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Energy Pricing and Regulation: Implications of Oil Pricing On Demand and National Output

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Abstract

This study examines the effect of gas pricing and gas demand on National output (GDP). The interactions among gas demand, gas price and GDP were investigated using the structural vector auto-regressive (SVAR) model. Time series monthly data were collected from 1996 -2019 on gas demand, gas supply, gas retail price, petrol retail price and GDP. The result indicated that gas price has a significant impact on gas demand and gas demand also determines gas pricing; gas demand has a significant impact on GDP. Furthermore the impulse response and variance decomposition all showed that gas demand contributed most to the variations and shocks in GDP compared to the other variables under study. Also petroleum retail price significantly affect Gas Demand positively, indicating that the higher the price of petrol the higher the gas demand as consumers will substitute gas for petroleum product. Finally, the causality testindicated bi-directional causality between GDP and Gas demand, bi-directional causality between gas price and gas demand and unidirectional causality from gas price to GDP

1.0 Introduction

The Gas sub-sector is recognised as a key sector capable of transforming the Nigerian economy through vital sub-sectors, such as electricity, petro-chemicals, cement, iron and residential. The sub-sector, therefore, had attracted special attention from Government in Nigeria. Among the efforts is the Gas Master Plan, aimed at providing a framework that would ensure the realisation of maximum value from the country's gas resources. It is intended to leverage on the multiplier effect of gas in the domestic economy and optimise the nation's share of the high value export market. Specifically, the Plan was targeted at addressing impediments to the development of the domestic gas sector, engender the monetisation of gas, reduce gas flaring and guarantee long-term gas security for Nigeria (Adeniji 2016). The plan is also expected to facilitate timely and cost-effective gas production to meet global and domestic demands. The plan was hinged on three critical elements, namely Gas pricing policy (the policy); domestic gas supply regulations (the regulation); and gas infrastructure blueprint (the blueprint). Other efforts include: the Gas-to-Power; Gas Processing Facility; the Nigeria LNG Company Limited; and the Nigeria Gas Company. The gas sub-sector is an area where government effort has produced significant results. Earnings from gas exports stood at US$ 9.6 billion in the last 10 years, while domestic supply increased by about 1,827.0 percent in the same period (CBN, 2015) .

Nigeria ranked 8th in the world in terms of proven reserves of Oil and Gas; it is the largest in Africa. This huge gas reserve has remained largely untapped since the ascendancy of crude oil as the nation's major cash earner. In fact, petroleum experts regard Nigeria "as a gas province with little oil". In Nigeria, natural gas is obtainable in two main forms, which are associated natural gas (AG) and non-associated natural gas (Non-AG). However, many of the gas fields discovered (or non-associated gas) was incidentally discovered in the course of searching for oil. Several of such fields remained largely unapprised or abandoned. Nigeria's proven natural gas reserve was estimated at 184 trillion cubic feet (TCF) in 2008 of which 209 billion cubic feet is produced annually (CBN, 2015). Out of this figure produced annually 44.82% are presently fared. This level of gas still flared is capable of generating 69GW of electricity and translating to a lost in economic value of $5 billion dollars annually (CBN, 2015). As at June 2020, proven natural gas reserve is estimated at 203.16 tcf (DPR). The onshore activities centred mainly in the Niger Delta area where massive wealth is being generated for the nation. Unfortunately, the oil industry has created serious health and environmental pollution problems for the host communities largely through gas flaring and oil spillage. The environmental impacts of these activities have been of concern to government regulatory agencies, oil companies' operators as well as the host communities. No wonder why gas flaring has reduced from 46.21 % of total gas produced in 2003 to 24.30% in 2014 (CBN, 2015). Yet, concerned parties have not shown adequate commitments and sincerity towards having robust environmental restoration and preservation. Various control programs and policies that are articulated by government for the mitigation of the environmental hazards have not been sincerely implemented. Violent protests by communities are the most eloquent testimonies of the resistance to the general pollution of the environment due to the activities of the oil companies. The government's amnesty and post-amnesty programs since 2010 have to some extent helped to bring peace to the area.

The major objective of this study is to examinethe interactions between gas pricing, gas demand and national output in Nigeria. In order to achieve this, time series quarterly data will be used to examine if there is a link between gas price, gas demand and national outputin Nigeria.

1.1 The Nigerian Gas Industry

The strategies of many countries are often woven around, and influenced by available resources such as mineral deposits, oil and natural gas. In view of this, one can say that the presence of natural resources plays an important role in national development strategy. This notwithstanding, the existence of natural resources does not always translate to development; situations that had led to the resource curse problem might have influenced certain views. In spite of these observations, in Nigeria for instance, there seems to be a determination to correct the perceived imbalances in the management of the oil and gas sector. For example, rather than allow the flaring of associated gas, the Nigerian National Petroleum Corporation (NNPC) hopes to transform Nigeria into a leading Liquefied Natural Gas (LNG) producing and utilization nation by commercializing Nigeria's abundant gas reserves and promoting a viable LNG industry. Nigeria intention to reduce flared gas from the current 7% to 2% by 2017 corroborates this desire (Adeniji and Sipasi, 2016). This is a laudable vision as better exploitation of natural gas resources, especially those underutilized in West Africa is seen as a significant way to satisfy the world's increasing natural gas demand, which has been projected to grow by 1.9% annually, estimated to reach 4700 billion cubic metres (bcm) in 2030, and to account for 24.4% of expected energy consumption (Adeniji and Sipasi, 2016). However, this vision can only be realized if established management principles and procedures are adopted. First, those assets and capabilities that could enhance the efficiency and effectiveness of adopted development strategies need to be identified.

As at 2001, the gas sector was largely undeveloped and most of the gas produced wereflared. Issues such as third party access to sector infrastructure, pipeline ownership, tariff structure, gas transportation code were either largely absent or not treated in the legal framework which was largely written for oil, and did not sufficiently address gas as a hydrocarbon (Udoh, 2009). Gas supply was controlled by the national oil company, the Nigerian National Petroleum Corporation (NNPC), in partnership with a number of international oil companies. Gas transmission and distribution was also controlled by NNPC through its subsidiary, the Nigerian Gas Company. The regulator, the Department of Petroleum Resources, was ineffectual in the regulation of the sector and effectively ceded policy making to the NNPC. Some gas - based industries such as the steel complex and an aluminium smelter plant had become comatose, and wholesale gas offtake was limited to a few government–owned power plants. Gas pricing was regulated and considered uneconomic by producers, whilst the main off-takers frequently default on payments for gas supplied. The two gas networks, located in the western and eastern parts of the country, were limited in coverage and unconnected to each other and often had operational issues due to gas quality, maintenance and pipeline sabotage. Fiscal incentives introduced by government in fact stimulated some export projects, mainly for liquefied natural gas (LNG) or natural gas liquids (NGLs). However, the incentives effectively subsidized these projects from government's share of oil taxation and resulted in significant losses in government's share of economic rent from project revenues.

