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Estimating and Forecasting the Impact of Inflation on Economic Growth in Nigeria Using Threshold Analysis

David O. K. Okoroafor[1], Sesan O. Adeniji[2] and Timilehin J. Olasehinde[3]

This study examined the causal relationship between inflation and economic growth as well as estimating threshold and forecasting of inflation in Nigeria for the period of 1961 – 2016. The study employed Granger causality test, Autoregressive Distributed Lag (ARDL), Autoregressive Integrated Moving Average (ARIMA) and a multivariate time series Vector Autoregressive (VAR) models. Granger causality test result showed that inflation does not granger cause economic growth and neither does economic growth granger cause inflation during the period of study. Using broad money supply to GDP as control variable, an inflation threshold of 14% -15% both in the short run and long run was established for Nigeria. As for the forecasting of inflation, the findings showed that VAR (1) could forecast inflation rate in Nigeria with high degree of accuracy. Hence, this result is vital for monetary policy formulation and need to be taken into consideration as a complement to the approach currently employed by the Central Bank of Nigeria in the targeting of a single digit inflation rate.

Keywords: ARDL; ARIMA; Economic Growth; Forecasting; Inflation Threshold VAR.
JEL Classification: E31; C53; E52; 040.

1.0 Introduction

Inflation is seen as a continuous and rapid rise in the price level. It is referred to as the tenacious and the significant rise in the overall level of prices (Jhingan, 2002). Ekpenyong, et. al., (2014) was of the opinion that, not all increase in price of goods and services in an economy can be referred to as inflation but only increase in price level that is enduring, continuous and affect all commodities in the economy. The Central Bank of Nigeria has used diverse approaches in operationalizing the monetary policy. The Central Bank of Nigeria (CBN) from the beginning employs two

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monetary policy framework viz: exchange rate targeting and monetary targeting. The first was adopted during the period of 1959 and 1974, while the later has been in use from 1974 to date. The attraction on the usage of monetary targeting as monetary policy framework was based on its capacity in enabling the CBN handle domestic issues, and ability to immediately signal monetary policy stance. But in recent time, this strategic approach has been criticized on the basis of poor performance and it not favouring the adoption of monetary and economic integration policy. Therefore, this gives credence to inflation targeting as an alternative option to be used by the monetary authority for macroeconomic management (Awogbemi and Taiwo, 2012). In addition, recent study by IMF staff on 88 non-industrialized countries shows that, inflation targeting was widely accepted by more than half of the participating countries IMF (2008). Hence, we cannot without any caution exclude Nigeria from this group as one of the priorities of the CBN is using monetary policy tools in maintaining single digit inflation and inflation targeting is a monetary policy framework directed at achieving the primary goal of price stability (CBN, 2011). Hence, studying the direction of inflation is crucial for the reason that it permits us to better understand the role of monetary authority in its control.

Every developing economy engages in ensuring sustainable economic growth which is driven by stable macroeconomic variables most especially low levels of inflation. Several studies in the past have established the relationship between inflation and economic growth. Studies like Fischer (1993), Bruno and Easterly (1998), Kremer, et. al(2009) are of the opinion that increased continuing levels of inflation affects economic growth negatively. Others, such as De Gregorio (1993), Hedgimichael, et. al., (1995), Khan and Senhadju (2000) maintained that low rates of inflation moves in the same direction with high level of economic growth. Hence, it can be concluded with the above assertion that, every developing economy must ensure keeping her inflation at a low rate to sustain economic growth.

On the same note, before being affirmative on the above deduction, some of the previous works still revealed that even though inflation is ill-disposed to economic growth (Barro, 1991 and Fischer 1993), others hold to the fact that significant level of continuous and persistent rise in price is necessary to attain economic growth

(Tobin 1969 and De Gregorio 1993). It then means that, as the economic managers try to maintain low rate of inflation, and also need to be conscious of that rate of inflation that is necessary to attain certain level of economic growth. Hence, this paper seeks to identify the causal relation between inflation and economic growth in Nigeria, estimate the level of inflation that is inimical to economic growth (inflation threshold) and fit a suitable model and use this model to forecast future values of inflation.

It is important to note that, to the best of our knowledge, although there are existing literature that estimated the inflation threshold in Nigeria using ARIMA and VAR models, a major departure from the previous works is the addition of ARDL model in achieving the objectives of this study.

Therefore, this study is imperative because apart from giving the monetary authority the clue to managing inflation, its in-depth knowledge can be used to take care of the lagged impact of macroeconomic variables in the economy which often trail the efficiency of monetary policy. Nevertheless, when the path of causality between inflation and economic growth is established, inflation verge estimated and future inflation values rightly forecasted with appropriate model, the performance of macroeconomic indicators can be tracked as well as ensuring their stability using threshold forecasted values. Hence, appropriate and timely measure can be taken to curb inflation rate forecasted that is above the inflation threshold and economic growth can then be sustained.

The rest of the paper is structured as follows: section two gives the theoretical framework and reviews literature related to the study, section three presents the methodology of the study, while section four presents analysis and interpretation of results and section five concludes the paper and makes some policy recommendations.

1.1 Stylized Facts on Inflation, Money Supply and Economic Growth in Nigeria

One major focus of monetary authorities the world over is the effective and efficient management of inflation and money supply, to achieve steady growth of the economy. Price stability is a cardinal objective of the government macroeconomic goals, given that it bears direct impact on the standard of living as well as cost of living of the citizenry. Hence, the CBN as a government institution is charged with the primary responsibility of managing or controlling money supply to achieve stable prices of goods and services in the economy. According to Sarah (2014), the CBN takes whatever growth and inflation levels that the Federal Government desire to achieve, to determine how much money would be adequate to grow the economy. In other words, in observing the growth rates of GDP and Inflation, the CBN determines the extent of money supply that matches the Government budgetary objectives. The CBN adopts fiscal and monetary policy coordination to ensure: financial stability, moderate interest rate, and stable exchange and inflation rates with no adverse effect on the economy.

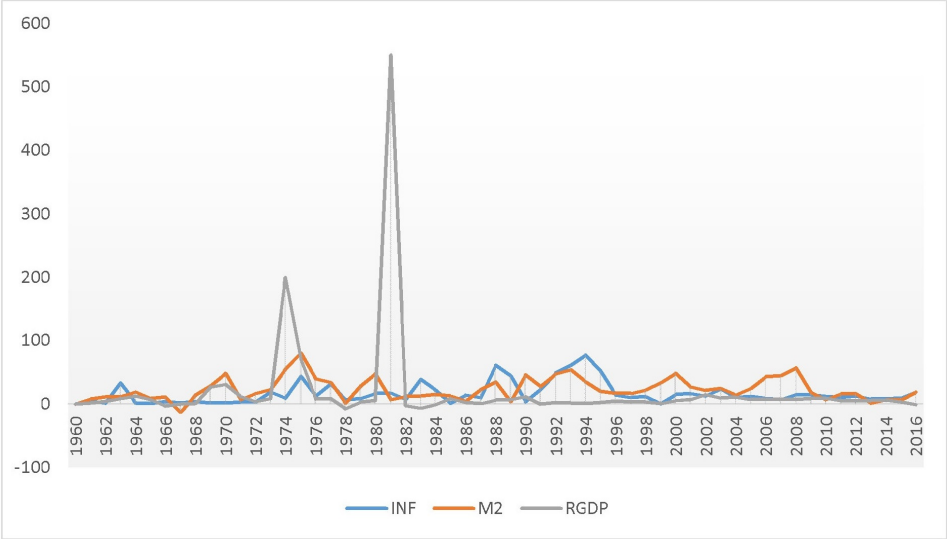

Figure 1: Trend Analysis of Annual % Growth Rate of INF, MS & RGDP in Nigeria: 1960-2016

For Nigeria, inflation rate was 5.2 percent in the first decade after independence. The money supply growth at the same period averaged 14.65 percent. The Real

Gross Domestic Product (RGDP) in the same decade after independence grew at an average of 8.78 percent. The performance of the economy and its associated variables over the period of 1960-1969 was characterized and influenced by drastic fall in output as a result of civil war. The actions of the CBN was more of contractionary monetary stance. The Government expenditure was more in favor of purchase of military hardware for the execution of Biafra-Nigerian war. So, the economy shrank, especially between 1966 and 1967. It recorded a negative growth rate of -3.24 and -0.17, respectively in those two years.

