THE DEMAND FOR RESIDENTIAL ELECTRICITY IN NIGERIA: A BOUND TESTING APPROACH

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Abstract

This paper examines the residential demand for electricity in Nigeria as a function of real gross domestic product per capita, and the price of electricity, the price of substitute and population between 1970 and 2006. We make use of the bounds testing approach to cointegration within an autoregressive distributed framework, suggested by Pesaran et al. [2001. Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics 16(3) 289–326]. In the long run, we find that income, the price of substitute and population emerges as the main determinant of electricity demand in Nigeria, while electricity price is insignificant. The relationship among variables is more stable and significant. The relationship among variables is more stable and significant

Keywords: Residential Electricity, Bound Testing, Cointegration, Nigeria
JEL Classification: Q41, C22.

I Introduction

Despite Nigeria's vast oil wealth, much of the country's citizens do not have access to uninterrupted supplies of electricity. Nigeria has approximately 5,900 megawatts (MW) of installed electric generating capacity. Power outages are frequent and the power sector operates well below its estimated capacity. A fundamental reason offered is the low generating capacity of the Nigerian power sector relative to installed capacity. Consequently, the sector had to undergo some reforms to increase power generation and distribution. Among the reforms is the setting up of the National Electricity Regulatory Commission (NERC), unbundling of PHCN and entry of Independent Power Producers (IPP) among others. These reforms are expected to increase power generation and distribution and also residential electricity demand in Nigeria.

Although much explanation has been offered on the supply of electricity in Nigeria quite a little is know about the fundamentals of residential electricity demand. The quest for more accurate estimates of key electricity demand parameters as short and long run price and income elasticities derives from two factors. First is their critical importance in the projection of future electricity demand. Second is the fact that understanding electricity demand dynamics through improved and more robust estimates of electricity demand parameters is

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essential for more informed and successful electricity policy decision making and implementation. Often times and for various reasons, unduly strong assumptions have been made in the estimation of these elasticities in many developing countries. The implications of these strong assumptions are hardly alluded to in drawing conclusions from the estimated results. In many cases, the estimated models are likely to have produced spurious parameter results. Obviously, policies based on such parameters are more likely to result in wrong policy actions. Consequently, the major objective of this paper is to develop and test an econometric model to identify the main economic fundamentals that influence the behavior of electricity consumption in Nigeria. To the best of our knowledge, this study is the first to empirically analyze the residential electricity demand for Nigeria.

The empirical analysis is for the period 1972–2006, employing annual data. The choice of this period is due to the availability of data. Income and price sensitivity of both the long- and the short-run demand for electricity are examined. Our study makes a methodological contribution to the literature on electricity demand. We use the bounds testing approach to cointegration, developed by Pesaran et al. (2001), within an autoregressive distributed lag (ARDL) framework, to test for a long-run level relationship in the demand for residential electricity. The sequence of the study is clear. Section one presents a brief introduction while section two presents stylized facts on electricity generation, distribution and consumption in Nigeria. Section three provides a brief overview of the literature while Section four explains the bounds testing approach to cointegration. The empirical results are presented in Section five. Section six summarizes the main findings of the paper and gives their policy implications.

II Electricity Generation in Nigeria: Stylized Facts

The Nigerian economy is heavily dependent on energy. Electricity is used for a number of purposes that include industrial, commercial and household purposes. Electricity generation in Nigeria began in 1896, fifteen years after its introduction in England. The Nigeria Electricity Supply Company (NESCO) commenced operations as an electric utility company in Nigeria in 1929 with the construction of a hydroelectric power station at Kurra near Jos. The Electricity Corporation of Nigeria (ECN) was established in 1951, while the first 132KV line was constructed in 1962, linking Ijora Power Station to Ibadan Power Station. The Niger Dams Authority (NDA) was established in 1962 with a mandate to develop the hydropower potentials of the country. However, ECN and NDA were merged in

1972 to form the National Electric Power Authority (NEPA). The law which established the National Electric Power Authority (NEPA) in 1972 stipulated that it should develop and maintain an efficient, co-ordinated and economical system of electricity supply for all parts of Nigeria. At the inception of NEPA in 1973, only five of the then 19 state capitals were connected to the national transmission grid system. Today, practically all state capitals are being served from the national grid, although haphazardly.

In 1988, the National Electric Power Authority (NEPA) was partially commercialized, supported by an upward review in tariffs. As part of the restructuring effort of the power sector, the Electric Power Sector Reform Act 2005 was enacted. Consequently, the defunct National Electric Power Authority (NEPA) is now known as Power Holding Company of Nigeria (PHCN). The law paved the way for the unbundling of NEPA into the 18 companies – 6 generating companies, 1 transmission company and 11 distributing companies. The generating companies are made up of 2 hydro and 4 thermal (gas based) stations.