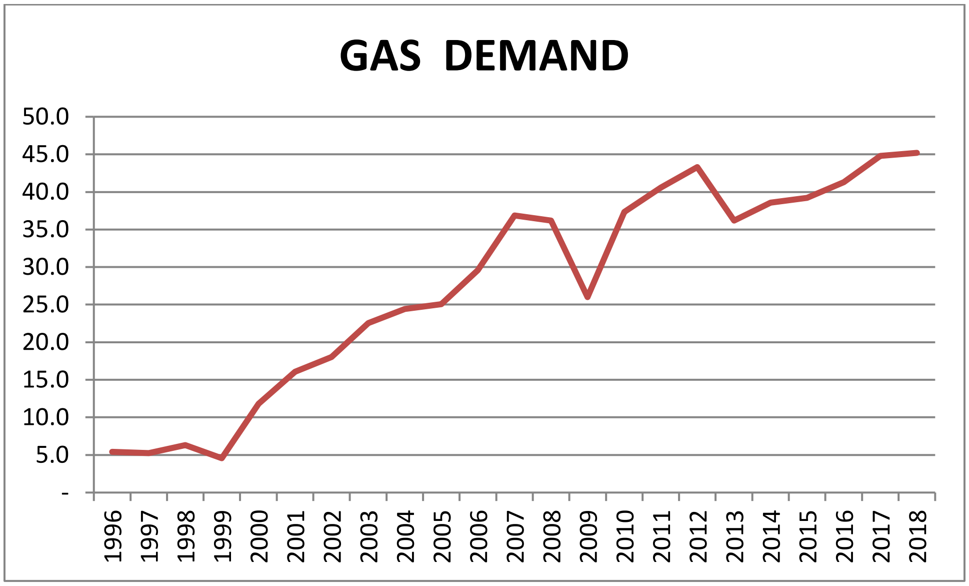
1.3 Natural Gas Demand in Nigeria

The global demand for natural gas was noted to have grown from 450.0 Mscf to 1,827.0 Mscf in the period 2000 - 2010 (IEA, 2013). The growth was projected to expand to 40 Bcf/d by end- 2018 and over 50 Bcf/d by 2025. The significant expansion in the projected global demand for natural gas was attributed to the growing desire in many countries to adopt cleaner energy.

Analysis of Energy Market Conditions in Nigeria shows that the rising demand for natural gasis propelled by the quest for reducing the impact of rising oil-based energy costs. The preference for natural gas as a source of energy is basically on account of its low carbon emissions, which is 43.0 per cent less than coal and 30.0 per cent lower than oil per every unit of energy supplied. The emerging economies of Asia, particularly China and India, including the Middle East and the South America, are ranked among the fastest growing gas markets in the world. The growing desire for gas in the international market is also driven by its cost-effectiveness among clean energy sources.

Gas demand in Nigeria hascontinued to increase over the years. Gas demand has notably increased between 2013 and 2018in Nigeria. Certain factor such as the increase in the price of other local energy resources like kerosene and petrol and the imposition of electricity tariff are responsible for the increase in gas demand in Nigeria. Figure 1 shows the trend in gas demand in Nigeria from 2013 to 2018, indicating rapid increment over the last Nine years (2013-2018).

Figure 1: Gas Demand in Nigeria



Source: International Energy Agency (IEA) 2018. http://www.bp.com/statisticalreview

2.0 Empirical Review and Theoretical Considerations

Literature on the interaction of natural gas and economic growth is very sparse compared with literature regarding coal. Energy-growth nexus or natural gas-growth nexus can be described by the following four hypotheses: growth hypothesis, conservation hypothesis, feedback hypothesis, and neutrality hypothesis. According to the growth hypothesis energy/gas use is critical for economic growth. So a reduction in energy/gas use lowers GDP implying that the economy is energy/gas dependent. The conservation hypothesis positsthe existence of a unidirectional causality from economic growth to energy/gas use. Therefore, economic growth may not be much affected by any policy to reduce energy/gas consumption. The feedback hypothesis assumes the existence of a bidirectional causality implying that energy/gas consumption and economic growth affect each other. Neutrality hypothesis states that lower energy/gas consumption does not affect economic growth, and vice versa.

Some empirical studies have been carried out linking natural gas resource and economic growth in gas producing nations. Soheila and Nikos (2014) used ARDL to examine the short-run and long-run relationship between Natural Gas consumption and economic Growth in Iran. They concluded that there exist a long run equilibrium relationship between Gas and Growth. Other studies such as Mohammed et al. (2012) also discovered that natural gas is an engine of economic growth with evidence from Pakistan economy. However, limited studies have been conducted in sub-Saharan Region as regards the linkage between Natural Gas and economic growth.

Yu and Choi (2012) found neutral effect between natural gas consumption and economic growth in case of USA and Poland, but one-way relationship from economic growth to natural gas consumption for UK which flows from Natural Gas to economic growth. Applying Sims and Granger causality technique on UK time series data for the post-war period1980 to2006, they find evidence of unidirectional causality running from natural gas consumption to economic growth.

Yang (2013) utilizing a time series data from 1980-2007 for Taiwan, found a one-way Granger causality from natural gas consumption to economic growth, but no cointegration between the two variables.

Aqeel and Butt (2011) studied causal relationships between real GDP and natural gas consumption for Pakistan. The first study used data from 1955 to 1996, and the second study used data from 1970 to 2009. They found absence of cointegration and causality between natural gas consumption and economic growth in Pakistan over the period investigated.

Fatai et al. (2009) used data from 1960 to1999 and employed ARDL, Johnson's Maximum Likelihood (JML) and Toda and Yamamoto causality test methods, and reported no cointegration between natural gas consumption and economic growth for New Zealand but found cointegration for Australia while neutral effect is validated between both variables.

Lee and Chang (2015) explored the importance of structural breaks using data of 1965 - 2012 in case of Taiwan including adopting export promotion and financial liberalization policies and found that Taiwan natural gas consumption Granger causes economic growth. This implies that a decrease in the volume of natural gas consumption will slow economic growth in case of Taiwan. However, with conventional vector error correction model, the study does not find long-run equilibrium.

Zamani (2007) used the vector error correction model for empirical purpose in case of Iranian economy over the period of 1967-2003. The author found the bidirectional causal relationship between natural gas consumption and economic growth in long run, but a unidirectional causality running from agricultural value added to gas consumption and a unidirectional causality from gas consumption to industrial value added. Therefore, it can be argued that the conversation of natural gas may have no effect on the agricultural output but detrimental effect on the industrial output in Iran.

Sari et al. (2010) identified cointegration relationship between natural gas consumption and economic growth, taking monthly data for the period of 2001:1-2005, they applied the ARDL bounds testing approach which can detect cointegration even for small samples. Their findings reveal no significant impact of industrial production on natural gas consumption in the long run.

Reynolds and Kolodziej (2013) conducted a study on the former Soviet Union to explore cointegration, and use Engle and Granger causality test. They found no causal relationship between natural gas consumption and economic growth mainly because Soviet Union has stable level of natural gas consumption due to low variable costs of production.

Lean and Smyth (2010) correctly identified some problems of using the bivariate framework in analyzing the relationship between energy and GDP. They argued that energy is not the only input to spur aggregate output. Actual output growth depends on the combination of inputs used, and the degree to which energy, capital and labour act as complements.

In addition, Nondo and Kahsai (2009), and Chien(2007) applied the techniques of panel unit root tests, panel cointegration, panel error correction and dynamic panel GMM causality test to estimate the causal relationship between Gas usage and total factor productivity for 19 COMESA countries for the period 1980-2005. Their analyses revealed that causation ran from energy usage to total factor productivity for low income COMESA countries.

Pradhan (2010) applying intertemporal growth model using the Computable General Equilibrium (CGE) and data from China found that total factor productivity is dependent on energy usage with infrastructure and transport as additional variables which also reports the importance of energy in the production function.