A two digit inflation rate became a phenomena in the 1970s. It averaged 15.12 percent between 1970 and 1979. Money supply over the same period grew at a double digit rate of 33.08 percent. The RGDP made improvement compared to the previous decade. It grew at an average of 31.01 percent. However the economy experienced negative growth rate in the period. For instance, the growth rate of RGDP for 1978 was -7.32 percent. Some of the events that explained the behavior of the economy included: massive expenditure to reconstruct the war torn economy.

The spike in the graph from 1980-1982 is an indication that the government policy of Structural Adjustment Programme (SAP) which commenced in 1980 and entailed a number of austerity measures was actually yielding some positive result as shown by the high growth of RGDP, before the Military intervention in the polity in December 1983. It shows that the economy was already on the path of recovery before the military coup of 1983; output of goods and services were improving as the economy was recovering from recession.

2.0 Literature Review

2.1 Theoretical Framework

This study employed the Keynesian theory using the Aggregate Demand (AD) and Aggregate Supply (AS) curve as the theoretical framework of this study. This theory explains the relationship between economic growth and inflation. It postulated that, the aggregate supply (AS) has its acute feature when it is upward sloping rather than when vertically sloppy. This is because, if the AS curve is

vertically sloppy, any changes with the aggregate demand (AD) will only affect price level, while in a situation of AS sloping upward, variations in AD impact both prices and output (Dornbusch, et al, 1977). This is informed by some factors that influence inflation and level of output in the short-run such as consumers and producers prospects; labour force; prices of other factors of production, fiscal and/or monetary policy.

On the other hand, the long-run analysis depicts a steady movement of the aforementioned factors as well as their shocks. The steady state of the economy is a state in which everything remain the same. Hence, the interaction of the short-run AD and AS curves will produce modification path which displays the first direct association between inflation and growth, this on the other hand goes opposite direction towards the later part of the alteration path. This first relationship between inflation and output is explained by Figure 2 depicting the movement from E^0 and E^1.

Based on this concept, the producers are divided into two parts, the first part believes that there is an increase in the price of their products while that of other producers remain the same. Contrary to this, what all the producers are experiencing is an overall increase in prices but the producers continue to produce more goods so as to enjoy the benefit of increased price showing positive relationship between inflation and output. Also, Blanchard and Kiyotaki (1987) explain that the positive relationship between inflation and output can be as a result of an agreement reached by firms in supplying goods and services at a determined price in the future time. Consequently, an increase in price will not reduce the level of output for the fulfilment of the agreement made between the producer and the consumer.

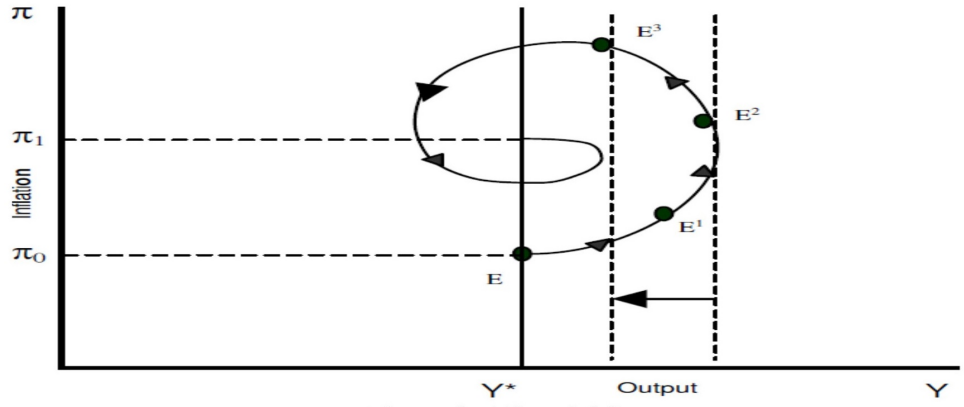

Figure 2: AD and AS curves

From Figure 2, the adjustment process shows that, points E^2 and E^3 describe a situation where output decreases and inflation rate increases which represents a negative relationship between output and inflation as obtainable in practice.

In the same vein, the economy respond to rise and fall in inflation rate and this leads only to trade-off between output and the change in inflation in the short run but not in the long run. Hence, to maintain a stable level of inflation, the production in the country (output) must be at the same level with the natural rate (Y^*).

2.2 Empirical Review

Estimation of inflation threshold, Inflation modelling and forecasting has been widely covered in the Literature as this has received the attention of scholars, academia and policy makers given the importance of its understanding in the formulation of effective and efficient policy. Those that are of a great insight to our study are deduced as follows:

Mubarik (2005) examined the relationship between inflation and output growth by estimating a threshold model of inflation and output growth for Pakistan economy. He employed Granger Causality and sensitivity analysis and his result revealed that, there is a unidirectional relationship between the existing rates of inflation and the levels of economic growth, while a 9 per cent inflation threshold was es-

tablished for economic growth in Pakistan within the period of the study and this was proposed as a threshold inflation for a well domestic output level.

Fabayo and Ajilore (2006) investigated inflation level that will affect negatively the level of economic growth in Nigeria using time series data for the period of 1970 to 2003. Their result showed 6 per cent inflation threshold in Nigeria and they put forward that, any inflation rate above this will have negative impact on economic growth and vice versa. Kremer, et. al., (2009) in another expository study that captured the inflation threshold levels in both developed and developing countries using a dynamic panel threshold model to examine the impact of inflation on long-run economic growth revealed a threshold of 2 per cent for developed economies while 17 per cent was established as the level at which inflation is not inimical to economic growth in developing countries. Even though below this threshold, there is no significant relationship between inflation and economic growth, their result does not suggest growth spur by inflation in emerging economies.

Chimobi (2010) using time series data for the period of 1970 to 2005 investigated the presence or absence association amid inflation and economic growth in Nigeria. He employed the Johansen-Juselius co-integration technique and Engle-Granger causality test. While the causality test result revealed a unidirectional causality running from inflation to economic growth, the co-integration result showed that there is long-run connection between inflation and economic growth in Nigeria. However, the study did not estimate or predict inflation threshold for Nigeria.

Frimpong and Oteng-Abayie (2010) on a study conducted for Ghana economy investigated if inflation is harmful to economic growth or not using a threshold regression model for the period of 1960-2008. The result revealed an established 11 per cent threshold point for inflation and any rate below this shows a positive relationship with economic growth and vice versa.