The Nigerian power sector is marked by low generating capacity relative to installed capacity and much of the country's citizens do not have access to uninterrupted supplies of electricity. At present electricity generation ranges from between 2,500 megawatts to about 3,000 (see Figure 1), even with the inclusion of three gas-powered independent power projects in the Niger Delta region, while estimated national consumption is in excess of 10,000 megawatts. Potential demand in the next few years is estimated at about 15,000 megawatts. This is despite the fact that Nigeria is endowed with massive reserves of hydro energy, petroleum reserves and one of the largest gas reserve. Government policy for the sector during the 1980s and the 1990s and until recently did not properly anticipate national needs. For example, the last major electric generation installation in Nigeria was in 1990 when the Shiroro power station was commissioned. Since then no new units have come on stream and none of the existing ones have had a major overhaul for 15 years. The Kainji Hydro electric plant in operation since 1968, for instance, was designed to generate 960mw of power out of its 12 turbines, but only 10 of those turbines have been installed. Today the Kainji plant can only generate 760mw of power. The per capita consumption of electricity is 0.054kw; only about 5% of our hydro electric capacity has been developed.

As at 2005, Nigeria has approximately 6,861 megawatts (MW) of installed electric generating capacity. As shown in Figure 1, a wide gap between the installed capacity and total electricity generation capacity started emerging in 1978. Thus, making power outages to be frequent and the power sector operates well below its estimated capacity. Low water levels at Kanji, Jebba, and Shiroro hydropower stations are frequently claimed to be responsible for the frequent power shortages, while the Lagos, Egbin, Delta, and Port Harcourt Afam plants are also operating at below capacity due to poor maintenance.

In 2005, the Power Sector Reform Bill was signed into law thus enabling private companies to participate in electricity generation, transmission, and distribution. Previously, the state-owned Power Holding Company PLC dominated the power sector. The government has separated NEPA into eleven distribution firms, six generating companies, and a transmission company, all of which will be privatized. Several problems, including union opposition, have delayed the privatization. In February 2005, the World Bank agreed to provide NEPA with $100 million to assist in it privatization efforts. Only 40 percent of the population has electricity, the majority of whom are concentrated in urban areas it is estimated that an additional 10,000 MW in capacity is required to meet current demand. Despite endemic blackouts, customers are billed for services rendered, partially explaining Nigeria's widespread vandalism and power theft and NEPA's problems with payment collection. Figure 2 below shows the categories of electricity consumption figures between 1970 and 2005. From the table, the proportion of electricity used for industrial purposes has been on the decrease since 1970 while residential consumption has been on the increase. This is easily explained by the epileptic power supply that has forced many of the big industry to generate more of their own power and using less power from the national grid.