Employing different methodology and different time period for China, Shunyun and Donghua (2011) examined the causality between Gas and fuel usage and productivity for the period 1985-2007 within a multivariate framework by applying fully modified OLS (FMOLS), the results indicated the presence of bidirectional relationship and productivity which contradicted the findings of Pradhan (2010).

From the literature reviewed, most of the studies on the response of economic growth to Natural gas use have been conducted on developed countries, and majority of the study used time series analysis in terms of ARDL models, VAR, ECM and time series simulation for their empirical analysis as such these studies did not consider the role of Gas, Gas pricing and its effect on key macroeconomic variables and the entire economic system. Very few study used the general equilibrium framework to model Gas in relation to the economic system but studies on Nigeria Gas industry is limited as such there is a need to examine the gas policies, pricing, gas demand and its effect on the economic system in Nigeria so as to determine the extent to which productivity in Nigeria is driven by gas use.

Theoretical Considerations

Reproducibility is a key concept in the economics of production. Some inputs to production are non-reproducible, whereas others can be manufactured at a cost within the economic production space. Primary factors of production are inputs that exist at the beginning of the period under consideration and are not directly used up in production (though they can be degraded and can be added to), whereas intermediate inputs are created during the production period under consideration and are used up entirely in production. Mainstream economists usually think of capital, labour, and land as the primary factors of production, and goods such fuels and materials as the intermediate inputs. The prices paid for all the different inputs are seen as eventually being payments to the owners of the primary inputs for the services provided directly or embodied in the produced intermediate inputs. In the theory of growth, this approach has led to a focus on the primary inputs, in particular on capital and land, and a much lesser and somewhat indirect treatment of the role of energy in the growth process. The primary energy inputs are stock resources such as Natural Gas and oil deposits. But these are not given an explicit role in the standard growth theories, which focus on labour and capital. However, capital, labour, and, in the longer term, even natural resources are reproducible factors of production, whereas energy is a non-reproducible factor of production, although, of course, energy vectors (Gas and fuels) are reproducible factors. Therefore natural scientists and some ecological economists have placed a very heavy emphasis on the role of energy and its availability in the economic production and growth processes. The first law of thermodynamics (the conservation law) implies the mass-balance principle. In order to obtain a given material output, greater or equal quantities of matter must enter the production process as inputs, with the residual as a pollutant or waste product. Therefore, there are minimum material input requirements for any production process producing material outputs. The second law of thermodynamics (the efficiency law) implies that a minimum quantity of energy is required to carry out the transformation of matter. All production involves the transformation or movement of matter in some way, and all such transformations require energy. Therefore, there must be limits to the substitution of other factors of production for energy. Energy is also an essential factor of production. Though all economic processes required energy, some service activities may not require the direct processing of materials. However, this is only true at the micro level. At the macro level (economy-wide level), all economic processes require the indirect use of materials, either in the maintenance of labour or in the production of capital goods. Some aspects of organized matter—that is, information— might also be considered to be non-reproducible inputs. Several analysts argued that information is a fundamentally non reproducible factor of production in the same way as energy.

3.0 Methodology

This research will use the Structural Vector Autoregressive (S-VAR) model to estimate the interaction between Gas price, Gas Demand and GDP in Nigeria. Structural Vector Autoregressive is chosen because it is not athereotic like the unstructured (traditional) VAR. it is an extension of the traditional (unstructured) VAR analysis that attempts to identify the atheoretic restriction used in traditional VAR (McCoy, 1997). Its major strength lies in its ability to capture the feedback, shock transmission on variables having considered the economy concerned and the dynamic relationships among macroeconomic variables (Udoh 2009).

The study of Reynolds and Kolodziej (2009) will be adopted. Reynolds and Kolodziej (2009) conducted a study on North America to explore the gas supply and forecasting, their model is expanded to include gas prices as regards to natural gas price and liquefy natural gas price.

The structural model is adopted from the theoretical framework.

The endogenous linear equations can be explicitly specified as follows:

$A_oY_t = a + A_1Y_{t-1} + A_2Y_{t-2} + \dots + ApY_{t-1} + E_t$……………………… (1)

Yt = {GDP, GD, GS, NGP, LNGP} is an nx1 dimensional vector of endogeneous variables.

a = vector of constant term

$A_o, A_1 \dots\dots A_p$ = the matrix of the coefficients of the variables in the system

E_t = the vector of random disturbance error term, which are assume to be independently and identically distributed error term with zero mean and finite variance.

Note;

GDP is Gross Domestic Product

GD is Gas Demand

GS is Gas Supply

GRP is Gas Retail Price

PRP is Petroleum Retail Price

Under the condition that the inverse of the matrix $A_o$exists, the $SVAR_P$ can be expressed in a Reduced-Form VAR representation of the $SVAR_P$ as

$Y_t = b + B_1Y_{t-1} + B_2Y_{t-2} + \dots + BpY_{t-1} + U_t$…………………………… (2)

Note: the information about contemporaneous causal dependence is incorporated exclusively in the residuals (not modeled among the variables) in the ordinary VAR model, once its structure is identified and recovered, the estimation of the lagged autoregressive coefficients permits us to identify the SVAR model by placing the necessary restriction (Pfaff and Taunus, 2008). Nesting both the recursive and non-recursive schemes for proper model specification using the traditional Cholesky identification ordering and the alternative to the Cholesky's (non-recursive scheme) are presented equation (3) Here, all the endogenous and exogenous variables are all nested in the VAR model (Alessio et al. 2011).

$AY_t = A_1^*Y_{t-1} + \dots + A_p^*Y_{t-p} + B_p^*X_{t-p} + CD_t + B\lambda_t$ ………………………………….. (3)

The idea of equation (3) is to nest both the endogenous and exogenous variables in the system. The A's and B's are n x n coefficient matrices and C is the coefficient matrix associated with the possible deterministic terms D_t(Bates and Hachicha, 2009).

From equation (3), the reduced-form model can be deduced since the inverse of A exists.

$$Y_t = z_0 + z_1 Y_{t-1} + \cdots + z_p Y_{t-p} + w_0 X_{t-p} + \cdots + w_p X_{t-p} + v_t \quad \text{.............(4)}$$

$z_i \quad A_i^* \, (i = 0, 1 \ldots p) \quad w_i \quad B_i^* \, (i = 0, 1 \ldots p)$

and $=A^{-1}$

The relationship between the reduced-form VAR residual (v_t) and the SVAR residual ($B\lambda_t$) is called the AB-model and presented below.