Mohanty, et al. (2011) examined likely nonlinear relationship between inflation and growth in India employing quarterly series and deduced inflation threshold of 4 to 5.5 per cent. However, their study do not find decisive proof of the reality of

an inflation threshold, they therefore inferred that inflation rate less than 5.5 per cent tend to have positive impact on Indian economic growth, while the reverse is the case in a situation of inflation rate above 5.5 per cent.

Following the framework of Li (2005), Bassey and Onwioduokit (2011) investigated the relationship between inflation and economic growth and at the same time examined a fitting inflation threshold. Their result revealed a negative relationship between inflation and economic growth and a statistically insignificant threshold level of 18 per cent was identified which served as the rate of inflation that still boost economic growth.

In the case of inflation modelling and forecasting, Landsman and Damodaran (1989) used the univariate autoregressive integrated moving average method in modelling and forecasting inflation. Their conclusion gave credence to Autoregressive Integrated Moving Average (ARIMA) parameter estimator for its ability to make accurate forecasting giving its low mean squared percentage error. Meyler, et. al., (1998) maintained that, even though ARIMA model perform greatly in forecasting compared to other models such as the vector autoregressive method (VAR), and the Bayesian VAR, it has been noticed that, ARIMA model cannot be relied on when applied to unstable and high frequency data.

In the study carried out by Ho and Xie (1998), using the ARIMA framework, they settled that ARIMA model is a realistic supernumerary giving suitable results in line with its prophetic presentation.

Kelilume and Salami (2013) also used a univariate time series in the form of ARIMA model advanced by Box and Jenkins and multivariate time series model in the form of VAR in Modeling and Forecasting Inflation in Nigeria using time series data for the period of 2003 to 2012. The result obtained shows that, VAR forecast well and gives rate close to the current inflation rate and also comes with minimum square error as an important criteria. Akdogan et.al (2012) employed numbers of models such as ARIMA model, Philips curve time varying model, decomposition based models, VAR and Bayesian VAR model and dynamic factor

model to investigate the short-term forecasts for inflation in Turkey. Their result revealed that the models which integrate additional economic statistics outperformed the random walk model at least up to two quarters ahead. Pufnik and Kunovac (2006) examined the possibility of improvement in final forecast of all item index of Croatia's CPI by employing univariate seasonal ARIMA models and forecasting future values of the variables from past behavior of the series. Their findings revealed that, with a fairly longer time horizon of three to twelve months, the most accurate forecasts of all items (CPI) are found by first forecasting the index's components and then aggregating them to obtain the all items index.

Also, Alnaa and Ferdinand (2011) employed ARIMA model in estimating inflation threshold in Ghana using monthly data from June 2000 to December 2010. They found that ARIMA (6,1,6) is best for forecasting inflation in Ghana. While, Suleman and Sarpong (2012) using an empirical approach to model monthly CPI data in Ghana applied the seasonal ARIMA model. Their result revealed that ARIMA (3,1,3) and (2,1,1) model was appropriate for modeling Ghana's inflation rate.

Akhter (2013) predicted the short-term inflation rate of Bangladesh using the monthly CPI from January 2000 to December 2012. Using seasonal ARIMA models recommended by Box, et al. (1994). Because of the incidence of structural break in the CPI, the study shortens the series and using data from September 2009 to December 2012 fitted the seasonal ARIMA (1,1,1) and (1,0,1) model. Omane-Adjepong et al (2013) investigated the greatest suitable short-term forecasting method for Ghana's inflation. The monthly dataset used was broken down into two sets, with the first set used for modeling and forecasting, while the second set was used as test. Seasonal ARIMA and Holt-Winters approaches are used to obtain short-term out of sample forecast. From the results, they concluded that an out of sample forecast from an estimated seasonal ARIMA (2,1,2) and (0,0,1) model far supercedes any of the Holt-Winters' approach with respect to forecast accuracy.

Adeleke (2012) employed Khan and Sendhadji's (2001) threshold regression technique to observe the existence of ideal inflation. Using Granger causality test to

examine the causal relationship between inflation and growth, the result showed that, there is a unidirectional causality from inflation to real GDP, with no response from output growth to inflation, while the threshold result showed an optimal rate of eight per cent level of inflation as that which will facilitate sustainable economic growth. The findings from the threshold model showed a negative relationship between inflation and growth. Hence, the idea of single digit inflation by the monetary authorities in Nigeria was upheld in this study. Also, Bawa and Abdullahi (2012) estimated a threshold level of inflation for Nigeria using a quarterly time series data for the period 1981 to 2009 by adapting a model developed by Khan and Senhadji (2001). The result of their empirical analysis revealed a threshold inflation level of 13 per cent for Nigeria and it was put forward that the negative and significant relationship between inflation and economic growth for inflation rates both below and above the threshold level is robust with respect to changes in econometric methodology, additional explanatory variables and changes in data frequency.

In furtherance to the above, Doguwa (2013) re-examined inflation threshold using three different approaches of Sarel's (1996), Khan and Senadji (2001) and Drukker et al (2005). The results revealed that Sarel's approach provides a threshold point estimate of 9.9 per cent that was not well identified by the data, the technique of Khan and Senhadji (2001) identifies a 10.5 per cent inflation threshold as statistically significant to explain the inflation-growth nexus in Nigeria and Drukker et al (2005) approach suggests a two threshold point model with 11.2 and 12.0 per cent as the appropriate inflation threshold points. He concluded that, the threshold level of inflation above of which inflation is inimical to growth is estimated at 10.5 to 12 per cent for Nigeria.

3.0 Methodology

For the purpose of this work, we first of all investigate the causal relationship between inflation and economic growth as well as the bearing of causality. We employed parametric linear causality proposed by Granger (1969) to examine the causal relationship between inflation and economic growth. The Granger causality

specification is presented below.

$$g_t = \alpha_{11} + \sum_{i=1}^{i=T} \alpha_i g_{t-i} + \sum_{j=1}^{j=T} \alpha_j i_{t-j} + \varepsilon_t^Y \tag{1}$$

$$i_t = \alpha_{21} + \sum_{i=1}^{i=T} \beta_i g_{t-i} + \sum_{j=1}^{j=T} \beta_j i_{t-j} + \varepsilon_t^{OP} \tag{2}$$

Then, testing $H_0 : \sum_{i=1}^{i=T} \alpha_i = 0$ against $H_A : \sum_{i=1}^{i=T} \alpha_i \neq 0$, is a test that i does not Granger-cause g.

Similarly, testing $H_0 : \sum_{i=1}^{i=T} \beta_i = 0$ against $H_A : \sum_{i=1}^{i=T} \beta_i \neq 0$, is a test that g does not Granger-cause i.

In order to investigate the inflation rate threshold that is optimal for economic growth in Nigeria, the traditional ARDL methodology was employed after the stationarity of the variables was established by both the graphical and the formal test. The ARDL optimal lags specification was selected using the information criteria. The threshold inflation rate was captured using dummy variable labeled as k and we used it to form inequality dummy variable constructed as $(i - k^* > 0)$ and $(i - (k^* + 1)) \leq 0)$. These dummies are included as fixed regressor in the specification window. Assuming that k^* is positive, we sequentially choose k^* arbitrarily within the range of variable i. $(i - k^* > 0)$ is represented as 1 while it is 0 otherwise. Also, $(i - (k^* + 1)) \leq 0)$ is represented as 1while it is 0 otherwise .There are four possible inequalities with only three being valid. $i > k^*$ and $i \leq k^* + 1$, $i < k^*$ and $i < k^* + 1$ and lastly $i > k^* + 1$.

