Original Research Article

Estimating Natural Gas Demand Elasticities in Nigeria

ABSTRACT

This study estimated natural gas demand elasticities in Nigeria. The objective of the study was to examine the responsiveness of natural gas demand to changes in price of natural gas, income and prices of other energy products. The study adopted the bound testing approach to cointegration within the framework of ARDL to estimate annual time series data over a period of 33 years (1984 – 2016). The findings of this research showed that the elasticity of natural gas demand is relatively price inelastic in both short and long run; cross-price elasticity of gas demand revealed that AGO and LNG are substitute energy products for natural gas in Nigeria; while the estimate of income elasticity of demand is not statistically significant in the short and long run.

Keywords: Natural gas demand, elasticity, power supply, gas price, autoregressive distributed lag model, bound test, Nigeria

Word Count:125

List of Abbreviations

ARDL – Autoregressive Distributed Lag
AGO – Automotive Gas Oil
LNG – Liquefied Natural Gas
ARIMA – Autoregressive Integrated Moving Average
PAM – Partial Adjustment Model
OLS – Ordinary Least Square
VAR – Vector Autoregression
UEDT - Underlying Energy Demand Trend
STSM - Structural Time Series Model
WAGP - West Africa Gas Pipeline
NNPC – Nigeria National Petroleum Corporation
EPCL – Eleme Petrochemical Limited
LPG – Liquefied Petroleum Gas

NGL – Natural Gas Liquid
Bcm – Billion Cubic Metre
Bscf – Billion Standard Cubic Feet
NLNG – Nigeria Liquefied Natural Gas
MMSCF/D – Million Standard Cubic Feet Per Day
MSCF – Thousand Standard Cubic Feet
MMBTU – Million British Thermal Unit
BP – British Petroleum
₦ – Nigerian Naira
BN – Billion
UECM - Unrestricted Error Correction Model
kWh – Kilowatt Hour
ADF - Augmented Dickey-Fuller
CUSUM – Cumulative Sum of Recursive Residuals
CUSUMQ – Cumulative Sum of Squares of Residuals

1. Background of the Study

Natural gas is an important energy resource that is crucial to the growth and development of every economy. Due to its growing demand, the issue of natural gas demand elasticities has been in the front line in recent times. Numerous studies have been conducted by researchers on natural gas demand and several methodologies have been adopted to estimate natural gas demand elasticities in different countries of the world. For example, Khan and Ahmed [1] estimated natural gas demand in Pakistan and adopted the Johansen (1988) and Johansen and Juselius (1990) cointegration techniques to estimate annual time series data from 1972-2007. The income elasticity of natural gas demand suggests that natural gas is a luxury good in Pakistan.

Erdogdu [2] examined natural gas demand in Turkey using the ARIMA model, PAM and OLS estimation techniques. The study found that price elasticity of natural gas demand is perfectly inelastic, while natural gas is a luxury good in the long run; and there is no relationship between natural gas demand and price and income in the short run. Similarly, Göncü *et al.* [3] proposed a framework to forecast future daily residential and commercial natural gas consumption in Turkey. The study employed OLS estimation technique to estimate a formulated demand model. The study concluded that natural gas prices in Turkey have little or no explanatory power on changes in natural gas demand because the price of gas is highly regulated.

Arora [4] estimated price elasticities of natural gas demand and supply in the United States for three different time periods comprising weekly, monthly and quarterly time series data from 1993 to 2013. The study adopted VAR model in estimating price elasticity of natural gas demand in the US. The result of the monthly and quarterly analysis shows that natural gas demand is price inelastic in both short and long run. However, when shale gas was added to the model, the quantity of natural gas demand became less responsive to price in the short and long run.

Wadud *et al.* [5] conducted a study on modeling and forecasting natural gas demand in Bangladesh using the PAM and OLS estimation techniques to estimate annual time series data spanning 1981-2008. The study revealed that natural gas in Bangladesh is a necessity good in the short run, while it is a luxury good in the long run. However, the result of price elasticity of natural gas demand is statistically insignificant in both short and long run. Burke and Yang [6] examined the elasticities of natural gas demand in 44 countries using three estimators to estimate panel data, which are: between estimator, pooled OLS and fixed-effects estimators. The result of the analysis shows that natural gas demand in the 44 countries is price inelastic for pooled OLS and fixed-effect estimator, while price elasticity of demand is perfectly inelastic in the between estimator in the long run. Further, between estimators and pooled OLS revealed that natural gas is a luxury good in these countries, while the outcome of the field-effect estimator suggests that natural gas is a necessity good.

Some studies have also been conducted on natural gas demand elasticities in Africa. For example, the study conducted by Ackah [7] on the determinants of natural gas demand in Ghana, examined the effect of economic and non-economic factors affecting demand using the UEDT within the framework of STSM to estimate annual time series data spanning 1989 – 2009. The study discovered that residential gas demand in Ghana is price inelastic in the short run, while it is perfectly inelastic in the long run. Income elasticity of demand reveals that natural gas is a necessity good in the short run, but a luxury good in the long run. In the same vein, Abdullahi [8] modeled petroleum products [LPG and others] demand in Nigeria using the UEDT within the framework of STSM and ARDL model. The outcome of the study revealed that LPG demand is price inelastic, while the result of income elasticity of demand shows that natural gas is a necessity good in Nigeria in the long run. However, the price of LPG and income do not have significant relationships with LPG demand in Nigeria in the short run.

Despite adopting several methodologies for estimating natural gas demand elasticities, none of the studies has adopted bound testing approach to cointegration within the framework of ARDL in estimating natural gas demand elasticities in Nigeria. In other words, there has been no study that has adopted the ARDL approach to estimate natural gas demand elasticities in Nigeria. This study aims to fill this gap that exists in literature. Thus, the objective of this study, is to estimate the short-run and long-run price, income and cross price elasticities of natural gas demand in Nigeria. The outcome of this study will serve as a framework for policy formulation for inducing investments in gas utilization projects.