From the above, the identification problem is solved by imposing restrictions on the A and B matrices assumed to be nonsingular. When B = I_n, we have A model as the required restrictions can now be imposed on the contemporaneous residual of matrix A in the AB-model in the E-views software statistic package. The contemporaneous residual relationship of the variables can now be modeled as:

$$GDP = \sum_{k=0}^{n} h_{11}(k)\varepsilon_{1t-k} + \sum_{k=0}^{n} h_{21}(k)\varepsilon_{2t-k} + \sum_{k=0}^{n} h_{31}(k)\varepsilon_{3t-k} + \sum_{k=0}^{n} h_{41}(k)\varepsilon_{41t-k} + \sum_{k=0}^{n} h_{51}(k)\varepsilon_{5t-k} \quad \text{..... (5)}$$

$$GD = \sum_{k=0}^{n} h_{11}(k)\varepsilon_{1t-k} + \sum_{k=0}^{n} h_{21}(k)\varepsilon_{2t-k} + \sum_{k=0}^{n} h_{31}(k)\varepsilon_{3t-k} + \sum_{k=0}^{n} h_{41}(k)\varepsilon_{41t-k} + \sum_{k=0}^{n} h_{51}(k)\varepsilon_{5t-k} \quad \text{..... (6)}$$

$$GS = \sum_{k=0}^{n} h_{11}(k)\varepsilon_{1t-k} + \sum_{k=0}^{n} h_{21}(k)\varepsilon_{2t-k} + \sum_{k=0}^{n} h_{31}(k)\varepsilon_{3t-k} + \sum_{k=0}^{n} h_{41}(k)\varepsilon_{41t-k} + \sum_{k=0}^{n} h_{51}(k)\varepsilon_{5t-k} \quad \text{..... (7)}$$

$$GRP = \sum_{k=0}^{n} h_{11}(k)\varepsilon_{1t-k} + \sum_{k=0}^{n} h_{21}(k)\varepsilon_{2t-k} + \sum_{k=0}^{n} h_{31}(k)\varepsilon_{3t-k} + \sum_{k=0}^{n} h_{41}(k)\varepsilon_{41t-k} + \sum_{k=0}^{n} h_{51}(k)\varepsilon_{5t-k} \quad \text{..... (8)}$$

$$PRP = \sum_{k=0}^{n} h_{11}(k)\varepsilon_{1t-k} + \sum_{k=0}^{n} h_{21}(k)\varepsilon_{2t-k} + \sum_{k=0}^{n} h_{31}(k)\varepsilon_{3t-k} + \sum_{k=0}^{n} h_{41}(k)\varepsilon_{41t-k} + \sum_{k=0}^{n} h_{51}(k)\varepsilon_{5t-k} \quad \text{..... (9)}$$

Thus, the SVAR equations above in a vector

$$\begin{pmatrix} GDP \\ GD \\ GS \\ GRP \\ PRP \end{pmatrix} = \begin{pmatrix} C_{11}(k) & C_{21}(k) & C_{31}(k) & C_{41}(k) & C_{51}(k) & C_{61}(k) \\ C_{12}(k) & C_{22}(k) & C_{32}(k) & C_{42}(k) & C_{52}(k) & C_{62}(k) \\ C_{13}(k) & C_{23}(k) & C_{33}(k) & C_{43}(k) & C_{53}(k) & C_{63}(k) \\ C_{14}(k) & C_{24}(k) & C_{34}(k) & C_{44}(k) & C_{54}(k) & C_{64}(k) \\ C_{15}(k) & C_{25}(k) & C_{35}(k) & C_{45}(k) & C_{55}(k) & C_{65}(k) \end{pmatrix} \begin{pmatrix} E_{1t} \\ E_{2t} \\ E_{3t} \\ E_{4t} \\ E_{5t} \end{pmatrix} \quad \text{.......(10)}$$

The E_{1t} are uncorrelated white noise disturbances and their individual coefficients are expressed as $C_{ij}(k)$. Equation 3.11 is compactly expressed as:

$$Yt = C(k)\, E_t \quad \text{..(11)}$$

In order to properly estimate the parameters in the SVAR, there is need to place some restrictions on the model.

	GDP	GD	GS	NGP	LNGP
GDP	1	0	0	0	0
GD	*	1	*	0	0
GS	*	*	1	0	0
GRP	*	0	0	1	*
PRP	*	*	0	0	1

The system above is identified with n(n-1)/2 zero restrictions on $A_{o.}$ The non-recursive restrictions above are over-identified. The restrictions placed were based on theory of how the economic variables relates with one another. The zero (0) elements are restrictions, while the asterisks (*) elements are the matrix estimated elements.

Variance Decomposition

Forecast error variance decomposition (FEVD) is an econometric tool used by many economists in the Vector autoregressive (VAR). It aids in the interpretation of a Vector autoregressive (VAR) model once it has been fitted. The variance decomposition indicates the amount of information each variable contributes to the other variables in the autoregressive. Also, it determines how much of the forecast error variance of each of the variables can be explained by exogenous shocks to the other variables.

Impulse Response Function

Impulse response function (IRF) of a dynamic system is its output when presented with a brief input signal. An impulse response, generally, is the reaction of any dynamic system in response to an external shock.

Stability Tests

Stability test is performed to ascertain whether the estimated SVAR model is stable or not. The estimates of SVAR model are valid if the estimated SVAR model is stable. The test of stability of the estimated SVAR will be achieved using the autoregressive (AR) root test. The AR roots report the inverse roots of the characteristic AR polynomial indicating whether the estimated SVAR equation is stable or not. If all roots have modulus less than one and lie inside the unit circle, then the estimated SVAR is stable. Assuming the estimated SVAR equation is not stable, the impulse response standard errors result would be invalid and the variance decomposition is inefficient (Lütkepohl, 2007).

Data

The Study employed time series data on Nigeria's selected macroeconomic variables (Gas Demand, Gas Supply, Gas Price and GDP) covering the period 1996 – 2018 on a monthly basis which represents sample 324 months. In specific terms, the data employed represent series from January 1996 to December 2018. The series for Gas Demand

and Gas supply was sourced from the statistical review of word energy. Gas Retail Price and was sourced from the CBN Annual Report (various editions). GDP was sourced from the CBN statistical bulletin 2018. It should be noted that the series were obtained in Quarterly form but was sliced to monthly using the cubic spleen method incorporated in R console 3.4.1.

4.0 Data Analysis and interpretation of result

The data were analyzed with R console 3.4.1 and Econometric views (E-views) 9.0 using various econometric techniques to determine the direction of interaction amongst the variables under consideration. Graphical analysis was carried out in order to observe trend flows in the variables under consideration. Diagnostic tests were conducted on the data to be sure the data were valid enough for relevant inferences.

4.1 Descriptive Statistics and Trend Analysis

Table 1 shows the descriptive statistics of the variables in the study. The descriptive analysis gives the characteristics and properties of the time series in terms of mean, median, maximum and minimum values, coefficients of variation etcetera. The trend analysis shows the behavior of each variable over the time.

Table 4.1: Descriptive Statistics

	GD	GDP	GRP	GS	PRP
Mean	2.473842	37700.85	5.721007	25.93286	9.443409
Median	2.557986	28745.90	5.795196	26.16161	7.361769
Maximum	3.715225	97624.56	11.25137	43.93682	16.94025
Minimum	1.229295	3669.142	1.457337	3.780215	2.759878
Std. Dev.	0.734715	32140.07	3.077885	13.19985	5.149124
Skewness	-0.182509	0.598733	0.102578	-0.365693	0.247010
Kurtosis	1.811432	1.907734	1.597036	1.719438	1.376479
Jarque-Bera	16.23230*	27.58317*	21.10917*	22.83501**	30.23871*
Probability	0.234529	0.236501	0.355026	0.040211	0.895431
Sum	623.4081	9500615.	1441.694	6535.082	2379.739
Sum Sq.	135.4915	2.59E+11	2377.818	43733.22	6654.882
Observations	280	280	280	280	280

Note: * = 1per cent level of significance; ** = 5per cent level of significance; *** = 10per cent level of significance