The following $ARDL(1, 0, 0)$ equation is estimated using OLS technique due to its consistency property.

$$g_t = \alpha_0 + \alpha_1 g_{t-1} + \alpha_2 m g_t + \alpha_3 i_t + \alpha_4 * i_t * (i - k^* > 0) + \alpha_5 * i_t * (i - k^* \leq 0) + \varepsilon_t \tag{3}$$

Lastly, we try to model and forecast inflation in Nigeria with the aid of a traditional model i.e. ARIMA model and VAR model. The selection of these models was based on their recent forecasting ability. However, forecast performance evaluations statistics was reported to ascertain which model could predict inflation rate

in Nigeria better. The data was sourced from the World Bank statistical data. The frequency of the data is yearly and the period covered is 1961 to 2015.

4.0 Empirical Result

4.1 Data Analysis

Table 1: Descriptive Statistics

	i	g	mg
Mean	16.12854	4.050245	19.21593
Median	11.55783	4.345171	14.19678
Maximum	72.83550	33.73578	70.20216
Minimum	-3.726337	-15.74363	-9.764590
Std. Dev.	15.86867	8.293866	17.94250
Coefficient of variation	0.983888	2.047744	0.933031
Skewness	1.879473	0.776826	1.071354
Kurtosis	6.104617	5.893126	3.695067
Jarque-Bera	55.45943	25.16269	11.84008
Probability	0.000000	0.000003	0.002685
Sum	903.1982	226.8137	1076.092
Sum Sq. Dev.	13849.80	3783.352	17706.34
Observations	56	56	56

Table 1 shows the descriptive statistics of Inflation rate (i), real GDP growth rate (g) and the real GDP weighted broad money supply (mg) which proxy the level of financial deepening. It can be shown that the variables contained 56 observations. It can be shown that all the variables were positively skewed. Also all the variables were leptokurtic as their respective kurtosis are greater than three. The coefficient of variation statistics was computed to show the unitless dispersion comparison of the three variables and it shows that there is lesser variation in the real GDP weighted broad money supply (mg) followed by Inflation rate (i) . The probability value of the Jarque-Bera normality test based statistics shows that none of the variables were normally distributed.

4.2 Unit Root Test

Before one pursue formal tests, it is always advisable to plot the time series under study as it may reveal the integrating nature of the series. The variables (Inflation rate (i), real GDP growth rate (g) and the real GDP weighted broad money supply (mg)) used in this study are examined graphically below.

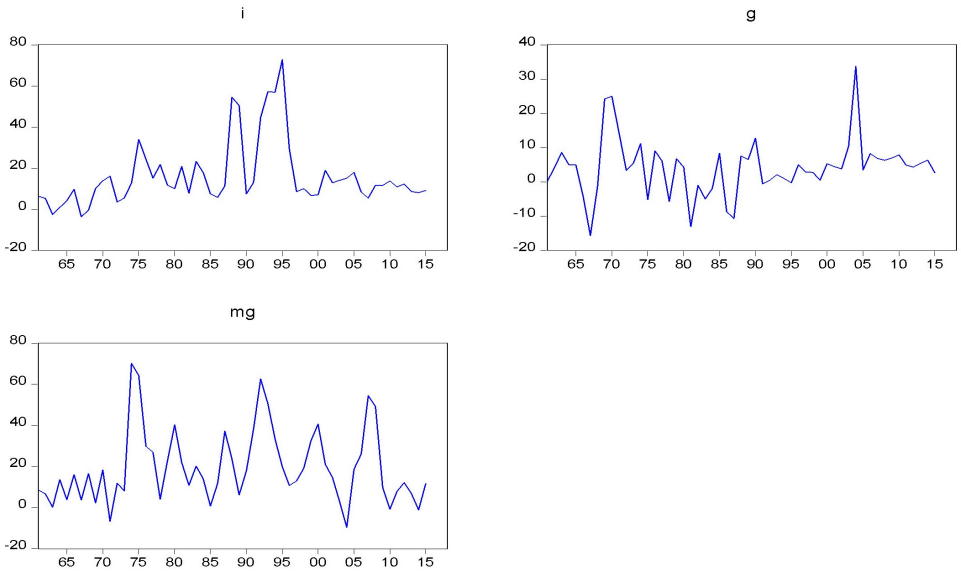

Figure 3: Trend Analysis

It can be shown from the table above that none of the three variables (Inflation rate (i), real GDP growth rate (g) and the real GDP weighted broad money supply (mg)) are upward trending. There is tendency for mean reverting and variance constancy overtime. The three variables show similar hovering around their respective means throughout the years. This also suggests their mean reverting and variance constancy over time. However, no statistical fact can be derived numerically from the graphical inspection of the variables. Based on this caveat, ADF unit root test and Phillip-Perron unit root test are employed to investigate statistically their integration properties.

Table 2: PP and ADF unit root test

		PP @ level			ADF @ level		
		i	g	Mg	i	G	mg
C	t-stat	-3.2969	-5.2858	-3.6556	-15.3699	-27.7413	-15.6823
	Prob.	0.0198**	0.0000***	0.0076***	0.0000***	0.0001***	0.0000***
C&T	t-stat	-3.2890	-5.2410	-3.5849	-17.0571	-27.8669	-17.3589
	Prob.	0.0788**	0.0004***	0.0404**	0.0000***	0.0001***	0.0000***
No C&T	t-stat	-2.1069	-4.5904	-2.6434	-14.9614	-28.1253	-15.9239
	Prob.	0.0348**	0.0000***	0.0091**	0.0000***	0.0000***	0.0000***

C represents Constant while T represents Trend. ** and *** shows stationarity at 5% and 1% level of significance

The result of the PP unit-root test and the ADF unit-root test is presented in Table 2. From the result, it can be shown that all the variables were stationary at level at 5% and 1% level of significance and there is no further need to proceed to the first difference. The stationarity nature of the variables had been suggested earlier by their graphical inspection above. There is no need to proceed to cointegration testing. The stationarity properties of the three variables comply with the use of traditional VAR, ARDL and ARMA methodologies.

4.3 Granger Causality Test

Table 3: Granger Causality

Hypotheses	F-stat	Prob.
g does not granger cause i	0.17544	0.6770
i does not granger cause g	0.12503	0.7251

From the Table 3, the result of the pair-wise Granger causality showed that, there is no direction of causality between g and i. In essence, none of the variable's past solely could be used to forecast each other.

