407</td>
<td>5% -2.951125</td>
<td>10% -2.614300</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-5.579299</td>
<td>5% -2.954021</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10% -2.615817</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### APPENDIX 2; CO-INTEGRATION TEST A

Series: LNINDP LNELEC IQ LNGFCF LNHCD LNTOP LNTGAP
Lags interval: 1 to 1

<table>
<thead>
<tr>
<th>Eigenvalue</th>
<th>Likelihood Ratio</th>
<th>5 Percent Critical Value</th>
<th>1 Percent Critical Value</th>
<th>Hypothesized No. of CE(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.767105</td>
<td>141.6641</td>
<td>124.24</td>
<td>133.57</td>
<td>None **</td>
</tr>
<tr>
<td>0.646472</td>
<td>93.57749</td>
<td>94.15</td>
<td>103.18</td>
<td>At most 1</td>
</tr>
<tr>
<td>0.474957</td>
<td>59.26430</td>
<td>68.52</td>
<td>76.07</td>
<td>At most 2</td>
</tr>
<tr>
<td>0.362588</td>
<td>38.00324</td>
<td>47.21</td>
<td>54.46</td>
<td>At most 3</td>
</tr>
<tr>
<td>0.332867</td>
<td>23.14208</td>
<td>29.68</td>
<td>35.65</td>
<td>At most 4</td>
</tr>
<tr>
<td>0.196293</td>
<td>9.784792</td>
<td>15.41</td>
<td>20.04</td>
<td>At most 5</td>
</tr>
<tr>
<td>0.075024</td>
<td>2.573599</td>
<td>3.76</td>
<td>6.65</td>
<td>At most 6</td>
</tr>
</tbody>
</table>
APPENDIX 3: ERROR CORRECTION MODEL
Dependable Variable: DLOG(INDP)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.250936**</td>
<td>0.115037</td>
<td>2.181352</td>
<td>0.0384</td>
</tr>
<tr>
<td>D(ELEC(-2))</td>
<td>5.73E-05**</td>
<td>2.64E-05</td>
<td>1.982145</td>
<td>0.0518</td>
</tr>
<tr>
<td>D(TOP(-1))</td>
<td>0.104286**</td>
<td>0.033260</td>
<td>3.135451</td>
<td>0.0042</td>
</tr>
<tr>
<td>D(TGAP(-2))</td>
<td>0.007064</td>
<td>0.006467</td>
<td>1.092244</td>
<td>0.2847</td>
</tr>
<tr>
<td>INDP (-1)</td>
<td>-3.09E-08*</td>
<td>1.62E-08</td>
<td>-1.905285</td>
<td>0.0679</td>
</tr>
<tr>
<td>F-Statistic</td>
<td>7.904***</td>
<td></td>
<td></td>
<td>0.0001</td>
</tr>
<tr>
<td>ECM (-1)</td>
<td>-2.63E-08**</td>
<td>141E-08</td>
<td>-1.97257</td>
<td>0.0536</td>
</tr>
</tbody>
</table>

$R^2 = 0.603$

**Diagnostic Test:**
- Arch Test = 0.203 (0.655)
- Breusch-Pagan-Godfrey Test=1.8 (0.07)
- Heteroskedasticity Test = 1.8 (0.07)
- B-G L.M Test = 0.001 (0.998)
- Jarque-Bera Test = 3.64 (0.16)

Adjusted $R^2 = 0.527$

D.W. = 1.97

***[**] (*) denotes significant of variable at 1% [5%] (10%) significance level respectively