The remaining part of this study is divided into four sections. Section 2 examines natural gas utilization and the Nigerian economy, while section 3 contains the theoretical framework and methodology adopted in this study. Presentation and discussion of results are carried out in section 4, while the conclusion and recommendations are expressed in section 5.

2. Natural Gas Utilization and the Nigerian Economy

Natural gas is an important energy resource to the Nigerian economy. The energy source generates huge revenue as well as serves as the major source of energy in Nigeria's energy mix. This section discusses the importance of natural gas to Nigeria and also examines the dynamics of natural gas demand in the economy.

2.1 Natural Gas Utilization in Nigeria

Nigeria is estimated to have the largest proven natural gas reserves in Africa and the 9th largest in the world; having an estimated proven gas reserve of 5,627bcm, which is 37% of the total gas reserves in Africa [9].There are several gas utilization projects in Nigeria. These projects utilize natural gas for power generation, process operations, as feedstock and for export purposes.

The country exports pipeline gas to some West African countries (Benin Republic, Togo and Ghana) through the WAGP and also exports LNG to Asia Pacific, North America (Mexico), South and Central America, Europe and the Middle East [10]. The total export of LNG from Nigeria in 2015 was 25.3bcm, which represents 7.59 percent of the total LNG traded globally; however, it increased to 27.76bcm in 2017 [10]. This rank the country as the 4th largest exporter of LNG in the world. The breakdown of natural gas demand by each of the gas utilization projects is shown in figure 1.

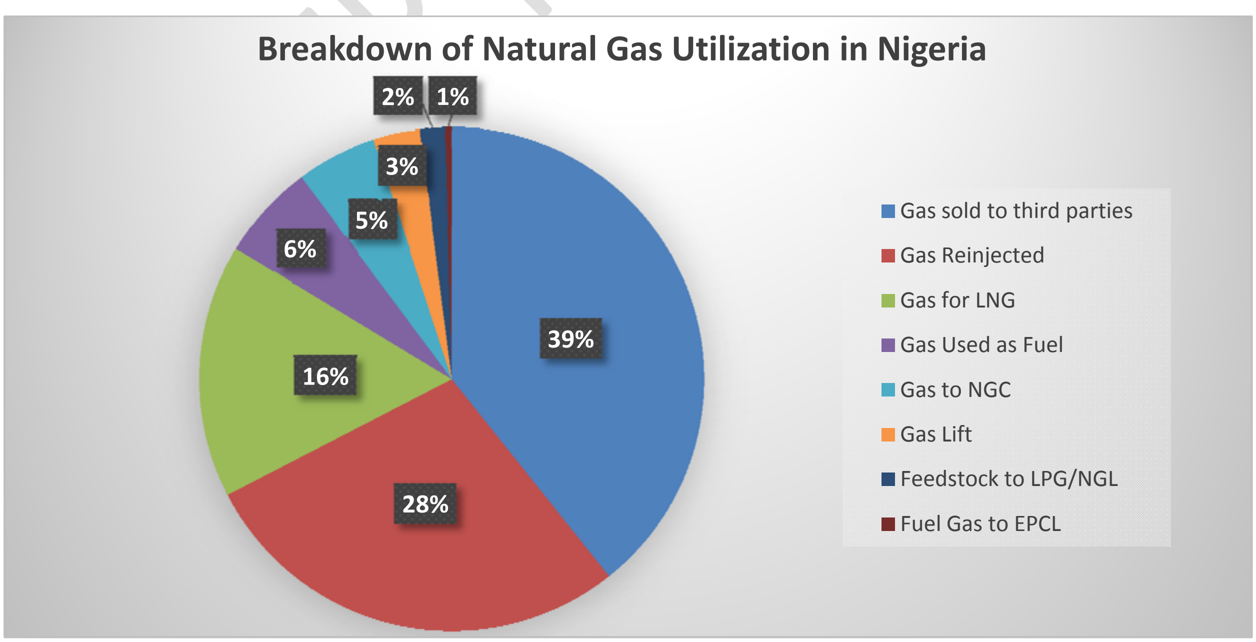

Figure 1 Natural Gas Utilization in Nigeria in 2015, NNPC Annual Statistical Bulletin, 2016.

Figure 1 shows that 39 percent of total gas utilized in 2015 was allocated to third parties who utilize gas for industrial heating and as feedstock for producing fertilizers, petrochemicals, etc., which makes it the largest consumer of natural gas in Nigeria, while natural gas reinjected had 28 percent of total gas utilized, making it the second largest consumer. However, fuel gas to EPCL and feedstock to LPG/NGL had 1 percent and 2 percent of total gas utilized respectively thereby making them the lowest consumers of Nigeria's natural gas.

The trend of natural gas utilization from 1984 – 2016 is shown in figure 2. The total natural gas utilized in 1984 was 121.41bscf. Gas utilization experienced slow growth up until 1999 when it increased to 751Bcf largely as a result of the commencement of operations of Nigeria's first LNG project – NLNG. Growth became much faster after this as the export project, which became and remains the largest gas utilization centre in Nigeria, added additional LNG trains. Gas demand was also boosted in the domestic market through the implementation of the Nigerian Gas Master Plan (NGMP) which increased demand from about 300MMscf/d to the current 1.2bscf/d.