Figure 1: Electricity Generation in Nigeria, 1970 -2005

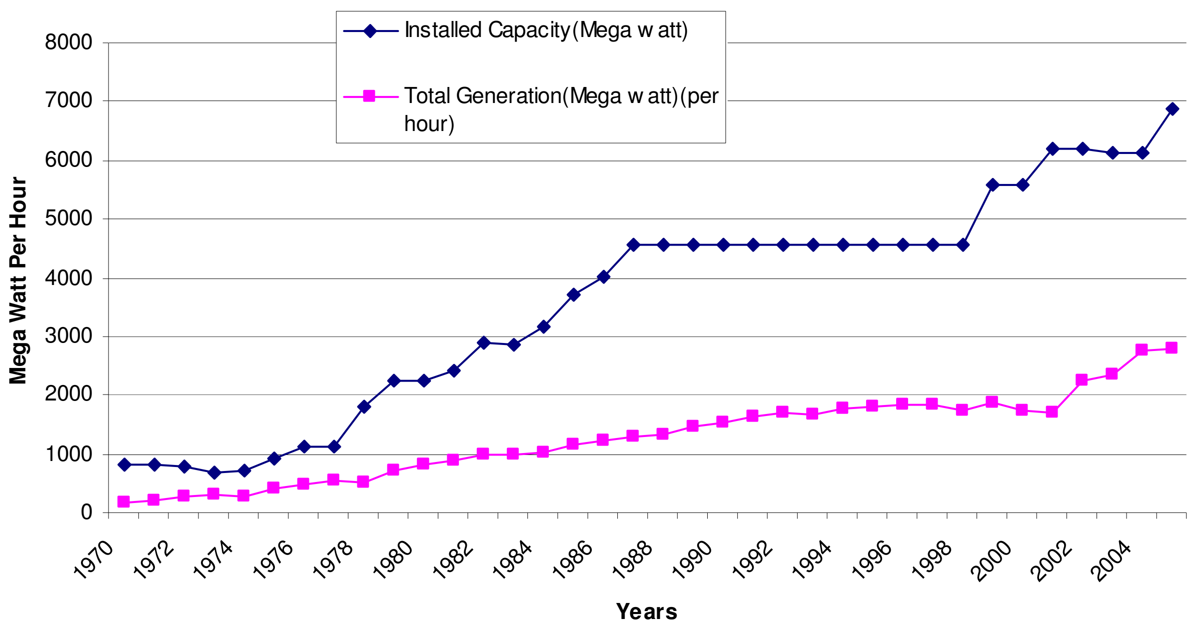
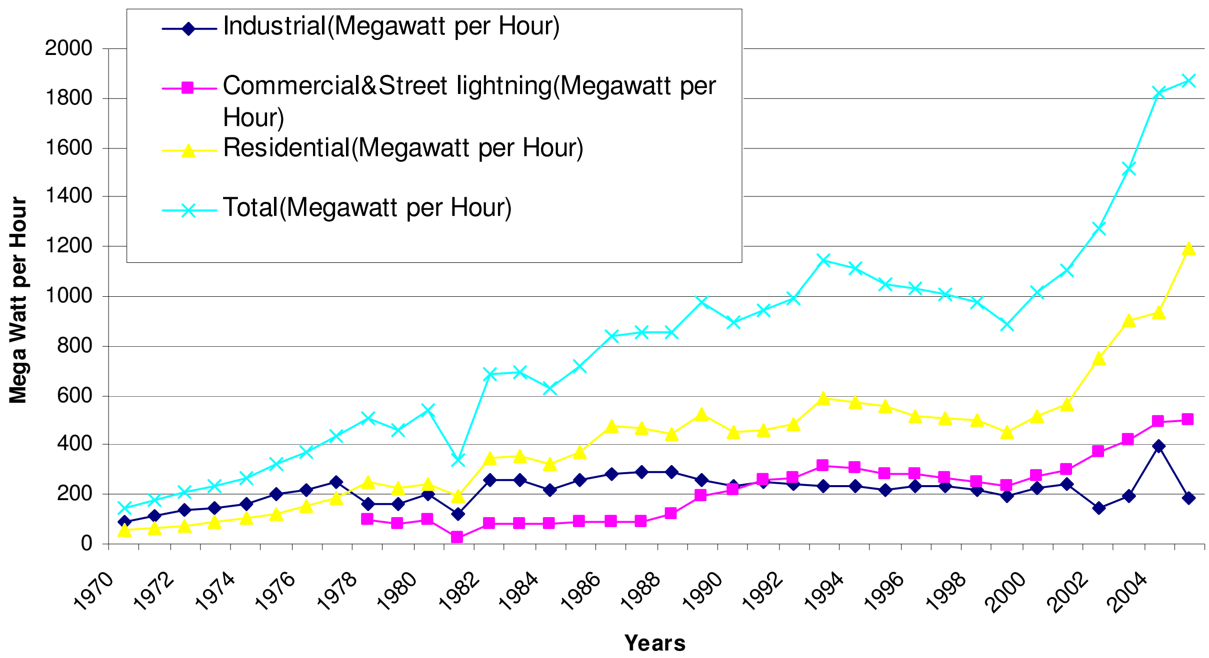


Figure 2: Electricity Consumption in Nigeria, 1970 to 2005



The Nigerian government has made an effort to increase foreign participation in the electric power sector by commissioning independent power producers (IPPs) to generate electricity and sell it to PHCN, soliciting investors for the construction of new independent power plants (IPPs). IPPs currently under construction include the 276-MW Siemens station in Afam, Agip's 450-MW plant in Kwale, ExxonMobil's 388-MW plant in Bonny, ABB's450-MW plant in Abuja, and Eskom's 388-MW plant in Enugu. Several state governments have also commissioned oil majors to increase generation including Rivers State, which contracted Shell to expand the 700-MW Afam station. The Nigerian government has approved the construction of four thermal power plants with a combined capacity of 1,234 MW to meet its generating goal of 6,500 MW by 2006: Geregu, Alaoji, Papalanto, and Omotosho. Fourteen hydroelectric and natural gas plants are planned for completion by 2010. In July 2004, Nigeria signed an MOU to secure funding for supplying power to Benin, Burkina Faso, and Niger with electricity through a new transmission line based on the New Partnership for Africa's Development (NEPAD).

