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Gas Price and Gas Demand: An Implication on 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 was investigated using the structural vector auto-regressive (SVAR) model. Time series monthly data were collected from 1996 -2016 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 test indicated 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. The causality analysis indicates that feedback hypothesis is validated between gas demand and national output which indicates that adoption of energy conservation policies should be discouraged.

INTRODUCTION

The Gas sub-sector is recognised as a key asset 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 and 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 with 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. 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 gas price, gas demand and GDP in Nigeria.

EMPIRICAL REVIEW AND THEORETICAL CONSIDERATIONS

Concept of Natural Gas

Natural gas is a naturally occurring hydrocarbon gas mixture mainly consisting of methane and also contains varying amounts of other higher alkanes, carbon dioxide, nitrogen, hydrogen sulphide, or helium. It is formed when layers of decomposing plant and animal matter are exposed to intense heat and pressure under the surface of the Earth over millions of years. The energy that the plants originally obtained from the sun is stored in the form of chemical bonds in the gas. It is classified into associated gas or wet gas, that is natural gas found in reservoirs that contain petroleum; and non-associated or dry gas which is found in reservoirs that do not contain any petroleum liquid.

Empirical Review

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 regards that there exists 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 that there exists 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 and research have been carried out on linkage between 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 for 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. As such there is a dearth on literature and empirical evidence Pertaining natural gas and 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 period from 1980 to2006, they find evidence of unidirectional causality running from natural gas consumption to economic growth.

Yang (2013) also conducted a study Taiwan's time series data period 1980-2007, and discovered a one-way Granger causality from natural gas consumption to economic growth, but no co-integration between two variables. The consumption of aggregate as well as different types of energy including coal, oil, natural gas and electricity. Yang's results suggest one directional causality between total gas consumption and GDP, but a unidirectional causality from natural gas consumption to GDP.

Theoretical Considerations

The Nigerian Gas industry is an oligopolistic in nature. The Nigerian gas sector's ownership of national reserve is in the hands of a few integrated suppliers. They are Shell, ChevronTexaco, ExxonMobil, Elf and Agip, and are regulated under a subsidiary of the NNPC the Nigerian Gas Company (NGMP, 2005). The sector also features huge sunk costs, long term gas supply agreements, and barriers to entry as there are no third party access rules in place. In essence, the current structure of the sector is not ready to handle sudden increase in domestic demand.

The theoretical framework is the energy production function theory. Mainstream economists usually think of capital, labor, 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 oil deposits. But these are not given an explicit role in the standard growth theories, which focus on labor and capital. However, capital, labor, 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 (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.

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 (2013) will be adopted. Reynolds and Kolodziej (2013) conducted a study on Russia to explore the linkage between gas demand and output, their model is expanded to include gas prices as regards 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:

$$A_oY_t = a + A_1Y_{t-1} + A_2Y_{t-2} + \dots + ApY_{t-1} + E_t \qquad (4.1)$$

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

a = vector of constant term

A_o, A_1.......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 $SVAR_P$

The contemporaneous residual relationship of the variables can now be modeled as:

$$GDP = \sum_{k=0}^{n} h_{11}(k)\varepsilon_{1t-k} + \sum_{k=0}^{n} h_{21}(k)\varepsilon_{2t-k} + \sum_{k=0}^{n} h_{31}(k)\varepsilon_{3t-k} + \sum_{k=0}^{n} h_{41}(k)\varepsilon_{41t-k} + \sum_{k=0}^{n} h_{51}(k)\varepsilon_{5t-k} \qquad (4.5)$$

$$GD = \sum_{k=0}^{n} h_{11}(k)\varepsilon_{1t-k} + \sum_{k=0}^{n} h_{21}(k)\varepsilon_{2t-k} + \sum_{k=0}^{n} h_{31}(k)\varepsilon_{3t-k} + \sum_{k=0}^{n} h_{41}(k)\varepsilon_{41t-k} + \sum_{k=0}^{n} h_{51}(k)\varepsilon_{5t-k} \qquad (4.6)$$