4.4 Inflation Threshold Modelling

In order to investigate the inflation rate threshold that is optimal for economic growth in Nigeria, the traditional ARDL methodology was employed since the stationarity of the variables had been justified that both the graphical and the formal test. The ARDL optimal lags specification was selected using the information criteria. $ARDL(1,0,0)$ over the periods of 1962 to 2016 was selected and estimated. The threshold inflation rate was captured using inequality dummy variables and it is included as fixed regressor in the specification window. The dummy

is constructed as $(i - k^* > 0)$ and $(i - (k^* + 1)) \leq 0)$. $(i - k^* > 0)$ is represented as 1 while it is 0 otherwise. Also $(i - (k^* + 1)) <= 0)$ is represented as 1 while it is 0 otherwise. There are four possible inequalities with only three being valid. $i > k^*$ and $i \leq k^* + 1$, $i < k^*$ and $i < k^* + 1$ and lastly $i > k^* + 1$. Various ARDL models with different inflation rate threshold intervals were estimated and only the one with statistically significant threshold interval coefficient is reported in this study. Inflation threshold within the range 2%-3% is not defined as this falls outside the feasible region. Inflation threshold within the range 14%-15% is highly statistically significant.

Table 4: ARDL short run and ECM representation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
d(mg)	-0.075914	0.058322	-1.301621	0.1991
d(i)	-0.713812	0.408143	-1.748929	0.0866*
d(i * (-14+i > 0))	0.788965	0.388465	2.030983	0.0477**
d(i * (-15+i <= 0))	1.335813	0.365869	3.651069	0.0006***
ecm(-1)	-0.755185	0.115550	-6.535576	0.0000***

Note: *, ** and *** denotes significance at 10%, 5% and 1% respectively.

From Table 4, it can be shown that mg and i impacted negatively on g in the short run respectively though, mg is not statistically significant. If inflation rate lies between 14%-15%, g will increase by -0.713812%+0.788965%+1.335813%=1.41%, if inflation rate is less than 14%, g will increase by -0.713812%+1.335813%=0.62% and if inflation rate is more than 15%, g will increase by -0.713812%+0.788965% =0.075% in the short run. The result in the table indicate that the coefficient of the error correction term ECM(-1) had a correct sign and significant at 1% level. The value of the coefficient is -0.76; this means that, about 76% of the disequilibrium in the level of g of previous year's shock adjust back to the long run equilibrium in the current year. In another word, the level of real GDP growth rate (g) adjust to equilibrium with lags and only about 76% of the discrepancy between long and short run real GDP growth rate (g) in Nigeria is corrected within a year.

Table 5: ARDL long run representation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
mg	-0.100523	0.078211	-1.285276	0.2047
I	-0.945215	0.554976	-1.703164	0.0949*
i*(i-14>0)	1.044731	0.534318	1.955261	0.0563*
i*(i-15<=0)	1.768855	0.537162	3.292962	0.0018***
constant	-0.137809	2.835398	-0.048603	0.9614

Note: *, ** and *** denotes significance at 10%, 5% and 1% respectively.

From Table 5, it can be shown that mg and i impacted negatively on g in the long run respectively though mg is not statistically significant. If inflation rate lies between 14%-15%, g will increase by -0.945215%+1.044731%+1.768855%=1.87%, if inflation rate is less than 14%, g will increase by -0.945215%+1.768855%=0.82% and if inflation rate is more than 15%, g will increase by -0.948185%+1.044731% =0.10% in the long run. In other words, the moderate inflation rate for Nigerian economy lies between 14%-15%. Out of the bound will reduce the growth rate of the economy.

4.5 Inflation Forecasting

In real life, it is glaring that many economic variables are related to each other in one, two or more ways. This, however, does not imply that a pure time series analysis is wrong or not ideal. However, building an interrelated system of model equations of course has advantages but do require a 'correct' representation of the underlying economy. In the time series approach, one is more concerned with predicting future values, including future uncertainty (variances or volatility). From the predictive point of view, a pure time series approach often outperforms a more structural approach and the fact that two variables are related does not imply that a pure times series approach like ARIMA/FARIMA/ARARA is invalid (see Verbeek, 2004).

In order to forecast inflation rate in Nigeria due to its importance in determining economic growth, VAR and ARMA methodology was employed since the stationarity of the variables had been justified by both the graphical and the formal test. The VAR optimal lag was selected using the information criteria while the ARMA specification was selected using automatic optimal model selection. The lag selection criteria selected lag period 1 for the VAR while the automatic ARIMA model

selector chose ARMA (1, 1) over the periods of 1962 to 2016. Both the VAR and the ARMA models were used to perform in sample-forecast for the period 2014 to the year 2016 and out of sample (2017-2020) is forecasted using the stochastic and dynamic method as uncertainty need to be taken into account while forecasting.

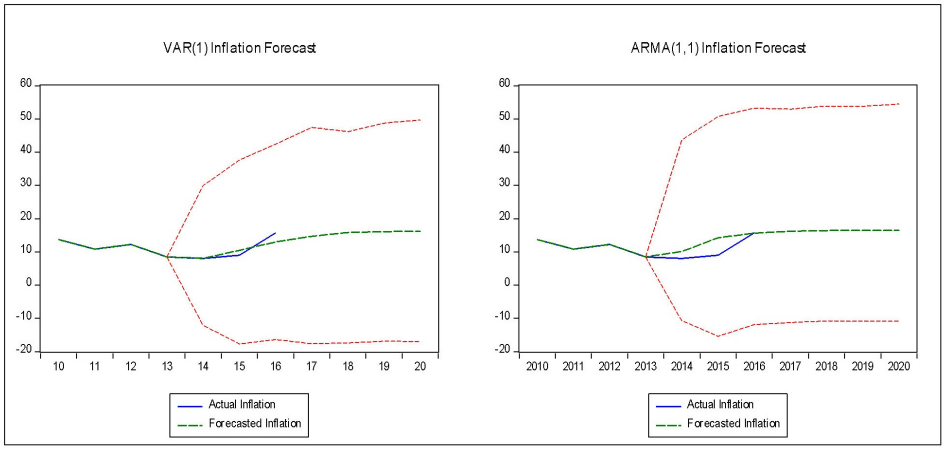

Figure 4: VAR and ARIMA Forecast

The Figure 4 shows the inflation forecast of both VAR (1) and ARMA (1,1). The red dotted line is the confidence bound that account for forecast uncertainty. As both forecasts fall within the bound, consistency is still retained.

Table 6: VAR and ARIMA Model

	2017	2018	2019	2020
VAR(1)	14.5%	15.5%	16.1%	16.1%
ARMA(1,1)	16.4%	16.7%	16.5%	16.4%

As reveled from Table 6, VAR(1) forecast inflation rate for the year 2017 to 2020 to be 14.5%, 15.5%, 16.1% and 16.1% on average respectively. Likewise, ARMA (1, 1) forecast inflation rate for the year 2017 to 2020 to be 16.4%, 16.7%, 16.5% and 16.4% on average respectively. It can be seen that there is a much agreement for both VAR (1) and ARMA (1, 1) inflation forecast for the year 2019 and 2020.

Table 7: VAR and ARIMA Model Forecast Performance

	RMSE	MAPE	THEIL	MAE
VAR(1)	0.38296	0.62661	0.00850	0.07460
ARMA(1,1)	0.67343	1.02085	0.01493	0.12772

From Figure 4, it can be shown that VAR (1) could forecast inflation better than the ARMA (1,1) . However, no statistical fact can be derived numerically from the graphical inspection of the variable in question. Based on this caveat, the forecast performance of the two methodologies is investigated and this is summarized in the Table 7. Four forecast performance evaluations are reported in the Table 6. The four forecast performance evaluations revealed that, the VAR (1) outperformed the ARMA (1,1) in inflation forecasting in Nigeria.