III Review of Related Studies

Most of the studies on determinants of residential electricity demand functions have focused on developed countries. There are studies for Canada (Bernard et al., 1996); the United States (Houthakker et al., 1974; Houthakker, 1980; Hsing, 1994; Silk and Joust, 1997); Mexico (Chang and Martinez-Combo, 2003) and the United Kingdom (Dodgson et al., 1990; Henley and Peirson, 1999; Clements and Madlener, 1999). For Asia–Pacific countries, such as Australia, India and Taiwan (Narayan and Smyth, 2005; Filippini and Pachauri, 2004; Holtedahl and Joutz, 2005); European countries, such as Greece, Norway, Cyprus and Switzerland (Donatos and Mergos, 1991; Ettestol, 2002; Zachariadis and Pashourtidou, 2006; Filippini, 1999); in G7 countries (Narayan et al., 2007) and countries in the Middle East (Al-Faris, 2002; Beenstock et al., 1999; Eltony and Hosque, 1996; Nasr et al., 2000). There is a paucity of research on energy demand in developing countries and only a few of the studies accounted for the time-series properties of the response of energy consumption to changes in income and relevant prices.

There is a glaring gap in Sub-Saharan Africa (except for Ziramba (2008) for South Africa and De Vita et al (2005) for Namibia despite the importance of improved and more robust estimates of electricity demand parameters in better electricity policy decision making and implementation. The central role of the residential demand for electricity in the Nigeria economy, the controversies about appropriate pricing and the twin issue of IPPs coupled with the inadequate supply of electricity in the country strongly suggest that more accurate estimates of these elasticities are of paramount policy importance.

A diversity of approaches to the estimation of electricity demand can be found in the literature ranging from aggregative analysis of the relationship between electricity demand, income and prices (Narayan et al., 2007; Lin, 2003, Holtedahl and Joutz, 2005), to more detailed disaggregated analysis (Bose and Shukla, 1999;) based on simultaneous model structure. In the most basic model, the demand for electricity, has been modeled as a function of a single variable, such as real income (Dincer and Dost, 1997) or temperature (Al-Zayer and Al-Ibrahim, 1996); real income and prices (Houthakker, et al., 1974; Zachariadis and Pashourtidou, 2006, Ziramba 2008) real income, residential electricity price and price of natural gas (Narayan et al., 2007); real income, electricity prices, population growth, structural changes in the economy and efficiency improvement (Lin, 2003); population, income, price of electricity, price of oil, urbanization, weather (Holtedahl and Joutz, 2005); real income, price of electricity and diesel (used in for captive power generation to meet the shortages), and reliability of power supply from utilities (Bose and Shukla 1999); real income, the real price of electricity, and the variable that captures the seasonal component of the demand for electricity (Chang and Martinez-Combo, 2003).

These set of studies examined the residential demand for electricity in the context of household production theory. If unconstrained by data limitations, studies of the empirical model of the residential demand for electricity are based on household production theory which can be expressed as a function of own price, price of a substitute source of energy, real income, price of household appliances and other factors that may influence household preferences, such as temperature. In practice, most existing studies have not been able to get data on all these potential explanatory variables. We therefore include price of electricity population, price of substitute and real income as determinants of the residential demand for electricity in Nigeria.

Narayan and Smyth (2005) analyzed the residential demand for electricity in Australia. They estimated two models of the residential demand for electricity. Both models include income and temperature variables, but differ in their representation of the price variable. In the first model, in addition to the income and temperature variables, the prices of electricity and natural gas (a substitute source of energy) are introduced as separate variables. In the second model the specification of the price takes the relative price format. In the long run, they found that income and own prices are the most important determinants of residential electricity demand, while temperature is significant some of the time and gas prices are insignificant. In addition, the short-run elasticities are much smaller than the long-run elasticities, and the coefficients on the error-correction coefficients are small consistent with the fact that in the short-run energy appliances are fixed. Similarly, in a study of residential demand for electricity in a panel of G7 countries, Narayan et al. (2007) use similar model specifications.

Our model takes the following form:

$$lnEC = \alpha_0 + \alpha_1 lnY + \alpha_2 EP + \alpha_3 PK + \alpha_4 lnPG + \varepsilon \qquad (1)$$

where lnE is the natural log of the per capita residential EC (kWh per capita), ln Y is the natural log of real per capita income; EP is the real residential electricity price (kobo/kWh); PK is the real pump price of kerosene; and ln PG is the natural log or population and ε is a random error, which is assumed to be white noise and normally and identically distributed. The nominal prices are deflated by the consumer price index.

Income is considered to be the most important determinant for electricity consumption in the literature. Economic growth and its impact on living standards is the main driving force of electricity consumption growth. Therefore, higher real per capita income will increase purchases of electrical equipment and hence increase electricity demand. Nevertheless, an increase in the price of residential electricity will cause the residential electricity demand to decrease. Population is another important factor to determine electricity demand in Nigeria. Higher population level is expected to increase electricity consumption. A positive correlation between population growth and electricity demand is therefore expected.