$$GS = \sum_{k=0}^{n} h_{11}(k)\varepsilon_{1t-k} + \sum_{k=0}^{n} h_{21}(k)\varepsilon_{2t-k} + \sum_{k=0}^{n} h_{31}(k)\varepsilon_{3t-k} + \sum_{k=0}^{n} h_{41}(k)\varepsilon_{41t-k} + \sum_{k=0}^{n} h_{51}(k)\varepsilon_{5t-k} \qquad (4.7)$$

$$GRP = \sum_{k=0}^{n} h_{11}(k)\varepsilon_{1t-k} + \sum_{k=0}^{n} h_{21}(k)\varepsilon_{2t-k} + \sum_{k=0}^{n} h_{31}(k)\varepsilon_{3t-k} + \sum_{k=0}^{n} h_{41}(k)\varepsilon_{41t-k} + \sum_{k=0}^{n} h_{51}(k)\varepsilon_{5t-k} \qquad (4.8)$$

$$PRP = \sum_{k=0}^{n} h_{11}(k)\varepsilon_{1t-k} + \sum_{k=0}^{n} h_{21}(k)\varepsilon_{2t-k} + \sum_{k=0}^{n} h_{31}(k)\varepsilon_{3t-k} + \sum_{k=0}^{n} h_{41}(k)\varepsilon_{41t-k} + \sum_{k=0}^{n} h_{51}(k)\varepsilon_{5t-k} \qquad (4.9)$$

Thus, the SVAR equations above in a vector

$$\begin{pmatrix} GDP \\ GD \\ GS \\ GRP \end{pmatrix} = \begin{pmatrix} C_{11}(k) & C_{21}(k) & C_{31}(k) & C_{41}(k) & C_{51}(k) & C_{61}(k) & E_{1t} \\ C_{12}(k) & C_{22}(k) & C_{32}(k) & C_{42}(k) & C_{52}(k) & C_{62}(k) & E_{2t} \\ C_{13}(k) & C_{23}(k) & C_{33}(k) & C_{43}(k) & C_{53}(k) & C_{63}(k) & E_{3t} \\ C_{14}(k) & C_{24}(k) & C_{34}(k) & C_{44}(k) & C_{54}(k) & C_{64}(k) & E_{4} \end{pmatrix} \qquad (4.10)$$

PRP $C_{15}(k)$ $C_{25}(k)$ $C_{35}(k)$ $C_{45}(k)$ $C_{55}(k)$ $C_{65}(k)$ E_{5t}

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:

$Yt = C(k)\ E_t$..........(4.11)

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 is over-identified. The restrictions placed were based on theory of how the economics variables relates with one another. The zero (0) elements are restrictions, while the asterisks (*) elements are the matrix estimated elements.

Data Requirement

The Study employed time series data on Nigeria's selected macroeconomic variables (Gas Demand, Gas Supply, Gas Price and GDP) covering the period of 1996 – 2016 on a monthly basis which represents sample period of 252 months. In specific terms, the data employed represent series from January 1996 to December 2016. 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 2016. 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.

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 to be made. The model was then estimated and interpretations of major findings were made.

Descriptive Statistics and Trend Analysis

Table 4.1: 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. D	135.4915	2.59E+11	2377.818	43733.22	6654.882
Observations	252	252	252	252	252