5.0 Conclusion and Policy Implications

This study examined the relationship between inflation and economic growth in Nigeria with the aim of determining the level of inflation that can sustain the economy. Therefore, the causality between inflation and economic growth was investigated as well as the inflation threshold forecasting for the period of 1961 to 2016. The result of the granger causality test shows that inflation does not granger cause economic growth and economic growth does not granger cause inflation. Using control variable of broad money supply to GDP (GLM2/GDP), we established an inflation threshold of 14%-15% both in the short run and long run for Nigeria. Also, we attempted to forecast inflation rate using VAR and ARMA methodologies. The findings shows that VAR (1) could forecast inflation rate in Nigeria with higher degree of accuracy. This result is relevant for monetary policy formulation as it shows that monetary authority in Nigeria needs to consider inflation threshold for the country in the process of targeting single digit inflation as one of its major objectives. One of government macroeconomic challenges is maintenance of price stability. Attainment of inflation threshold of 14% would boost the economy and bring it to a steady path of growth. The findings from this study would enable policy makers to forecast the level of inflation and maintain policy effectiveness.

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Macroeconomic Implications of Trade Diversification in Nigeria

Lukman O. Oyelami[1] and Philip O. Alege[2]

This study seeks to examine the effects of trade diversification on macroeconomic performance in Nigeria. To achieve this, the study employs bound test of ARDL to determine the existence of cointegration between trade diversification and key macroeconomic variables. We further estimate the short-run and long-run effects of Intensive and Extensive trade diversification on Economic growth and exchange rate movements. The results from bound tests confirm co-integration between trade diversification and economic growth on one hand and trade diversification and exchange rate movements on the other hand. Similarly, the results from our estimations show that trade diversification can propel economic growth in the country. Also, the trade diversification can reduce movements in exchange rate especially extensive diversification thus preventing it from substantial movement that can derail this important variable from its long run equilibrium. The study recommends that policy makers should pursue vigorously both intensive and extensive trade diversification to propel economic growth and guarantee stable exchange rate for the Nigerian currency.

Keywords: ARDL; Diversification; Macroeconomics; Trade.

JEL Classification: F13; F1; C22; E00.

1.0 Introduction

Several scholars have examined the concept of economic diversification but it seems the concept will still continue to receive attention especially in many resource dependent economies including Nigeria. According to Imbs and Wacziarg (2003), Economic and trade diversification is not only about significant changes in type of goods produced and exported but as well as the quality. In some cases, it includes a range of products and trading partners. This broad definition is crucial because a successfully diversified economy is expected to reduce the economy exposure to adverse external shocks and macroeconomic instability (Mobarak, 2005).

Generally, in the economic literature, economic measures of diversification can be

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captured in trade and domestic sectors. Though, domestic and trade diversification are closely related and interlinked but while trade diversification involves the external sector, the domestic sectors diversification involves diversification in production process across sectors of the economy (Hesse, 2009). There are dimensions through which Trade diversification can be achieved. This includes diversification across products or trading partners. It may also involve the introduction of new product lines which can be referred to as extensive margin or a more balanced mix of existing exports and this is known as intensive margin. While trade diversification focuses on all the aforementioned, domestic diversification basically entails diversification in sectoral output and allocation of labour.

In trade literature, trade diversification (intensive and extensive) has been argued to be of serious macroeconomic importance. Ghosh and Ostry (1994) and Jansen (2004), for instance argue that diversification makes country less vulnerable to term of trade shocks and this positive terms-of-trade shocks can be channeled into economic growth. Also, Moore and Walkes (2010) argued that diversified production structures tend to have lower volatility on output, consumption, and investment which ultimately ensure macroeconomic stability. More directly, several studies (Al-Marhubi , 2000; Hasan and Toda ,2004; and Herzer and Nowak-Lehnmann 2006) have argued that trade diversification has potential to increase economic growth though without a clear cut consensus as regard the channel(s) by which trade diversification transmits to growth . It could be that it is growth that propels diversification.

Also of serious importance to the Nigerian economy is the issue of exchange rate movement and its volatility. To this effect, export diversification has been put forward in several policy documents and debates as antidote without any empirical investigation. Unfortunately, research findings are controversial on the effect of exchange rate movement on trade flow and this controversy extends to trade diversification. But, study by Agosin, Álvarez, and Bravo-Ortega (2011) has reported insignificant positive effect of exchange rate volatility on export concentration and this constitute about a major study in this direction. Other studies like Lin (2007), Berthou and Fontagné (2008) and Cavallari and D'Addona (2013) focus on effect

of export diversification on exchange rate regime. This introduces element of dynamic interaction between the two variables and economic growth.

Consequently, the motive of this study is to examine the dynamic interaction between trade diversification and macroeconomic performance in Nigeria with particular attention to economic growth and exchange rate movements. This is critical because many studies in this area have removed oil rich countries like Nigeria in the analyses of export diversification and macroeconomic performance nexus. Also, many of these studies are panel in nature and most times African countries are not properly captured, thus, there is a need to investigate if the results from panel studies can be replicated in Nigeria. More importantly, many studies in this area focused attention on the nexus of export diversification and economic growth without looking at the channels through which export diversification impacts on economic growth. Based on this, the study does not only examine the link between trade diversification and economic growth but exchange rate movement as the intermediate channel of transmission.

Apart from this introductory section, the paper is divided into four sections. Section two x-rays the Nigerian economy and its efforts towards economic diversification. Section three discusses both theoretical and empirical issues on trade diversification while section four focuses on methodology. The last section of the paper gives attention to the results from the analysis and policy implications.

2.0 Stylized Facts on Economic Diversification in Nigeria

Pre-independent and earlier Post-independent era of Nigerian economy was a relatively diversified economy. Each region of the country specialized in different range of products which they exported to earn foreign exchange. There was groundnut in the North, cocoa in the West and Palm oil in East. In spite of fluctuation in world price during this era, agriculture contributed about 65 per cent of total GDP, 70 per cent of total exports and almost 80 per cent of foreign earnings (Amuzegar, 1983). During this period, Nigerian was one of the leading producers of many of these products especially cocoa and groundnuts.

The discovery of crude oil in commercial quantity altered the structure of this relatively stable Nigerian economy and this created an expanded national wealth that saw the federal government witnessing annual revenue increment of 26 per cent between 1970 and 1980. During the same period, the average growth of expenditures and net loans was 21 per cent (Amuzegar, 1983) .This development renders a serious blow to agriculture. While Nigeria had attained some level of self-sufficiency in stable food production in the earlier stage of post-independence, by 1980 and onward, Nigeria degenerated to a position of being largest food importer in the Africa couple with the destruction of agricultural export production (Watts and Bassett, 1986). Precisely during this period, food importation rose by 700 per cent and real food output per capita reduced by 1.5 per cent annum, also per capita food production in 1981 was 18 percent lower than 1967-70 (Hunt and D'Silva, 1981). This ushered in the era of food insufficiency in the country.

According to the 2016 British Petroleum report, Nigeria had proven oil reserves of 37.1 billion barrels at the end of 2015 and that is roughly 2.2% of the world's reserves. In addition, the country has proven natural gas reserves of 5.1 trillion cubic meters which contributes to 2.7% of the world total at the end of 2015. On the average in 2015, Nigeria oil production stands at 2.1 million barrels per day with refining capacity of 407,800 barrels per day. Also, the value of petroleum exports stood at 41,818 million dollars out of 45,365 million dollars total export value (OPEC annual statistical report 2016). This sector generates about 91% of foreign earnings and contributes 82% of government revenue. Despite its huge impact on foreign earning and government revenue, this sector merely contributes 8.26 per cent to total real GDP as at 2016. This suggests that the sector has not been adequately connected along its value chains to other sectors of Nigerian economy for the benefits of the Nigerian populace.