Economic theory suggests that electricity purchases will depend on the prices of substitutes: natural gas and petroleum products. However, the independent influences of diesel and gasoline prices may be rather small because a sizeable number of people in Nigeria do not have access to a power generating set to generate electricity when there is power outage. In our view, natural gas is not also appropriate in the case of Taiwan, since its consumption is concentrated on the urban rich and can be said to be comparatively small. Thus, we make use of price of kerosene as our measure of alternative prices. This is because kerosene is used for cooking (alternative for electric cooker) and lightning in the absence of power supply. Because kerosene is a substitute for electricity, an increase in the price of kerosene is expected to generate an increase in the consumption of electricity. Thus, we expect α_1, α_3, α_4 are expected to be positive and α_2 is expected to be negative.

IV. The Bound Testing Approach and Data Sources

Pesaran *et al*. (2001) developed a new Auto-Regressive Distributed Lag (ARDL) bounds testing approach for testing the existence of a cointegration relationship. The bound testing approach has certain econometric advantages in comparison to other single cointegration procedures (Engle and Granger, 1987; Johansen, 1988; Johansen and Juselius, 1990). Firstly, endogeneity problems and inability to test hypotheses on the estimated coefficients in the long-run associated with the Engle-Granger (1987) method are avoided. Secondly, the long and short-run parameters of the model in question are estimated simultaneously. Thirdly, the econometric methodology is relieved of the burden of establishing the order of integration amongst the variables and of pre-testing for unit roots. The ARDL approach to testing for the existence of a long-run relationship between the variables in levels is applicable irrespective of whether the underlying regressors are purely $I(0)$, purely $I(1)$, or fractionally integrated. Finally, as argued in Narayan (2005), the small sample properties of the bounds testing approach are far superior to that of multivariate cointegration (Halicioglu, 2007). The approach, therefore, modifies the Auto-Regressive Distributed Lag (ARDL) framework while overcoming the inadequacies associated with the presence of a mixture of $I(0)$ and $I(1)$ regressors in a Johansen-type framework. A priori we expect electricity to be significantly influenced by income and price.

The ARDL representation of electricity consumption, real income and electricity price, can be constructed as:

$$\Delta LEC_t = \alpha_0 + \sum_{i=1}^{Q} \alpha_{1i} \Delta EC_{t-i} + \sum_{i=0}^{Q} \alpha_{2i} \Delta LY_{t-i} + \sum_{i=0}^{Q} \alpha_{3i} \Delta EP_{t-i} + \sum_{i=0}^{Q} \alpha_{4i} \Delta PK_{t-i}$$
$$+ \sum_{i=0}^{Q} \alpha_{5i} \Delta PP_{t-i} + \alpha_6 LY_{t-1} + \alpha_7 EP_{t-1} + \alpha_8 PK_{t-1} + \alpha_9 PK_{t-1} + \mu_t \quad (2)$$

where the variables are defined in equation (1). The procedure of the bounds testing approach is based on the F or Wald-statistics and is the first stage of the ARDL cointegration method. The null hypothesis is tested by considering the UECM in equation (2) while excluding the lagged variables $\Delta LEC_t, \Delta LY_t, \Delta EP_t, \Delta PK_t, \Delta PP_t$, based on the Wald or F-statistic. The asymptotic distribution of the F-statistic is non-standard under the null hypothesis of no cointegration relationship between the examined variables, without recourse to whether the underlying explanatory variables are purely I(0) or I(1). The null hypothesis of no cointegration ($H_0 : \alpha_6 = \alpha_7 = \alpha_8 = \alpha_9 = 0$) is therefore tested against the alternative hypothesis ($H_1 : \alpha_6 \neq 0, \alpha_7 \neq 0, \alpha_8 \neq 0, \alpha_9 \neq 0$).Thus, Pesaran *et al.* (2001) compute two sets of critical values for a given significance level. One set assumes that all variables are *I*(0) and the other set assumes they are all *I*(1). If the computed F-statistic exceeds the upper critical bounds value, then the H_0 is rejected. If the F-statistic is below the lower critical bounds value, it implies no cointegration. Lastly, if the F-statistic falls into the bounds then the test becomes inconclusive. Consequently, the order of integration for the underlying explanatory variables must be known before any conclusion can be drawn.