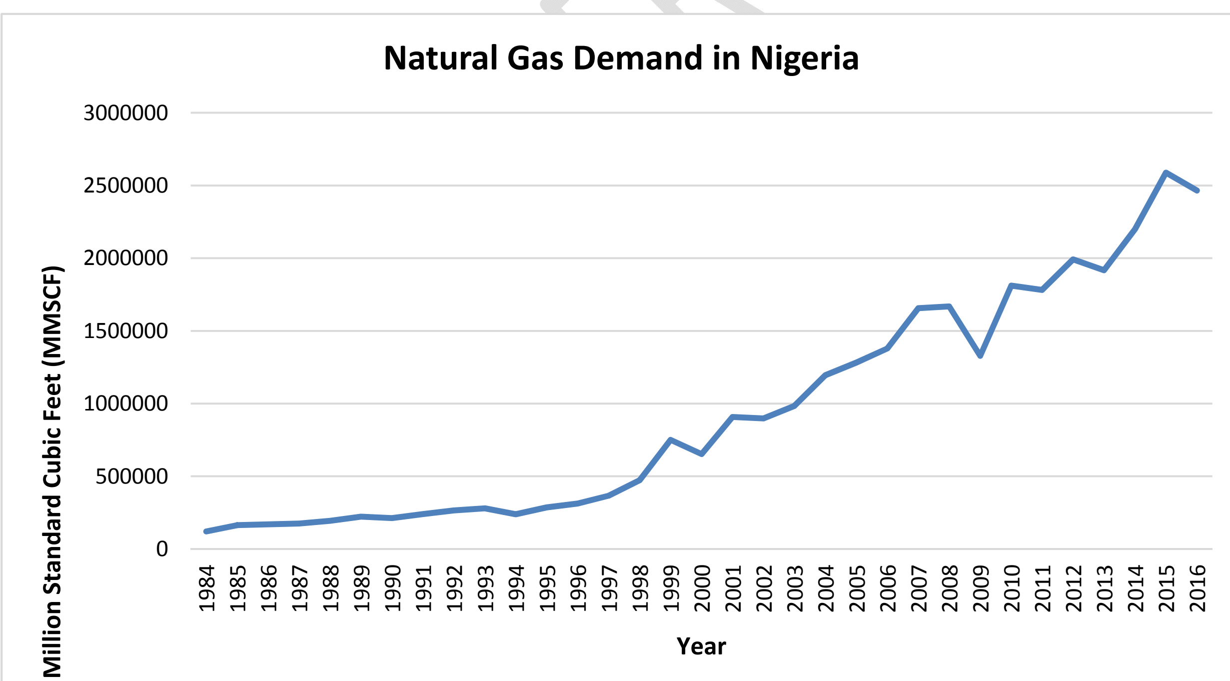

Figure 2 Natural Gas Demand in Nigeria 1984 – 2016, NNPC Annual Statistical Bulletin, 2016.

2.2 Energy Prices

Gas utilization in Nigeria is in two folds: gas for domestic consumption – domestic market; and gas for export – international market. These two markets have different pricing frameworks which is based on different factors. The Nigerian government through the National Domestic Gas Supply and Pricing Policy (2008) has grouped the country's gas demand sectors into three: the strategic power sector, the strategic industrial sector and the commercial/wholesale sector. This study adopted the price of natural gas in the strategic power sector, which is regulated. The trend of natural gas price is presented in figure 3.

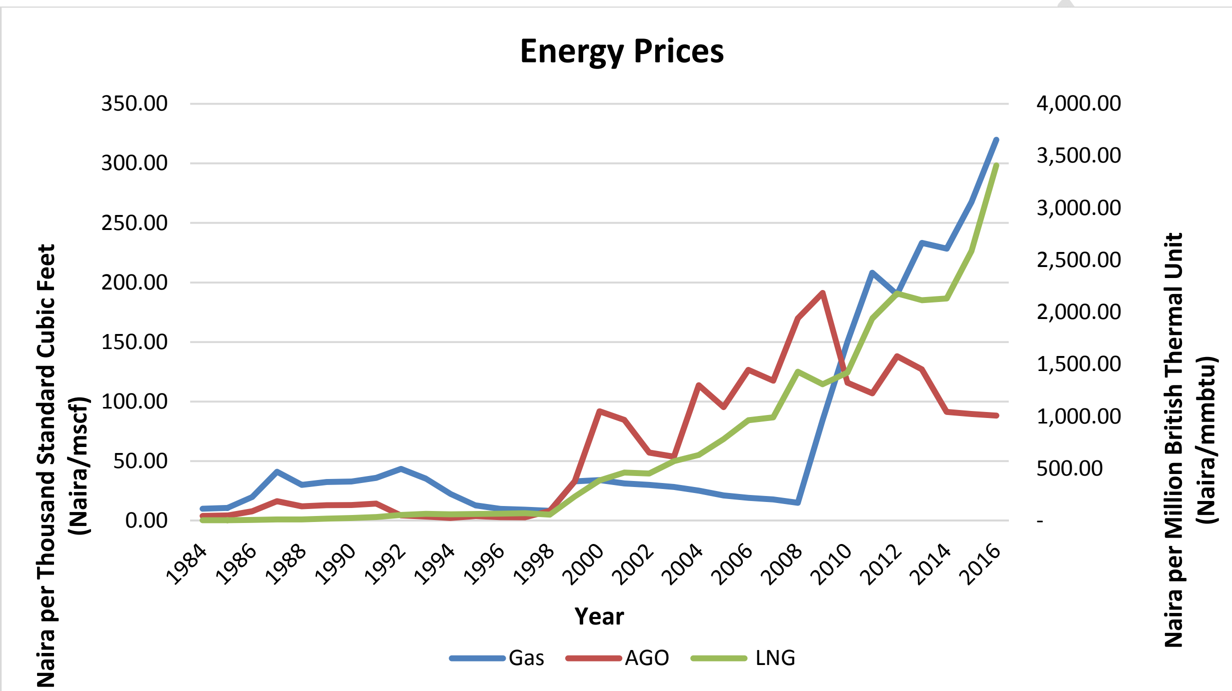

Figure 3 Energy Prices 1984 – 2016, NNPC (2016); World Bank (2016); BP (2018)

Domestic natural gas price maintained a fairly stable trend from 1984 to 2008. This is attributable to the adoption a fixed price regime for natural gas. The national gas pricing policy of 2008, however, led to the rise in gas price in 2009 until it reached a high of ₦208.22/mscf in 2011, before rising to ₦233.19/mscf in 2013 [11]. Gas prices increased in the following year and has since maintained an upward movement.