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

Source: *Computed using E-Views 9 Software Package (2018)*

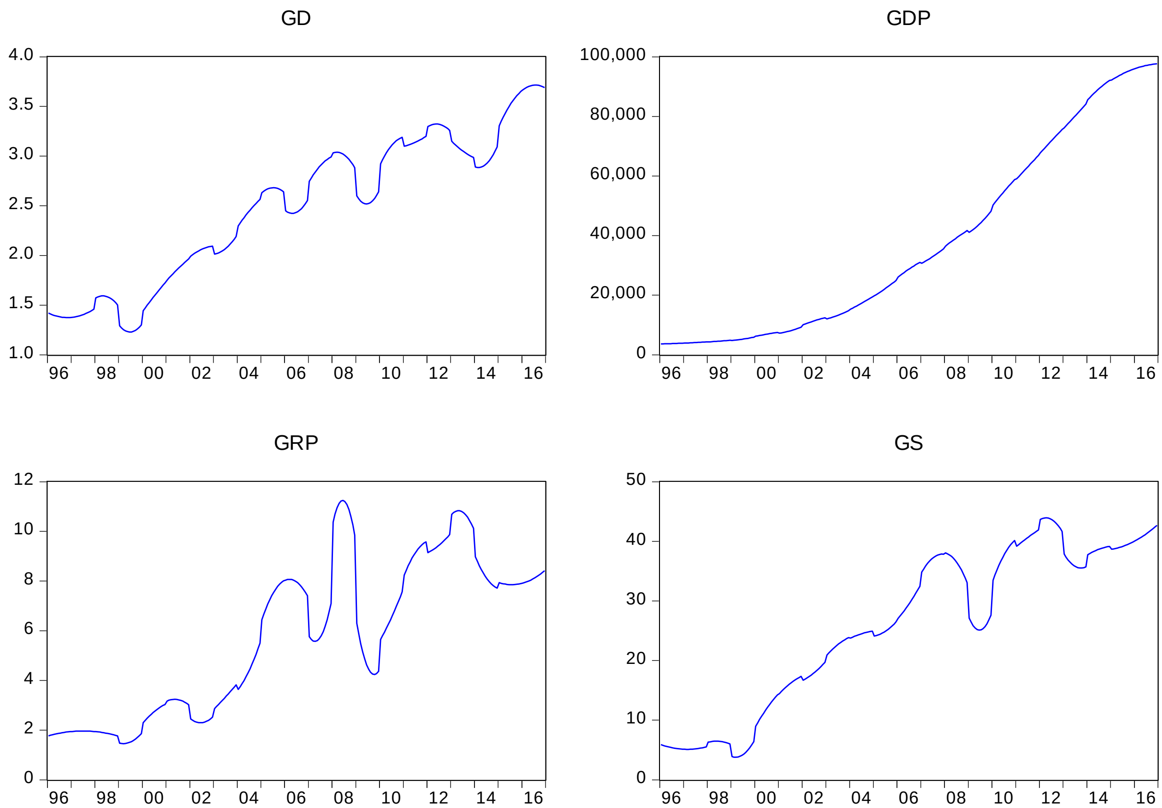

Figure 1. Graphical Trend on Data

From figure 1, all the variables fluctuate over the period investigated except GDP that exhibit an upward trend from 1996 January to 2016 December.

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 (2018)*

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 porousness.

Co-integration

With the observation of some of the variables have unit root problem, that is, not 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: Co-integration 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 (2018)*

Table 4.3 shows co-integration result using Johansen Co-integration test. The result indicates 5 co-integrating equation indicating that all the variables are co-integrated at 1% level of significance. This result indicate that there exist a long-run equilibrium relationship among the variables under study.

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 (2018)*

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 asterik (*) indicates the selected lag from each column of the criterion statistic. From the result 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 criterions such as the Akaike information criterion (AIC).

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 (2018)*

The equations below are extracted from table 4.8:

$$GDP = 477.8454 + 22.08835GD \quad (4.1)$$

$$GD = 32.8879 - 0.14376GRP + 0.168989PRP \quad (4.2)$$

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

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) signify apriori expectation. With an increase in gas demand, more output will be produced. The lower probability value when compared to the conventional level of significance 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 which is lower than the conventional level of significance.

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 which is higher than the conventional level of significance.

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 is higher than the conventional level of significance, which means the Gas Demand (GD) coefficient is insignificant.

Gas Price will increase by approximately 0.00908unit if there is a unit change in Gas Supply (GS) with other variables held constant. The impact of a unit change in GS is insignificant as shown by the probability value, it is higher than the conventional level of significance.

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 (2018)*

Table 4.5 is granger causality test it illustrate the direction of causality among the variables under study. From the table 4.5, there is bi causality between GDP and GD (Gas Demand). This means that gas demand Granger cause 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 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.

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 scope under consideration. The result of Structural VAR model and Granger Causality indicate that Gas Demand significantly affect GDP and Gas Price significantly affect 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 Decomposition all show that variation in GDP is caused by changes in Gas demand compared to the other variables under study. Thus it recommended that government should strive to make Gas Demand 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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