Source: *Computed using E-Views 9 Software Package*

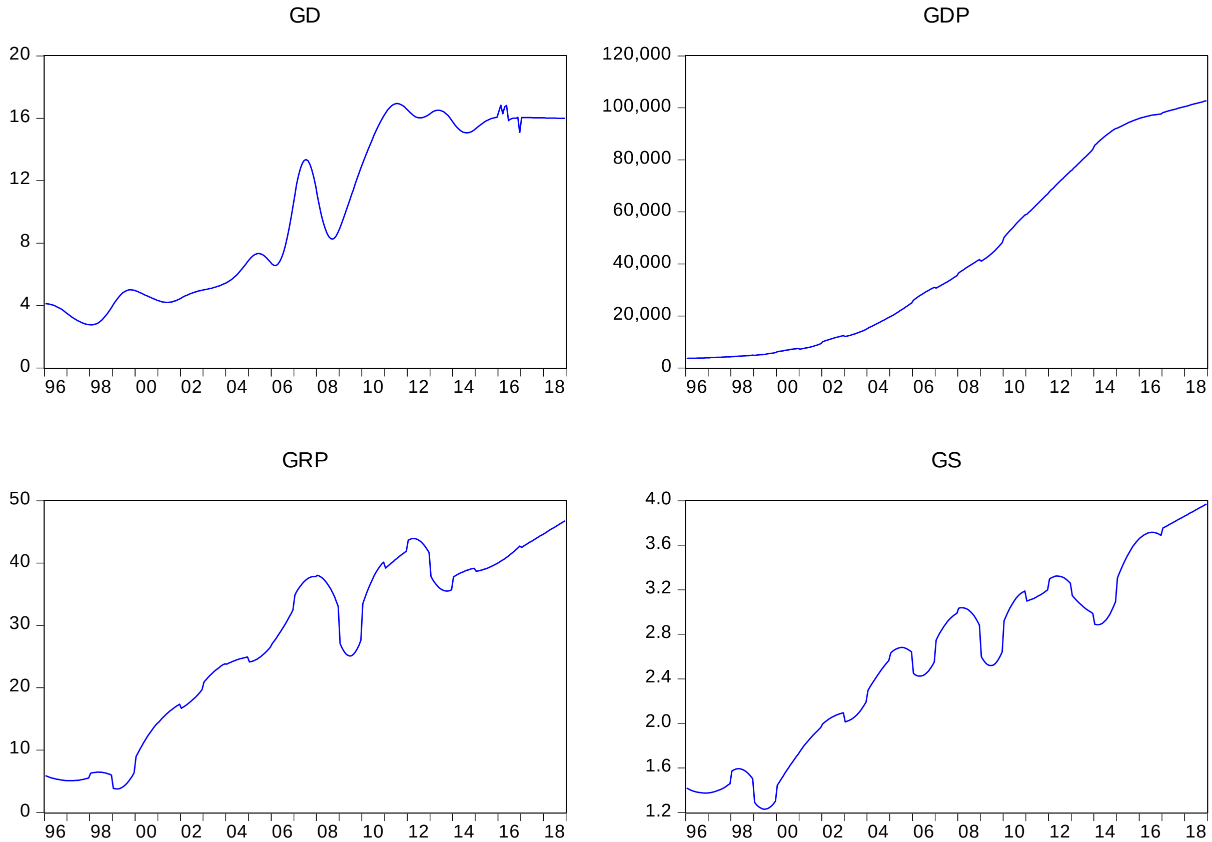


Figure 1. Graphical Trend on Data

From figure 1, all the variables fluctuate over the period investigated except GDP that exhibit an upward trend from 1996 January to 2019 December.

4.2 Unit Root Tests

The results of the unit root tests is shown in Table 4.2

Table 4.2: Unit root test using the SIC and Newey-West Bandwidth Criterion

Variables	ADF Test Statistic	Longest Lag	Order of Integration	PP Test Statistic	Longest Bandwidth	Order of Integration
GDP	-3.974267*	14	I(0)	-3.714131*	4	I(0)
GD	-11.11705*	14	I(1)	-10.95364*	5	I(1)
GS	-20.03443*	14	I(1)	-19.98948*	1	I(1)
GRP	-13.83175*	14	I(1)	-13.88077*	4	I(1)
PRP	-3.546240*	14	I(0)	-3.823885*	4	I(0)

Note: *= 1per cent level of significance; ** = 5per cent level of significance; *** = 10per cent level of Significance

Source: *Computed using R console 3.4.1 Software Package*

As seen in table 4.2, Augmented Dickey Fuller (ADF) test for stationarity at various lag lengths using selected by the SIC criterion shows that GD, GS and GRP are not stationary at their levels but stationary at their first difference, while GDP and PRP arestationary at their level. The Philip Perron (PP) test confirms the same results. Thus, we can conclude that the series are integrated of order one, I(1). In addition, the results suggest that the variables need to be transformed in order to be devoid of spuriousness.

4.3 Co-integration

With the observation that all the variables were stationary at their levels, a co-integration test becomes a necessity. This test is carried out using the Johansen approach. *Table 4.3*is an extract from the co-integration result.

Table 4.3: Cointegration Test

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.46253	361.1595	95.75366	0
At most 1 *	0.356925	236.983	69.81889	0
At most 2 *	0.272348	148.6844	47.85613	0
At most 3 *	0.217986	85.0978	29.79707	0
At most 4 *	0.110609	35.92124	15.49471	0

Source: *Computed using R console 3.4.1 Software Package*

Table 4.3 shows co-integration result using Johansen Co-integration test. The result indicates 5 co-integrating equations, which means that all the variables are co-integrated at 1% level of significance; indicating the existence of a long-run equilibrium relationship among the variables.

4.4 VAR Lag Order Selection Criteria

Table 4.4: Lag Length Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-4412.980	NA	3.67e+09	36.21295	36.28462	36.24182
1	-1399.453	5878.849	0.084373	11.71683	12.14681	11.89000
2	-1197.685	385.3431	0.019818	10.26791	11.05621*	10.58539
3	-1150.967	87.30919	0.016597	10.08989	11.23651	10.55169
4	-1098.242	96.37367*	0.013239*	9.862643*	11.36757	10.46874*
5	-1085.745	22.33220	0.014696	9.965119	11.82836	10.71553
6	-1077.328	14.69519	0.016883	10.10105	12.32261	10.99577
7	-1069.830	12.78243	0.019565	10.24451	12.82439	11.28354
8	-1063.426	10.65586	0.022906	10.39694	13.33513	11.58028

Source: *Computed using E-Views 9 Software Package*

In order to properly estimate VAR model which is an input in estimating SVAR model, it is necessary to get the optimal lag length using Lag length selection criteria. Lag length selection criteria of VAR starts with the specification of maximum lag of 8. An asterisk (*) indicates the selected lag from each column of the criterion statistic. From the result as shown in table 4.6, we considered the fourth (4) lag length as the optimal lag length for each endogenous variable based on the Schwarz information criterion (SIC). Schwarz information criterion is chosen because it has been shown to have a higher degree of precision when compared to other criteria such as the Akaike information criterion (AIC).

4.5. Estimated Vector Autoregressive (VAR) Model.

Table 4.5 shows VAR estimates considering the fourth lag length selected based on SIC.