In order to estimate the cross elasticity of natural gas demand, this study adopted the price of AGO and LNG prices. These are presented in figure 4. The price of AGO witnessed a steady trend from 1984 to 1998 before experiencing an increase in 1999. AGO price however, experienced an undulating trend until it reached a peak in 2009 before declining [12]. The international price of LNG maintained a steady pace from 1984 to 1999 before increasing in year 2000 [10]. It has since been experiencing an upward trend.

2.3 Overview of Nigeria's Industrial Sector

In spite of abundant natural gas resources, output of the industrial sector of the Nigerian economy that utilizes Nigeria's natural gas, has been low. This is shown in figure 4. The output has an undulating trend from 1984 to 2016. The output in 1984 was ₦5,621.18bn; it increased to ₦8,531.59bn in 1990 as a result of the International Monetary Fund (IMF) loan obtained by Nigeria in 1985, before declining in 1991 [13]. The output trend was fairly stable from 1992 till 2002 before rising to ₦11,674.74bn in 2005. Output experienced a slight decline in 2006 till 2008 before experiencing an upward movement in 2009 till it reached an all-time peak at ₦13,791.24bn in 2014 due to the positive effect of the National gas pricing policy of 2008. However, output fell the following year and declined further in 2016.

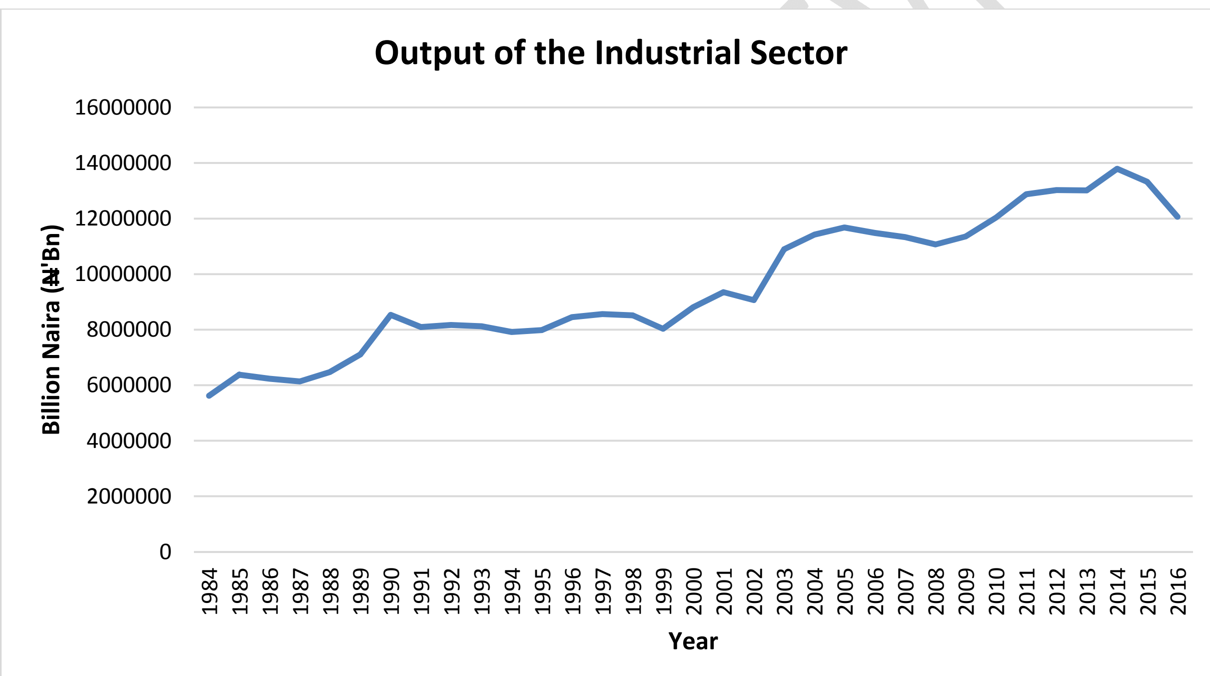

Figure 4 Output of the Industrial Sector of Nigeria 1984 – 2016, Ministry of Finance, 2016.

3. Theoretical Framework and Model Specification

3.1 Theoretical Framework

The theory adopted in this study is the theory of consumer choice (optimal choice of consumer). This theory states that consumer problem is a utility maximization problem and as such, the consumer puts together the theory of preferences and the budget set and also assumes differentiable preferences and convex budget set [14].

$$Max\ U = U(g) - - - - - - - - (1)$$

Subject to $B = \{g\ in\ G; \bar{p}.g\ \leq \bar{Y}\} - - - - - - - - - - - (2)$

In equations 1 and 2 above, g stands for natural gas, p represents price of natural gas and Y denotes real output of the industrial sector of the economy. It is worthy of note that p and Y are fixed.

Solving the consumers' choice problem using calculus of optimization-method of Lagrange multipliers yields the individual demand functions which are also called Marshallian demand functions. In the Marshallian demand function below, GD denotes natural gas demand, GP stands for gas price, PLNG stands for price of LNG, DP stands for diesel price, ELECT stands for electricity consumption per capita (which serves as a control variable), while Y is the same as explained above.