2.1 Domestic Diversification

Figure 1 shows the sectoral distribution of Real Gross Domestic Products from 1981 to 2015. It is clear from the figure that while the contributions of some sectors to RGDP are declining, some are increasing and some are static. Specifically, industrial sector has declined tremendously. As at 1981, the sector contributed almost 45 per cent to Real GDP making the sector largest contributor to RGDP, the position it maintained till 1999 albeit some fluctuations. By 2015, the sector barely contributed 16 per cent making it third largest contributor to GDP. This is an unfortunate development to Nigerian economy because of the implication of this shrinking sector on unemployment and balance of payment. The problem of the sector might not be unconnected with poor availability of infrastructural facilities, especially electricity. In an attempt to ensure proper diversification of Nigerian economy, the industrial sector must be put back to full operation with modern day competitive technology that give room for development of new products and improve the quality of the existing ones.

In the same figure, the contribution of agriculture has been relatively steady until 1999 when there was a remarkable increase in the contribution of the sector. As at 1981, the sector contributed just 15 per cent to RGDP and average of 18 per cent afterward. This is relatively small given the huge number of labour the sector employs. In 1999, the sector's contribution increased to about 26 per cent from average of 18 per cent in the previous decade but this has not been sustained afterward. Despite the increased contribution in this sector, Nigeria still remains the largest importer of food and consumables in the continent and this reflects low labour productivity in the sector and weak link between the agricultural sector and industrial sector of the Nigerian economy.

In addition, in the same figure, the construction sector has remained stagnant in term of its contribution to RGDP. The sector barely contributed 5 per cent in 1981 and it has not surpassed it since then. This basically reflects low activities in infrastructural provision; and this sector is very important for optimum performance of other sectors of the economy. Despite poor performance in the real sector of the economy, the trade and services sector has been doing well. As at 2015, the

service sector was the leading contributor to RGDP while trade moved up from 11 per cent contribution in 1981 to 17 per cent in 2015. This shows a big distortion in the structure of the Nigerian economy. As it is, the Nigerian economy is not well diversified and more balanced mix of existing structure is required. The ideal structure should be industrial sector led follow by agriculture.

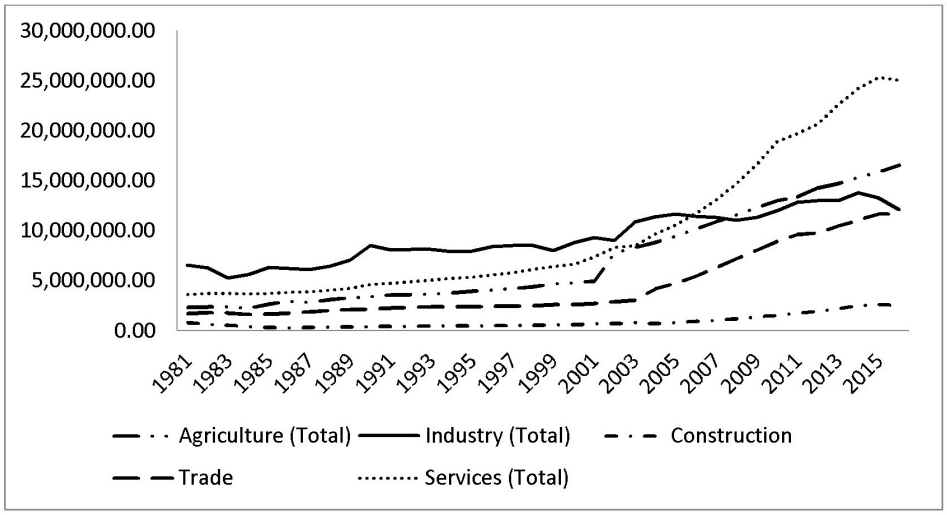

Figure 1: Sectoral Contributions to Real GDP in Naira Million (1965-2015)

2.2 Trade Diversification

Figure 2 shows the trend in number of trading partners with Nigeria from 1965 to 2015. From the figure, no doubt Nigeria has been able to increase the number of trading partners tremendously from about 50 partners in 1965 to about 130 partners in 2015. This is a remarkable progress as far as number of trading partners is concerned and this can afford the country the opportunity to replace partners with unfavourable conditions of trade which Nigeria has demonstrated in recent time with United State of America. In fact, Figure 3 shows that Nigeria is actually shifting attention from developed countries to emerging and developing countries. Unfortunately, the country's trade relations with other African countries have not witnessed any remarkable progress. From 2014 to 2015, Nigerian volume of trade with emerging and developing countries has surpassed that of developed nations though this might basically due to improved trade relations between Nigeria and China on one hand and Nigeria and India on the other in terms of crude oil export.

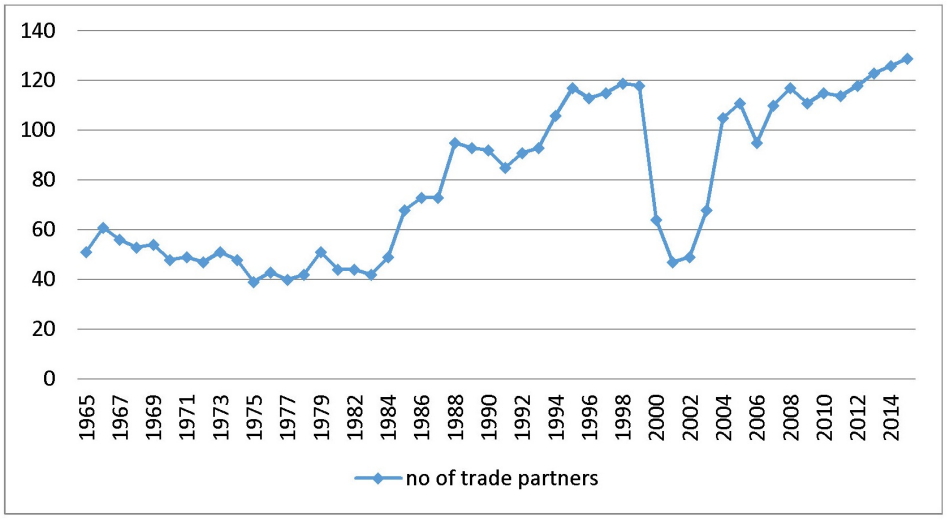

Figure 2: Number of countries as trading partner countries (1965-2015)

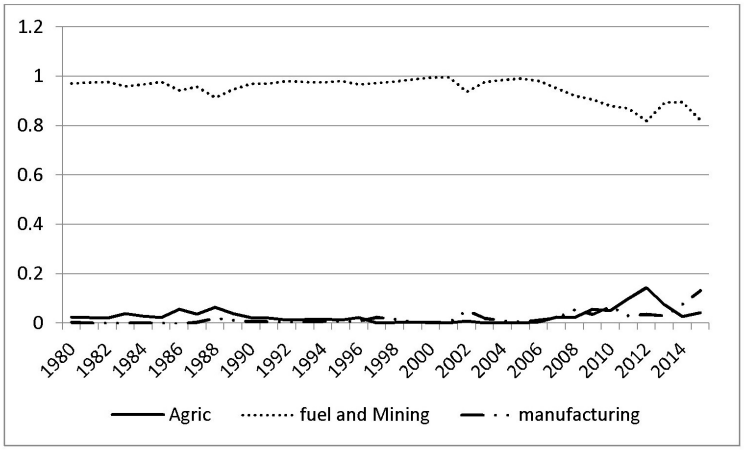

Figure 3: Percentage contribution of three leading export products (1980-2015)