Table 4.5 VAR Estimates

Vector Autoregression Estimates
Date: 09/03/17 Time: 08:16
Sample (adjusted): 1996M05 2016M12
Included observations: 248 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	GDP	GD	GS	GRP	PRP
GDP(-1)	1.321908	1.99E-06	-1.26E-05	-7.14E-06	3.27E-05
	(0.08733)	(2.1E-05)	(0.00035)	(0.00017)	(6.2E-05)
	[15.1367]	[0.09571]	[-0.03627]	[-0.04098]	[0.52542]
GDP(-2)	-0.044809	-4.23E-08	4.65E-05	2.82E-05	2.57E-05
	(0.14788)	(3.5E-05)	(0.00059)	(0.00029)	(0.00011)
	[-0.30302]	[-0.00120]	[0.07908]	[0.09566]	[0.24374]
GDP(-3)	-0.021378	-4.44E-07	4.42E-05	3.76E-05	2.54E-05
	(0.14791)	(3.5E-05)	(0.00059)	(0.00029)	(0.00011)
	[-0.14453]	[-0.01261]	[0.07516]	[0.12752]	[0.24131]
GDP(-4)	-0.260594	-8.86E-07	-7.99E-05	-6.78E-05	-7.85E-05
	(0.08789)	(2.1E-05)	(0.00035)	(0.00018)	(6.3E-05)
	[-2.96504]	[-0.04229]	[-0.22851]	[-0.38686]	[-1.25437]
GD(-1)	259.8283	1.124544	-0.431044	0.314202	0.046957
	(402.031)	(0.09579)	(1.59947)	(0.80177)	(0.28625)
	[0.64629]	[11.7400]	[-0.26949]	[0.39189]	[0.16404]
GD(-2)	-71.11336	-0.032168	-0.100035	-0.063743	-0.112874
	(618.939)	(0.14747)	(2.46243)	(1.23435)	(0.44069)
	[-0.11490]	[-0.21814]	[-0.04062]	[-0.05164]	[-0.25613]

GD(-3)	-60.17829	-0.021433	-0.115805	-0.091042	-0.081539
	(618.951)	(0.14747)	(2.46248)	(1.23437)	(0.44070)
	[-0.09723]	[-0.14534]	[-0.04703]	[-0.07376]	[-0.18502]
GD(-4)	-29.74355	-0.128096	0.692534	0.178705	-0.007258
	(396.828)	(0.09455)	(1.57877)	(0.79139)	(0.28255)
	[-0.07495]	[-1.35483]	[0.43865]	[0.22581]	[-0.02569]
GS(-1)	-26.22547	0.002130	1.223078	-0.004219	-0.004115
	(27.5450)	(0.00656)	(0.10959)	(0.05493)	(0.01961)
	[-0.95210]	[0.32449]	[11.1608]	[-0.07681]	[-0.20982]
GS(-2)	0.668471	-0.000549	-0.049514	-0.003819	0.002599
	(44.6510)	(0.01064)	(0.17764)	(0.08905)	(0.03179)
	[0.01497]	[-0.05156]	[-0.27873]	[-0.04289]	[0.08174]
GS(-3)	-1.350309	-0.000517	-0.036140	-0.003342	0.001386
	(44.6560)	(0.01064)	(0.17766)	(0.08906)	(0.03180)
	[-0.03024]	[-0.04860]	[-0.20342]	[-0.03752]	[0.04359]
GS(-4)	23.22691	0.002509	-0.144750	0.010575	0.007382
	(27.9394)	(0.00666)	(0.11116)	(0.05572)	(0.01989)
	[0.83133]	[0.37690]	[-1.30222]	[0.18979]	[0.37109]
GRP(-1)	-57.53994	-0.001605	-0.063623	1.024342	-0.002165
	(38.1002)	(0.00908)	(0.15158)	(0.07598)	(0.02713)
	[-1.51023]	[-0.17686]	[-0.41973]	[13.4812]	[-0.07982]
GRP(-2)	7.318828	0.000500	0.011005	-0.024609	0.014404
	(56.1811)	(0.01339)	(0.22351)	(0.11204)	(0.04000)
	[0.13027]	[0.03737]	[0.04923]	[-0.21964]	[0.36008]
GRP(-3)	4.577136	0.000392	0.006834	-0.014725	0.009949
	(56.1775)	(0.01338)	(0.22350)	(0.11203)	(0.04000)
	[0.08148]	[0.02930]	[0.03058]	[-0.13143]	[0.24872]
GRP(-4)	36.47983	-0.005859	-0.017339	-0.085245	-0.004748
	(37.3988)	(0.00891)	(0.14879)	(0.07458)	(0.02663)
	[0.97543]	[-0.65749]	[-0.11653]	[-1.14294]	[-0.17832]
PRP(-1)	-29.32126	0.005346	0.042775	-0.190161	1.285737
	(89.4218)	(0.02131)	(0.35576)	(0.17833)	(0.06367)
	[-0.32790]	[0.25093]	[0.12024]	[-1.06632]	[20.1940]
PRP(-2)	27.30542	-0.000292	0.043572	0.057452	-0.202302

	(157.711)	(0.03758)	(0.62745)	(0.31452)	(0.11229)
	[0.17314]	[-0.00776]	[0.06944]	[0.18266]	[-1.80157]
PRP(-3)	26.27159	0.002085	0.092583	0.036699	0.470037
	(157.991)	(0.03764)	(0.62856)	(0.31508)	(0.11249)
	[0.16629]	[0.05538]	[0.14729]	[0.11647]	[4.17844]
PRP(-4)	8.471941	-0.008665	-0.132393	0.156764	-0.600364
	(93.9920)	(0.02239)	(0.37394)	(0.18745)	(0.06692)
	[0.09013]	[-0.38694]	[-0.35405]	[0.83631]	[-8.97092]
C	-156.7014	0.080443	0.102033	-0.456684	0.275179
	(108.204)	(0.02578)	(0.43049)	(0.21579)	(0.07704)
	[-1.44820]	[3.12029]	[0.23702]	[-2.11633]	[3.57179]
R-squared	0.999975	0.997201	0.997573	0.988915	0.999500
Adj. R-squared	0.999972	0.996954	0.997359	0.987939	0.999456
Sum sq. resids	6453024.	0.366318	102.1399	25.66510	3.271423
S.E. equation	168.6043	0.040171	0.670787	0.336247	0.120048
F-statistic	447758.4	4043.503	4664.275	1012.593	22674.61
Log likelihood	-1612.559	456.2957	-241.8982	-70.62797	184.8005
Akaike AIC	13.17386	-3.510449	2.120147	0.738935	-1.320972
Schwarz SC	13.47137	-3.212941	2.417655	1.036443	-1.023464
Mean dependent	38249.33	2.491041	26.25849	5.784221	9.529604
S.D. dependent	32104.26	0.727898	13.05182	3.061702	5.145180

Determinant resid covariance (dof adj.)	0.008041
Determinant resid covariance	0.005166
Log likelihood	-1106.552
Akaike information criterion	9.770581
Schwarz criterion	11.25812

Source: *Computed using E-Views 9 Software Package*

Table 4.5 presents the estimates of VAR model. The decision not to give the practical interpretation of the result above is due to the fact that it serves as an input to the estimation of Structural Vector Autoregressive (SVAR) which is our main model.