$GD = g(GP, PLNG, Y, DP, ELECT)$where$GD = (g_1, g_2, g_3, \ldots, g_n) - - - - - (3)$

In order to estimate the equation above, a mathematical form is needed, therefore this study adopts log-linear demand equation as adopted by Erdogdu [2] and Medlock [15] in setting up the econometric model. This equation, Medlock [15] posits, is often used in modeling energy [natural gas] demand in empirical studies. Equation 3 can then be written as:

$$lnGD_t = \beta_1 + \beta_2 lnGP_t + \beta_3 lnPLNG_t + \beta_4 lnY_t + \beta_5 lnDP_t + \beta_6 lnELECT_t + \varepsilon_t - - - - (4)$$

The log of natural gas demand is equal to the explanatory variables, also expressed in log. ε_t is the error term, while β_i are the parameters to be estimated; these parameters represent elasticities.

According to the standard demand theory, there is a negative relationship between price and quantity demanded of every product. This means that an increase in the price of natural gas will lead to a fall in quantity demanded ($\beta_2<0$). Conversely, an increase in real output of the manufacturing sector will lead to a rise in demand for natural gas. Therefore, there is a positive relationship between real output and natural gas demand ($\beta_4>0$). LNG is one of the many gas utilization projects in Nigeria. By implication, its availability largely depends on the availability of natural gas. It is expected that an increase in the international price of LNG will lead to an increase in Nigeria's natural gas demand ($\beta_3> 0$). AGO is a substitute good for natural gas when an increase in its price leads to an increase in the demand for natural gas ($\beta_5 > 0$). On the other hand, AGO is regarded as a complementary good to natural gas if an increase in its price leads to a decrease in the demand for natural gas ($\beta_5 < 0$). Since natural gas is used in generating over 80 percent of Nigeria's electricity, it is expected that an increase in electricity consumption per capita will lead to an increase in natural gas demand ($\beta_6 > 0$).

3.2 Model Specification

This study adopts the ARDL bound testing approach to cointegration developed by Pesaran *et al.* [16] and adopted by Shahbaz *et al*. [17], Marbuah [18], Belloumi [19] and Onolemhemhen *et al.* [20]. The choice of this methodology is influenced by three factors: First, this approach has better small sample properties [21]. In other words, it is the best approach for analyzing model with a small sample size. Secondly, it can be used to analyze any model irrespective of the order of integration of the series of data [18]. In other words, no pre-testing is required as it can be applied to any series with either I (0) or I (1) qualities. Thirdly, the true or unbiased estimate of the long-run model is obtained by applying the ARDL technique. In this approach, dynamic models are estimated by adding the lag of the dependent variable as well as the lagged and contemporaneous values of the independent variables [18].

3.2.1 Formulation of the Estimated Model

The error correction model is specified as:

$$\Delta lnGD_t = \beta_1 + \beta_2 \Delta lnGP_t + \beta_3 \Delta lnPLNG_t + \beta_4 \Delta lnY_t + \beta_5 \Delta lnDP_t + \beta_6 \Delta lnELECT_t + EC_{t-1} + \varepsilon_t - - - (5)$$

In this case, the parameters β_2, β_3,β_4, β_5 and β_6 would be interpreted as short-run effects, while Δ represents the difference operator. The deviation from equilibrium in the previous period, that is, the error, is responsible for the change in natural gas consumption in the next period. This deviation, as denoted by EC_{t-1}, is the error that is to be adjusted in the next period [21].

Model 6 is therefore specified as an ARDL model by "including lags of the dependent variable and of the potentially non-stationary explanatory variables on the right-hand side" [21]. Furthermore, replace the error correction term, EC_{t-1} in equation (5) by its components from the long run relationship in equation (7) instead of adopting a two-step process to estimate the model. This is expressed as:

$$EC_{t-1} = \varepsilon_{t-1} = (lnGD_{t-1} - \beta_1 - \beta_2 lnGP_{t-1} - \beta_3 lnPLNG_{t-1} - \beta_4 lnY_{t-1} - \beta_5 lnDP_{t-1} - \beta_6 lnELECT_{t-1}) - - - - - - (6)$$

And this yields the UECM with the form:

$$\Delta lnGD_t = \beta_1^* + \beta_{1A}^t + \sum_{i=1}^{p} \beta_{2i} \Delta lnGP_{t-i} + \sum_{j=0}^{q} \beta_{3j} \Delta lnPLNG_{t-j} + \sum_{k=0}^{r} \beta_{4k} \Delta lnY_{t-k} + \sum_{l=0}^{s} \beta_5 \Delta lnDP_{t-l} + \sum_{m=0}^{t} \beta_6 \Delta lnELECT_{t-m} + \beta_7^* lnGD_{t-1} + \beta_8^* lnGP_{t-1} + \beta_9^* lnPLNG_{t-1} + \beta_{10}^* lnY_{t-1} + \beta_{11}^* lnDP_{t-1} + \beta_{12}^* lnELECT_{t-1} + \varepsilon_t - - - (7)$$

The UECM above is estimated as part of the ARDL framework in equation (4). β_2, β_3, β_4, $\beta_5$and β_6 are parameters representing the short-run effects while β^*_7, β^*_8, $\beta^*_9\beta^*_{10}$, β^*_{11}, and β^*_{12} denote the long-run elasticities.