However, the critical values of Pesaran et al (2001) are generated on sample sizes of 500 and 1000 observations and 20 000 and 40 000 replications, respectively. Narayan and Narayan (2005) argue that such critical values cannot be used for small sample sizes like the one in this study. Given the relatively small sample size in the present study (27 observations), we extract the appropriate critical values from Narayan (2005) which were generated for small sample sizes of between 30 and 80 observations. Data on electricity consumption KW per capita, the real GDP per capita, population were sourced from the World Bank World Development Indicator 2008 edition. The data on electricity prices was sourced from FGN (2006) "25 Years Power Projection Plan for Nigeria". *Report Prepared by the Presidential Committee on Electricity Requirement for Making Nigeria an Industrializing Country by the Year 2030, 2006 December.* The data series ends at 2001. The electricity prices data was then updated with statistics from the Nigerian Regulatory Electricity Commission. The data on kerosene (DPK) was updated with data from the Nigerian National Petroleum Corporation (NNPC).

V. Empirical Results

In the first step of the ARDL analysis, we tested for the presence of long-run relationships in equation (1). The maximum number of lags in the ARDL was set equal to 2 since we use annual data. The calculated F statistics together with the critical values are reported in Table 1. The results of the bounds F test in Table 1 imply that at 10% level, the null hypothesis of no cointegration among the variables in equation (1) cannot be accepted. Having found a long-run relationship between electricity consumption, national income, electricity price, price of kerosene and population, we then estimate the long-run elasticities.

We investigate the impact of national income, electricity prices, price of kerosene and population on the consumption of electricity. In the ARDL estimation, a maximum of 2 lag was used (i_{max} = 2). The estimated model is based on minimizing the Schwartz Bayesian Criterion. The empirical results for the model, obtained through normalizing on the log of per capita electricity consumption (LEC) in the long run are reported in Table 2. The empirical results for the model in the short run, together with standard diagnostic tests are presented in Tables 3. The error term ECM_{t-1} in the short-run UECM is statistically significant with a negative sign in the short-run model, which confirms that a long-run equilibrium relationship exists between the variables. The error correction term is -0.525 which indicates that 52% of the previous year's deviation from long-run equilibrium will be restored within one year. The short-run models pass all the standard diagnostic tests for autocorrelation, functional form, normality and heteroskedasticity.

Table 1: Bounds Testing for Cointegration Analysis

Panel A

	Unrestricted intercept and no trend F-test Statistic
F_{EC}(EC/LY, EP,PK, PP)	5.0792*

Panel B

	1%		5%		10%	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
	5.604	7.172	4.036	5.304	3.374	4.512

Notes: *** Statistical significance at 1% level; ** Statistical significance at 5% level; * Statistical significance at 10% level. The lag length k=2 was selected based on the Schwarz criterion (SC). Critical values are obtained from Narayan (2005) for 35 observations. The number of regressors is 4.

Table 2: Estimated Long Run Coefficients using the ARDL Approach. ARDL (1, 0, 0, 0) selected based on Schwarz Bayesian Criterion, 1970-2006.

Explanatory Variables	Dependent Variable is LY
Constant	-5.9852* (-1.6786)
LY	0.1925* (1.8850)
EP	0.0577 (0.1849)
PK	-0.2282* (-1.5626)
LPP	0.9404*** (3.3168)

Notes: *** Statistical significance at 1% level; ** Statistical significance at 5% level; * Statistical significance at 10% level; Figures in parenthesis are t-ratios.

Table 3: Error Correction Representation for the Selected ARDL Model ARDL(1,0,0,0) selected based on Schwarz Bayesian Criterion

Explanatory Variables	Dependent Variable is LY
ΔLY	0.1010* (1.9050)
ΔEP	0.03030 (0.1846)
ΔPK	-0.1198* (-1.7241)
ΔLPP	0.4937** (2.3014)
ΔC	-3.1424* (-1.7592)
ECM(-1)	-0.5250*** (-3.3699)
Diagnostic Statistics	
R-Square	0. 766
Adjusted R-Square	0. 722
$\chi^2_{Auto}(1)$	3.0971
$\chi^2_{Norm}(2)$	0.2153
$\chi^2_{Hetero}(1)$	3.6820
$\chi^2_{RESET}(1)$	0.7097

Notes: 1.*indicates that a coefficient is significant at the 1 percent level; **indicates that a coefficient is significant at the 5 percent level; ***indicates that a coefficient is significant at the 10 percent level. 2. Figures in parenthesis ( ) are t-ratios.