4.6. Estimated Structural Vector Autoregressive (SVAR) Model.

Table 4.6: SVAR Estimates

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	477.8454	23.83276	20.04994	0
C(2)	32.8879	1.640299	20.04994	0
C(3)	6.859805	0.342136	20.04994	0
C(4)	-1.62778	0.081186	-20.0499	0
C(5)	-0.49773	0.024825	-20.0499	0
C(6)	22.08835	1.101667	20.04994	0
C(7)	0.168989	0.071535	2.362335	0.0182
C(8)	-0.14376	0.07129	-2.01652	0.0437
C(9)	0.07026	0.070767	0.99282	0.3208
C(10)	0.00908	0.070647	0.12854	0.8977
Log likelihood	1197.761			
LR test for over-identification:				
Chi-square(3)	0.254855	Probability		0.9683

Extimates of Matrix A					
GDP		**GD**	**GS**	**GRP**	**PRP**
GDP	477.8454	0	0	0	0
GD	0	32.8879	0	0	0
GS	0	0	6.859805	0	0
GRP	0	0	0	-1.62778	0
PRP	0	0	0	0	-0.49773

Extimates of Matrix B					
GDP		**GD**	**GS**	**GRP**	**PRP**
GDP	1	22.08835	0	0	0
GD	0	1	0	-0.14376	0.168989
GS	0	-0.02961	1	0	0
GRP	0	0.07026	0.00908	1	0
PRP	0	0	0	0	1

Source: *Computed using E-Views 9 Software Package*

The equations below are extracted from table 4.8:

GDP = 477.8454 + 22.08835GD (4.1)

Prob. (0.0000) (0.0000)

GD = 32.8879 – 0.14376GRP + 0.168989PRP (4.2)

Prob. (0.0000) (0.0437) (0.0182)

GRP = -1.62778 + 0.07025GD + 0.00908GS (4.3)

Prob. (0.0000) (0.3208) (0.8977)

Where:

GDP is Gross Domestic Product

GD is Gas Demand

GS is Gas Supply

GRP is Gas Retail Price

PRP is Petroleum Retail Price

The structural VAR model is interpreted as follows;

A unit change in Gas Demand (GD), will results in increase in GDP by approximately 22.08835 units, while holding other variables constant. The positive sign on gas Demand (GD)fulfilled the*apriori* expectation. With an increase in gas demand, more output will be produced. The lower probability value of 0.0000 when compared to the conventional level of significance of 0.05 (5 percent level) denotes the impact is significant.

A unit change in Gas retail Price (GRP), while holding other variables constant will lead to decrease in Gas Demand (GD) by 0.1437 unit. The results satisfy basic economic *apriori* reasoning of inverse demand price relationship. The change is significant judging by the probability value of 0.0437 which is lower than the conventional level of significance of 0.05.

A unit increase Petroleum Retail Price(PRP) will increase Gas Demand (GD) by approximately 1.68989 units, with other variables being held constant. The PRP coefficient is not significant considering the probability value of 0.0182 which is higher than the conventional level of significance of 0.05.

A unit change in Gas Demand (GD) with other variables held constant will increase Gas Prices (GP) by approximately 0.07025 units. The probability value of 0.3208 is higher than the conventional level of significance (0.05), which means the Gas Demand (GD) coefficient is insignificant.

Gas Price will increase by approximately 0.00908unit if there is a unit increase in Gas Supply (GS) with other variables held constant. This result does not follow the law of demand and supply which stats that the higher the supply the lower the price, the reason could be because gas is an essential commodity for cooking and thus may not follows the law of demand and supply as consumers may still buy gas even when the price is increasing as it is superior to most forms of cooking energy. The impact of a unit change in GS is insignificant as shown by the probability value of 0.8977 which is higher than the conventional level of significance of 0.05.

4.7 SVAR Forecast Error variance decomposition

Table 4.7 Variance Decomposition

Variance Decomposition of GDP: Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5
1	176.4030	76.35688	23.64312	0.000000	0.000000	0.000000
2	333.3528	80.23185	18.19875	0.202867	1.363006	0.003531
3	489.4533	80.41804	15.85986	0.477607	3.224024	0.020474
4	640.4417	79.51213	14.79155	0.713520	4.833771	0.149029
5	784.8135	78.30123	14.30456	0.890516	6.057735	0.445954

Variance Decomposition of GD:

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5
1	0.040281	0.000000	20.56155	78.98978	0.000000	0.448668
2	0.063098	0.000135	19.90387	79.34254	0.019110	0.734342
3	0.079059	0.000203	17.96505	80.67585	0.287282	1.071616
4	0.090919	0.002020	15.66660	81.69734	1.103507	1.530530
5	0.100453	0.008530	13.43713	81.75557	2.652672	2.146106

Variance Decomposition of GRP:

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5
1	0.367236	0.000000	96.78716	3.16E-09	3.212836	0.000000
2	0.549807	0.002202	94.93580	0.040105	3.370019	1.651876
3	0.683220	0.008982	92.38554	0.125647	3.312338	4.167494
4	0.786371	0.069501	90.05432	0.261199	3.150256	6.464724
5	0.866890	0.207338	88.26705	0.461882	2.959771	8.103962

Source: *Computed using E-Views 9 Software Package*

Variance decomposition indicates the amount of information each variable contributes to the other variables in the autoregressive. It determines how much of theforecast error variance of each of the variables can be explained by exogenous shocks to the other variables.It is generated from the estimated SVAR. *Table 4.7*considering five periods.Shock1 represent GDP, Shock2 represent GD, shock3 represent GRP, shock4 represent GS, and Shock5 represent PRP. From the variance decomposition for GDP, Gas Demand (GD) contributes the most to the variations in GDP followed by Gas Supply. From the Variance decomposition for Gas Demand (GD), Gas Retail Price (GRP) contributes the most to the variations in Gas Demand. Finally, from the variance decomposition of GRP (Gas Retail Price), Gas Demand (GD) contributes the most to the variations in Gas Retail Price (GRP).

4.8 Impulse Response Function

Impulse is an unexpected shock on an economy variable, the reaction of another economy variable to the impulse is referred to as response; it is derived from the estimated SVAR. Just like the Variance Decomposition, Shock1 represent GDP, Shock2 represent GD, shock3 represent GRP, shock4 represent GS, and Shock5 represent PRP.Impulse Response Function (IRF) graphical representation for five periods is given as:

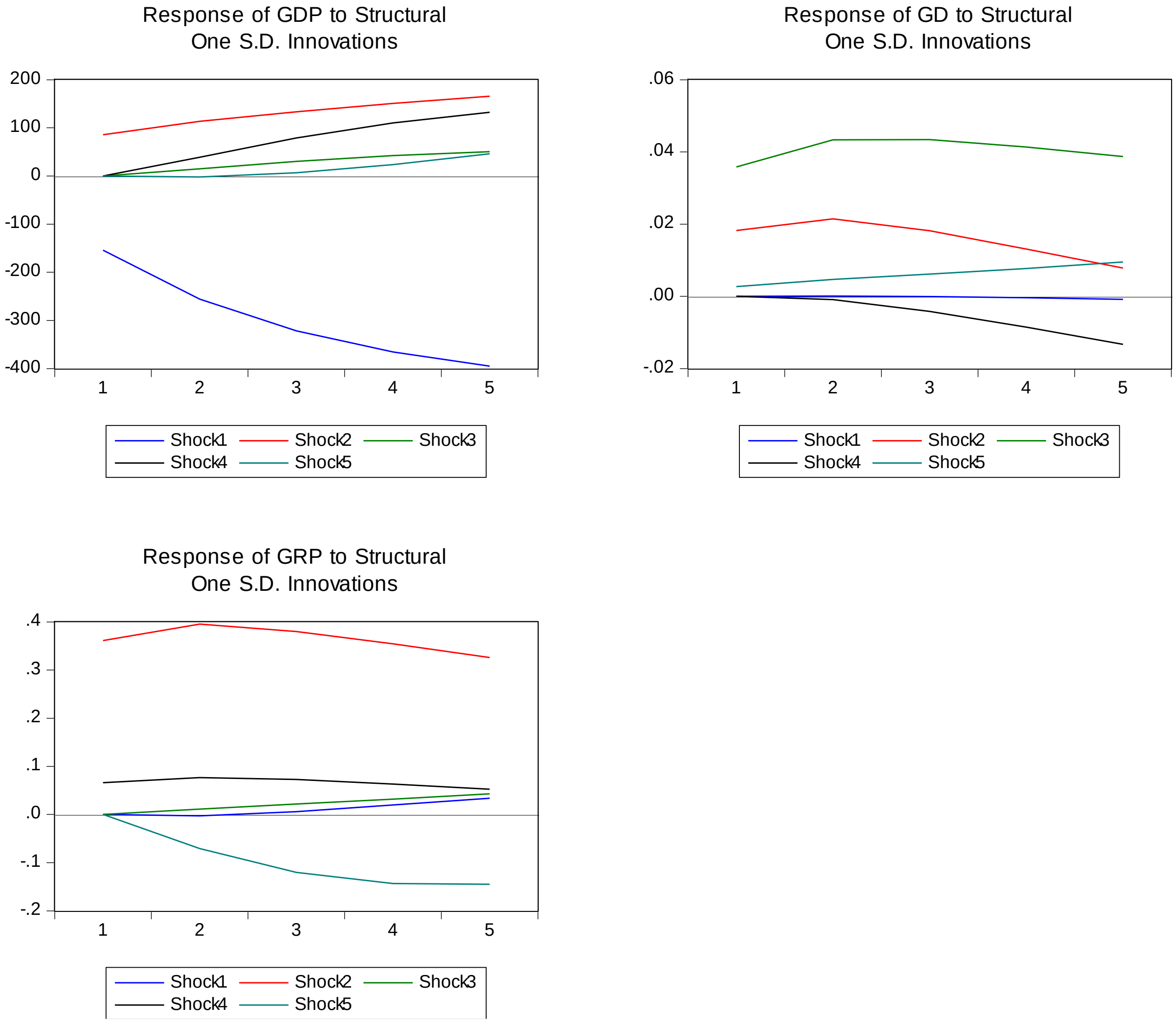


Figure 4.2 ***Source:*** *Computed using E-Views 9 Software Package*

From GDP impulse response graph, GDP respond positively to changes in the variable but negatively to changes in GDP itself over the five periods. From Gas Demand (GD) impulse response graph, GD respond positively to changes in GDP, GS and GRP but negatively to changes in Petroleum Retail Price (PRP). From Gas Retail Price (GRP) impulse response function, GRP respond positively to changes in the variables under study except Gas Supply (GS).

4.9 Granger Causality Test

Table 4.8 Causality Test

Null Hypothesis (H0)	Chi-Square	Probability	Decision
GD does not cause GDP	10.51789	0.0917	Reject Ho
GDP does not cause GD	13.74877	0.0081	Reject Ho
GRP does not cause GD	14.90053	0.0877	Reject Ho
GD does not cause GRP	10.60593	0.0314	Reject Ho
GRP does not cause GDP	4.986681	0.2887	Accept Ho
GDP does not cause GRP	10.96944	0.0269	Reject Ho

Source: Author's Computation

Table 4.8 is granger causality test it illustrate the direction of causality among the variables under study. From the table 4.8, there is bi causality between GDP and GD (Gas Demand). This means that gas demand Granger causes GDP and GDP Granger cause Gas Demand.

There is two-way causality between GRP (Gas Retail Price) and GD (Gas Demand); this means that Gas Retail Price Granger cause Gas Demand and Gas Demand Granger cause Gas Retail Price.

There is one way causality between GRP (Gas Retail Price) and GDP. The causality flows from GDP to Gas Retail Price. This means that GDP granger cause Gas Retail Price.

4.10 Post Estimation

It is a necessity to test the SVAR model for stability to validate the Impulse response function and variance decomposition results. This can be done using the AR Root method. The conditions to declare a model stable using AR roots are: all roots must lie within the polynomial bound and the roots must be less than one. Below is the tabular and graphical representation of the AR Roots test.

Table 4.9: SVAR Stability Test

Roots of Characteristic Polynomial	
Endogenous variables: GDP GD GRP GS PRP	
Exogenous variables: C	
Root	Modulus
0.898715	0.898715
0.851265	0.851265
0.565784	0.565784
-0.331091	0.331091
0.216677	0.216677
-0.039658	0.039658
No root lies outside the unit circle.	
VAR satisfies the stability condition.	

This shows that values of the roots are less than unity. Also, the modulus values are also less than unity and the inverse roots of the AR characteristic polynomials lie within the unit circle. This is as shown in table 4.9. Based on these observations we conclude that the estimated SVAR model is stable.

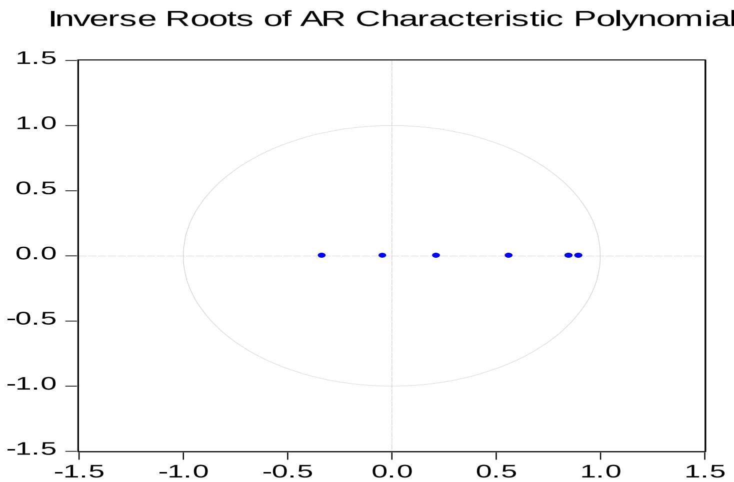


Figure 4.3 AR Stability Test

The laying of all the roots within the polynomial is an indication that the model is good and stable and can be used for forecasting and policy decision.

6.0 Conclusion and Recommendations

The research empirically established the significant impact of gas demand on national output and it is observed that gas price significantly determine gas demand in Nigeria during the periodunder consideration. The result of Structural VAR model and Granger Causality indicate that Gas Demand significantly affects GDP and Gas Price significantly affects Gas Demand. Also petroleum retail price significantly affect Gas Demand positively, indicating that the higher the price of petrol the higher the gas demand as consumers will substitute gas for petroleum product. Impulse Response and Variance Decompositionall show that variation in GDP is caused by changes in Gas demand compared to the other variables under study. Thus, the study recommends that government should strive to make Gas available since it has a positive impact on GDP. Also gas retail price should be regulated to promote more gas demand in the country. Gas supply should be increased to meet the rising gas demand so as to avoid escalating gas prices which will hamper energy access to the populace.

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