3.2.2 Estimation Method for the Model

In equation 7 above, the variables GD, GP, PLNG, Y, DP and ELECT would each be subjected to unit root test. This is to investigate if the order of integration of the series are integrated of order 2, that is, if it has I (2) properties. Estimation of the model is done and the test of hypothesis that H_0: $\beta^*_7 = \beta^*_8 = \beta^*_9 = \beta^*_{10} = \beta^*_{11} = \beta^*_{12} = 0$ which is the null hypothesis, and/ or H_1: $\beta^*_7 \neq \beta^*_8 \neq \beta^*_9 \neq \beta^*_{10} \neq \beta^*_{11} \neq \beta^*_{12} \neq 0$ which is the alternative hypothesis is carried out using a standard F-statistic, although this F-test has a non-standard distribution. The critical value that enables a bounds test to be conducted is provided by Pesaran *et al.* [16].

The decision rule, therefore, is that if the calculated F falls below the lower bound at some significance level, the null hypothesis is accepted and this means that there is no cointegration among the variables. On the other hand, if the F statistic exceeds the upper critical bound at some significance level, we reject the null hypothesis. This means that there is cointegration among the variables. Lastly, if the F statistic falls between the upper and lower bounds, the result is inconclusive and the knowledge of the order of integration of the variables involved would be the resolution of this uncertainty.

3.3 Description of Data

Empirical analysis is carried out on time series data covering the period 1984 – 2016 (33 years). This period was adopted because of availability of data. Time series data on natural gas consumption in Nigeria was sourced from [11]. It is measured in million standard cubic feet (mmscf). The source of time series data on real output (Y) of the industrial sector is [13]. The data on real output (Y) of the manufacturing sector was extracted from GDP at 2010 constant basic prices and is expressed in million Naira (₦' Million).

The time series data on gas price was obtained from [11]. It was specified in United States' dollars. However, for the purpose of this study, the price was converted to the Nigerian Naira (₦), and was further deflated by Nigeria's Consumer Price Index (CPI) (2010 = 100) in order to get the real price of gas. The same process was applied to price of diesel and the international price of LNG in order to obtain their real prices in Naira terms; though the time series data on LNG price was obtained by taking the average price of LNG in two markets (Japan and Germany) before its conversion to the Nigerian Naira. The time series data of price of diesel was sourced from [12], while the price of LNG was sourced from [10]. The price of AGO is measured in ₦/litre while the LNG price is measured in ₦/mmbtu. Electricity consumption per capita was obtained from [22] and is expressed in kWh.

4. Discussion of Results

4.1 Unit Root Test

ADF test was conducted to ascertain the order of integration of the time series data. It was discovered after the test that none of the variables was integrated of order 2, and none of the variables adopted is stationary at level. In other words, all the variables have unit roots. However, all the variables became stationary at first (1^{st}) difference. This is shown in table 1.

Table 1 Unit Root Test

Variable	Level	1st Difference
GD	-2.193931	-7.725809***
GP	-1.404493	-4.460467***
PLNG	-2.734929	-4.265754**
Y	-2.564917	-5.230566***
DP	-2.166937	-3.983713**
ELECT	-2.412257	-6.463673***

Note: ***, denote rejection of the null hypothesis at 1%, 5% and 10% level of significance
**, denote acceptance of null hypothesis at 1% level of significance but rejection at 5% and 10% level

4.2 Results of Cointegration Test

Results of the bounds test are presented in table 2. The cointegration test was carried out on gas demand and all the independent variables. The F-statistic of the cointegration test was 4.45. This result is higher than the upper critical bounds at only 10 percent and 5 percent levels of significance, and this indicates that there is cointegration among the variables at both 10 percent and 5 percent levels of significance; hence, there is a long run relationship between gas demand, gas price, price of LNG, real output of the industrial sector, price of AGO and electricity consumption per capita. However, the value of the bounds test falls in between the lower and upper bounds at 2.5 percent and 1 percent significance levels.

Table 2 Bounds Test for Cointegration

Variable	F-Statistics	Critical Bounds			
		5%		**10%**	
		I(0)	**I(1)**	**I (0)**	**I(1)**
F_{gd}(gd|gp, plng, y,dp,elect)	4.45**	3.12	4.25	2.75	3.79

NOTE: ***, denote rejection of null hypothesis at 1%, 5% and 10% level of significance, while ** denote rejection of hypothesis at 5% and 10% level of significance

4.3 Estimated Short-Run and Long-Run Results

The error correction term has the correct sign (negative) and is statistically significant as shown in table 3. The error correction term of -1.295843 is similar to the error correction term obtained by Narayan and Smyth [23]. Narayan and Smyth [23] posit that this value "implies that instead of monotonically converging to the equilibrium path directly, the error correction process fluctuates around the long-run value in a dampening manner." The economy returns rapidly to equilibrium once the process is complete. Additionally, with an R^2 of 0.801913, the results show that 80 percent variation in natural gas demand in Nigeria is explained by the independent variables. The residuals of the short-run models were subjected to a diagnostic test and it shows that they are well behaved with respect to serial correlation, heteroskedasticity, normality as well as constant variances. Lastly, the parameters were subjected to stability tests using the CUSUM and CUSUMQ developed by Brown *et al.* (1975). In the estimated models, CUSUM and CUSUMQ tests indicate that the parameter stability falls within the 5% critical bounds; hence, they are stable. This is shown in table 5.

The short run estimate is shown in table 3, while the long run estimate is presented in table 4. The estimate of the short run price elasticity of demand is -0.15 and is statistically significant. This means that, in the short run, natural gas demand in Nigeria is relatively price inelastic. In other words, a 1 percent increase in the price of gas will lead to 0.15 percent decrease in the quantity demanded of natural gas and vice versa, *ceteris paribus*. In the long run, the estimate of price elasticity of natural gas demand is -0.089 and is statistically significant. This means that elasticity of natural gas demand in Nigeria in the long run is also relatively price inelastic just like the short run; but as we approach the long run, price elasticity shrinks from 0.15 percent to 0.09 percent. Therefore, if there is a 1 percent increase in the price of natural gas in the long run, the quantity demanded for gas would fall by 0.09 percent and vice versa, *ceteris paribus*. The short run and long run estimates follow our apriori expectation.