Income Elasticity of demand

Expectedly the income elasticity of demand has a positive sign and is statistically significant in the long run. Electricity consumption is income elastic in Nigeria. The income variable is statistically significant at 10 per cent level of significance. The long-run elasticity is 0.19 in the ARDL model while it is 0.10 in the short run. As expected, the long-run income elasticity is larger than the short-run one. The results indicate that residential EC is a normal good as it increases with income. Our estimate of the long-run price elasticity of residential demand is at the lower and upper end of the range of estimates found in some of the previous studies for other countries. For example, Filippini (1999) and Ziramba (2008) found that the income elasticity of residential electricity demand for Switzerland and South Africa to be 0.33 and 0.31 respectively. In addition, De Vita et al., (2006) and Pesaran et al (1998) reported an elasticity of 0.41 and 1.252 for Namibia and Bangladesh respectively. Nevertheless, Yoo et al (2007) reported an income elasticity of 0.0593 for Seoul Korea. The short-run income elasticity is 0.30 and is also statistically significant at the 5% level. These results suggest that income policies will have stronger effects on residential electricity consumption over time.

Own price and Cross Price Elasticity

The consumption of electricity in Nigeria is own price and cross price inelastic. Contrary to the a-priori expectation, the own price elasticity is positive in the short and the long run. The long-run own price elasticity is 0.057, while the short-run value is 0.030. The explanation for the result is not far-fetched. The price of electricity has long been regulated in Nigeria. The price of electricity is usually fixed by the government and reviewed infrequently. Also, the inadequate supply of electricity in Nigeria could be responsible for the positive coefficient. In addition contrary to the expected result, the cross price elasticity is negative and significant. The cross-price long run and short run elasticities are -0.228 and -0.119. This implies that kerosene is a complementary good with electricity rather than being a substitute good. An increase in the price of kerosene was expected to generate an increase in the consumption of electricity, however the reverse was found to be the case. Electricity is usually not available in Nigeria and most households usually make use of kerosene for cooking and lightning due to the unreliable nature of electricity irrespective of whether there is a price increase or not.

Population

The population variable is significant in the short run and the long run. The long run population elasticity is 0.9404 while the short run population elasticity is 0.4937. This means that the higher the population the higher the demand for electricity in Nigeria. This result is consistent with Lin (2003) who found population to play an important role in increasing electricity demand in the Peoples Republic of China.

Constancy of Cointegration Space

Following Narayan and Smyth (2005), we used Pesaran and Pesaran (1997) to test for parameter stability. According to Pesaran and Pesaran (1997), short-run dynamics are essential for testing the stability of the long-run coefficients. The Pesaran and Pesaran (1997) test involves estimating the following error correction model:

$$\Delta LY_{t=}\beta_0+\sum_{i=1}^{n}\beta_{1i}\Delta LY_{t-i}+\sum_{i=1}^{n}\beta_{2i}\Delta LE_{t-i}+\sum_{i=1}^{n}\beta_{3i}\Delta LK_{t-i}+\beta_{4i}\Delta LF_{t-i}+\lambda ECM_{t-1}+\varepsilon_t$$

In this case, all variables are as previously defined and the error-correction term is calculated from the long-run cointegrating vector. Once the models have been estimated, Pesaran and Pesaran (1997) suggest applying the cumulative sum of recursive residuals (CUSUM) and the CUSUM of square (CUSUMSQ) tests to assess the parameter constancy. After estimating the model the cumulative sum of recursive residuals (CUSUM) and the CUSUM of squares (CUSUMSQ) tests were applied to test for parameter constancy. Figures 1 and 2 plot the CUSUM and CUSUM of squares statistics for Equation (4). The results clearly indicate the absence of any instability of the coefficients because the plot of the CUSUM and CUSUMSQ statistics is confined within the 5% critical bounds of parameter stability.