The price elasticity of demand of the international price of LNG in the short run is 0.311573. This estimate is positive and is statistically significant. The estimate indicates that a 1 percent increase in the international price of LNG will lead to a 0.31 percent increase in Nigeria's natural gas demand and vice versa, *ceteris paribus*. In the same vein, the long run estimate of the international price of LNG is 0.101994, which is positive and is statistically significant. The result reveals that a 1 percent increase in the international price of LNG will lead to an increase of 0.10 percent in Nigeria's natural gas demand in the long run and vice versa, *ceteris paribus*. This result follows our a-priori expectation.

The estimate of income elasticity of demand in the short-run and long-run are not statistically significant.

The cross-price elasticity of demand of AGO in the short run is 0.101363. The elasticity obtained is positive and is statistically significant. This means that, in the short run, AGO is a substitute product for natural gas in Nigeria. Hence, a 1 percent increase in the price of AGO will lead to a 0.10 percent increase in demand for natural gas and vice versa, *ceteris paribus*. In the same vein, the long run estimate of price of AGO is 0.097945. This means that AGO is a substitute energy product for natural gas in Nigeria. Therefore, a 1 percent increase in the price of diesel will lead to a 0.09 percent increase in natural gas demand in Nigeria and vice versa, *ceteris paribus*.

Lastly, the short run estimate of electricity consumption per capita is positive and is statistically significant, while its long run estimate is not statistically significant. The short run estimate of 0.471537 indicates that natural gas demand increases by 0.47 percent when there is a 1 percent increase in Nigeria's electricity consumption per capita and vice versa, *ceteris paribus*. This result follows our a-priori expectation.

Table 3 Error Correction Representation for the Selected ARDL Model ARDL (1, 0, 1, 0, 0, 2)Selected based on Schwarz Criterion (SIC) 1984 – 2016

Explanatory Variables	Dependent Variable is GD
ΔGD (-1)	-0.496123*** (-2.261794)
ΔGP	-0.149683*** (-4.293318)
ΔPLNG	0.311573*** (5.562112)
ΔY	0.126850 (0.614177)
ΔDP	0.101363*** (3.341430)
ΔELECT	0.471537*** (3.900847)
ΔC	0.141812*** (8.706127)
ΔECM(-1)	-1.295843*** (-8.900937)

NOTE: ***, denote the rejection of null hypothesis at 1%, 5% and 10% level of significance
The figures in brackets represent t-statistic

Table 4 Estimated Long-Run Coefficients Using the ARDL Approach ARDL (1, 0, 1, 0, 0, 2) Selected based on Schwarz Criterion (SIC) 1984 – 2016

Explanatory Variables	Dependent Variable is GD
Constant	10.932110*** (4.517216)
LGP	-0.089228*** (-5.344379)
LPLNG	0.101994*** (2.423419)
LY	0.043753 (0.266551)
LDP	0.097945*** (5.944668)
LELECT	-0.116009 (-1.209397)

NOTE: ***, denote the rejection of null hypothesis at 1%, 5% and 10% level of significance
The figures in brackets represent t-statistic

Table 5 Regression Statistics and Diagnostic Tests

R – Square	0.801913
Adjusted R – Square	0.754373
F – Statistic	16.86790 (0.000000)
Durbin – Watson Statistic	2.034899
Serial Correlation	0.697320 (0.5081)
Normality	1.254495 (0.534060)
Heteroscedasticity	0.842740 (0.5491)
CUSUM	Stable
CUSUMQ	Stable

5 Conclusion

The results of the analysis conducted in this study suggest that domestic gas price, price of AGO, international price of LNG and electricity consumption per capita are important determinants of Nigeria's natural gas demand. Elasticity of natural gas demand in Nigeria is relatively price inelastic. Thus, a fall in the price of natural gas will lead to an increase in the quantity demanded of natural gas by less than the percentage fall in price and vice versa, *ceteris paribus*. This study concludes that natural gas price is a major determinant of the quantity demanded of natural gas in Nigeria. Furthermore, the result of the cross elasticity of demand reveals that AGO and LNG are substitute energy products for natural gas in the Nigerian economy.

Therefore, this study recommends that policy makers should adopt natural gas price as a tool for increasing the quantity demanded of natural gas in Nigeria. A downward review of gas price is important, because, a lower domestic gas price will lead to an increase in quantity of natural gas demanded by power plants, commercial centers and industries. Cheap and affordable gas would reduce the cost of electricity generation; production of glass, steel, paper, etc.; and, production of fertilizer, petrochemical, etc.

However, gas producers have argued that the current gas price is low and uneconomic. In essence, it is difficult to make a reasonable profit from harnessing associated gas and selling same at the prevailing market price. This is partly attributable to high cost of harnessing and converting associated gas into usable gas. This claim is consistent with the law of supply. Therefore, in order to ascertain the equilibrium gas price, further studies should be conducted to estimate natural gas supply elasticities in Nigeria. The major limitation of this study is the inaccessibility of monthly or quarterly time series data.