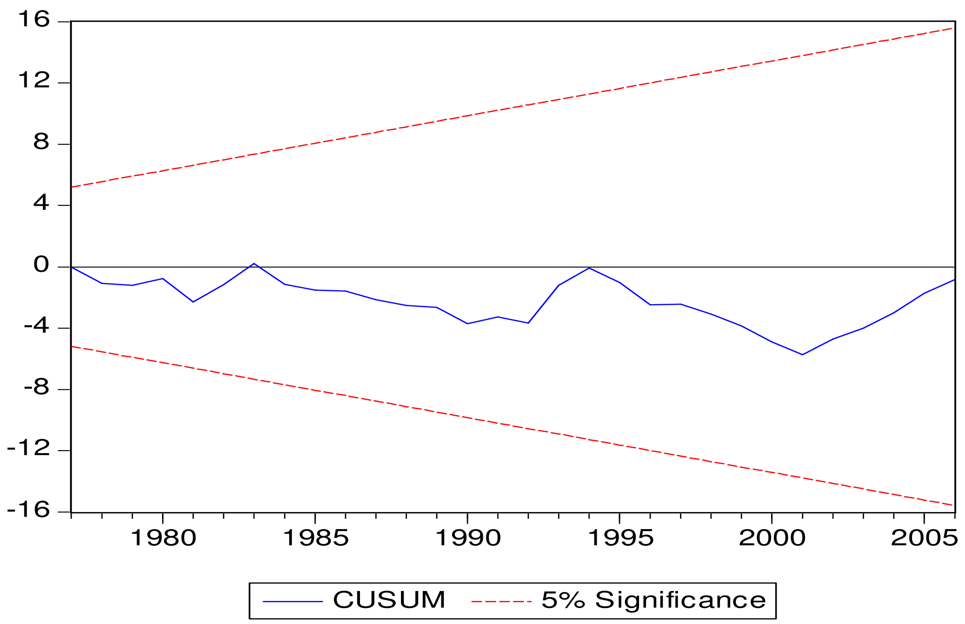


Figure 2: CUSUM Plots for Stability Tests

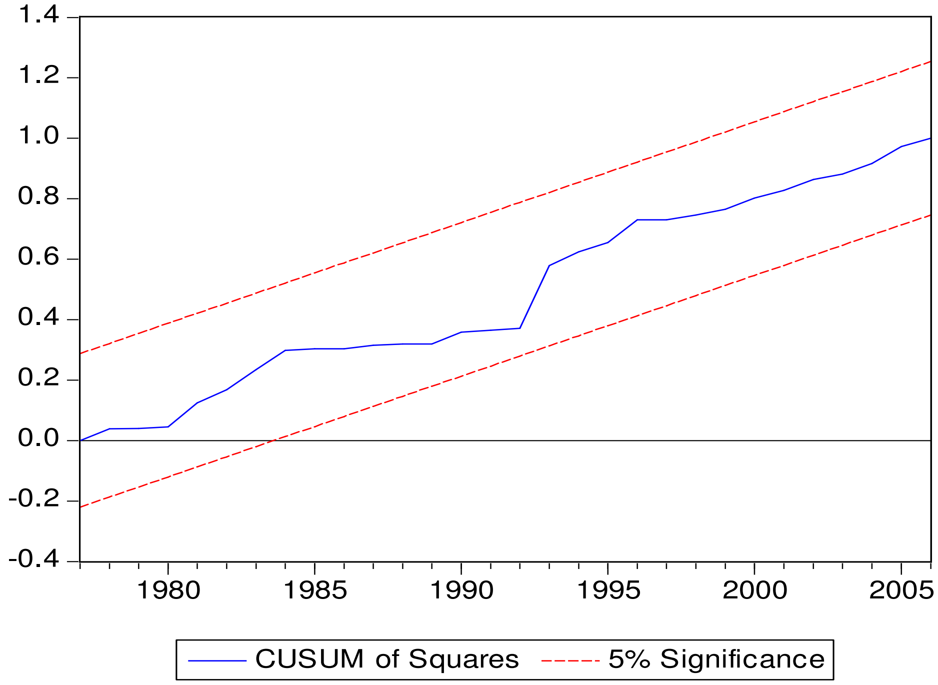


Figure 3: CUSUM of Squares Plots for Stability Tests

VI Concluding Summary

The paper examined the residential demand for electricity in Nigeria, employing annual data over the period 1970–2006. To best of our knowledge, this study is the first to analyze the residential electricity demand for Nigeria. Bounds testing approach to cointegration analysis was applied to estimate residential electricity demand and to examine the issues of stability of both long- run and short-run residential demand for electricity. The bounds testing approach has shown to provide robust results in finite sample sizes just like in the present study (Narayan and Smyth, 2005).

The income elasticity of demand has a positive sign as is expected and is statistically significant in the short run and in the long run. This result indicates that residential electricity consumption is a normal good as it increases with income. The own and cross price elasticities did not have the expected negative and positive sign. While the cross price elasticity was found to be significant, the own price elasticity was found to be statistically insignificant. In addition, population was found to be an important determinant of electricity consumption in Nigeria. The stability tests performed demonstrate that the long-run residential demand for electricity in Nigeria remained stable throughout the estimation period.

Electricity demand studies have important practical implications. The results indicate that the estimated residential demand for electricity can be used for policy purposes since it is stable. The finding that a stable aggregate residential electricity demand function seems to exist would make forecasting of electricity need at the national level possible. The estimated price and income elasticities of 0.192 and 0.057 imply that residential electricity demand in Nigeria is price and income inelastic. It shows that income, population and the price of substitute will influence residential electricity consumption in Nigeria. In addition, it shows that increase in residential electricity price does not induce a significant increase in residential electricity demand. Such useful information is expected to help policy-makers in supplying residential electricity in Nigeria.

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