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COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

Ethical: NA

Consent: NA

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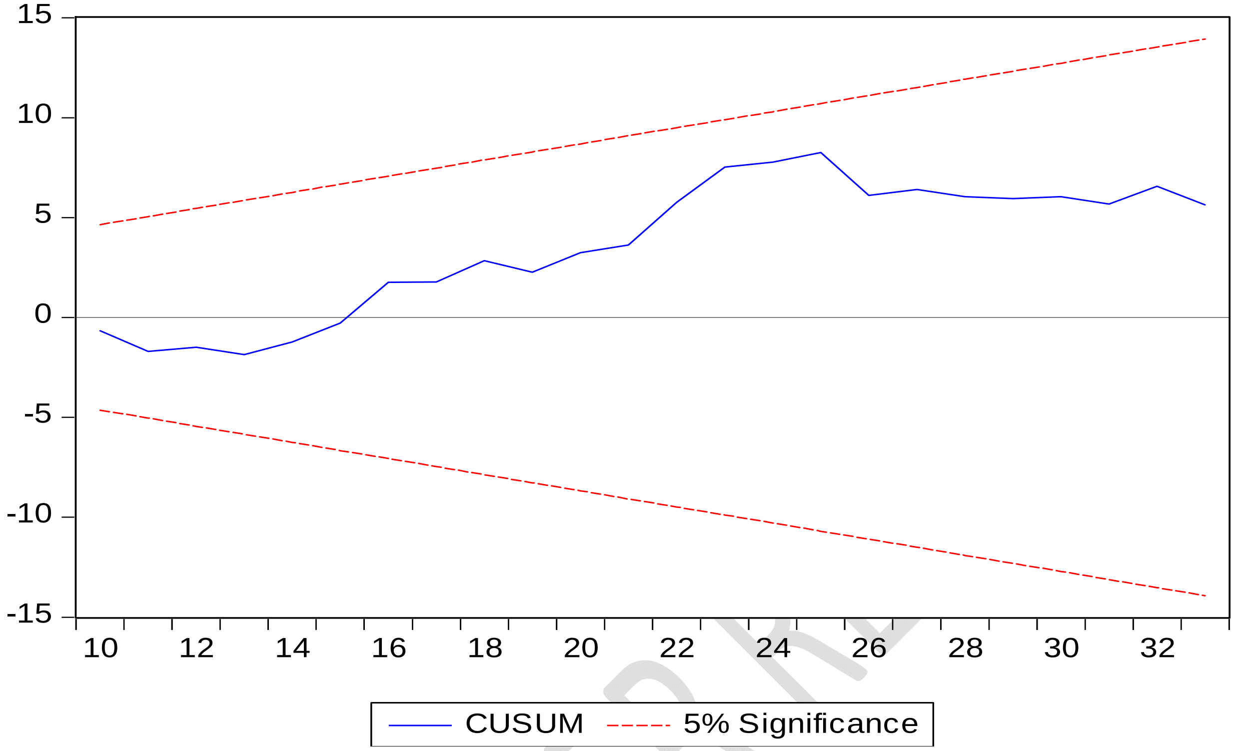
Appendix



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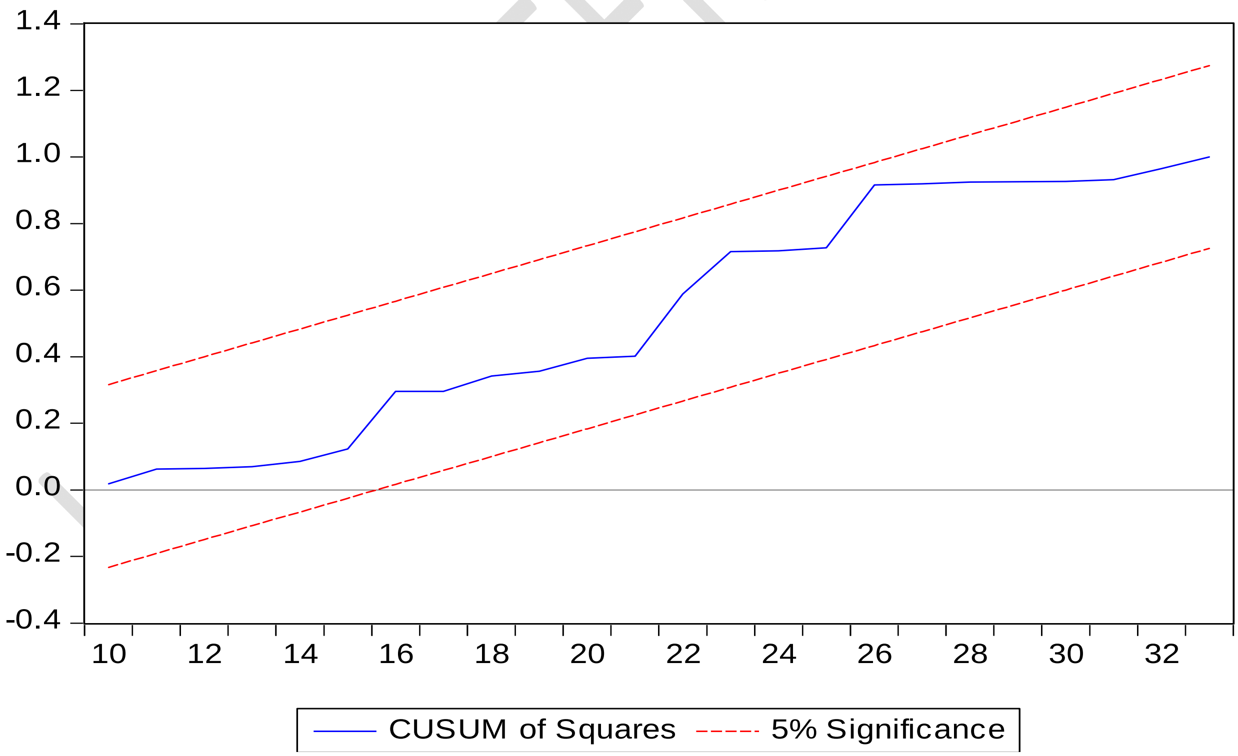

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