Figure 3 shows the percentage contribution of three leading export products from Nigerian export. From the figure, it is clear that Nigeria has performed well in term of bridging the gap between crude oil export which is the leading product and other tradable products. As at 1981, oil sector contributed over 90 per cent of total export, Agriculture sector contributed mere 0.2 per cent and manufacturing contributed 0.4 per cent. In 2012, there was a sign of resurgence in agricultural products export but this seems not be sustained in subsequent years ditto for manufacturing sector. This might basically be due to decrease in the price of crude oil

at the international market which caused decline in government revenue and necessitated a shift of attention to other tradable sector of Nigerian economy. Given this situation, Nigerian economy will continue to be vulnerable to shocks in crude oil price due to over reliance on the export of the product to finance her economy. Conclusively, the number of trading partners a country relates with might not be very important but the range of tradable products involved in the trade.

3.0 Literature Review

3.1 Theoretical Framework

A thorough review of theory of trade diversification will kick starts from the discussion of classical theory of trade that comprises of Mercantilism, theory of absolute advantage by Adam Smiths and its refined form known as theory of comparative advantage by David Ricardo. Discussing these theories in details will not be of great relevance in this study, thus we will succinctly present them and move to move relevant sections. Basically, Mercantilism is a theory that promotes exportation at the detriment of importation. The theory encourages country to amass big trade surplus from trading activities by exports more than imports. Mercantilism as a theory has not been given serious attention as trade theory however, many countries still indulge in the doctrine directly or indirectly. As a result of this, theories of absolute advantage by Adam Smiths and comparative advantage by David Ricardo have over the years served as foundation theories of trade. Basically, the two theories argue that specialization by countries engaging in international trade will increase the world outputs. However, the theories disagree on how country should specialize. While absolute advantage by Adam Smith contends that country specialise on commodity which they can produce more given the available resource, comparative advantage by David Ricardo contend that country should specialise on commodity where they have least opportunity cost given the available resources.

In comparative advantage trade theory, open economies are generally speculated to specialize in producing a specific range of goods where they have comparative advantage and this is also extended in Heckscher–Ohlin's two factors general equilibrium model. But in recent time, other trade scholars have argued that export

instability is one of the major reason for export diversification, which is similar to the portfolio diversification in finance (Brainardand Cooper,1968; Kemp and Liviatan, 1973 and Ruffin ,1974). This position is somewhat contradictory to classical trade theory but in modern time commodity products are often subjected to very volatile market prices so that countries that are dependent on these commodities may suffer from export instability (Bleaney and Greenaway, 2001). Export instability could increase risk factor in such an economy, thus discourage necessary investments by risk-averse investors. Export diversification could therefore help to stabilize export earnings in the longer run (Ghosh and Ostry, 1994).

Also, the study by Imbs and Wacziarg (2003) and Aditya and Roy (2007) found another perspective to the issue by arguing that country should first domestically diversify and then specialize. This is based on the outcome of their investigation of the relationship between domestic sectoral concentration and per capita income patterns across countries with conclusion that there exist U-shaped patterns such that countries in their early stages of economic development diversify production and specialize when higher income levels have been attained. In a more technical manner, Agosin (2007) aligns with this position in his model of export diversification and growth where he argues that countries below the technological frontier widen their comparative advantage by imitating and adapting existing products. By implication, producing an increasing set of export products can be seen as a dynamic effect of export diversification which can translate to higher per capita income growth.

3.2 Empirical Literature

Empirically, several studies have examined the nexus between trade diversification and growth and few studies extend to other macroeconomic variables but the focus of this brief review is on developing countries, especially African countries. Starting with study of dePiñeres and Ferrantino (2000), using panel data, find that export diversification is associated with income growth in Latin America. This position is closely corroborated by Feenstra and Kee (2004) in their study where they found that export product variety explains 13 percent of productivity gains in 34 industrial and developing countries though their study capture more countries.

Similarly, country specific studies by Hasan and Toda (2004), Herzer and Nowak-Lehnmann (2006) and Zaharieva (2016) provided evidence in the same direction for Bangladesh, Chile and Bulgeria, respectively.

In Sub Saharan African (SSA) as well, study by Hammouda, Karingi, Oulmane and Jallab (2008) found that deepening diversification has been associated with increases in total factor productivity in SSA. Similarly study by Naudé and Rossouw (2008) argued that export diversification Granger cause growth in GDP per capita in South Africa. But study by Songwe & Winkler (2012) implied that export concentration in a few products where countries have a high comparative advantage yields more benefits than product diversification in goods in which they have less comparative advantage. This position can be refuted with more recent study by Hodey, Oduro, & Senadza (2015), which argued that export diversification has a positive and significant effect on economic growth in SSA. Apart from these general studies in SSA, studies have not seriously explored diversification-growth nexus on the merit of each country. Thus, there is crucial need to consider such especially for a resourced based economy like Nigeria.

There is an extensive debate on the relationship between economic diversification and exchange rate in the literature. This discussion has been expanded around different concepts of economic diversification with a lot of controversy. One of the earliest study by McKinnon (1963) and Kenen (1969) focused on product diversification and exchange rate regime. Specifically, Kenen (1969) argued that product diversification makes fixed exchange rates most appropriate to well-diversified economies. McKinnon (1969) presents the same idea in a more subtle manner that the more diversified an economy, the stronger the case for fixed exchange rates.

However, subsequent empirical investigations produced mixed results. Studies by Rizzo (1998), Poirson (2001) Markiewicz (2006) and Frieden et al (2010) produced empirical evidences that a more diversified economy is more likely to adopt a fixed exchange rate regime. To the contrary, studies by Heller (1978), Melvin (1985), Jin (2009) and Chowdhury et al (2014) presented evidences that a more diversified economy is more likely to adopt a flexible exchange rate regime. Apart from this

basic controversy, more recent study by Liu and Zhang (2015) found that when export diversification is classified into extensive and intensive margins, there is evidence that higher level of product diversification at the extensive margin supports adoption of fixed exchange rate regime, while intensive margin does not support fixed exchange regime. Another recent study by Tran, Phi and Diaw (2017) which focused on causality, presented evidence to support bi-directional causality between export diversification and real exchange rate in emerging Latin America and Asia.

4.0 Research Methodology

4.1 Model Specification

To empirically estimate the relationship between export diversification and real GDP per capita, we adapted a simple augmented Solow growth model as employed in similar study (Hesse, 2009). Specifically, we estimated this model within the framework of Autoregressive Distributed Lag (ARDL) using annual data between 1965 and 2015.This gives room for large observations required for the model estimation and it also provides opportunity to cater for both the period of agriculture dominated export and oil dominated export.

$$\Delta \ln RGDP_t = \lambda_0 + \sum_{j=1}^{n1} a_{ji}\Delta RGDP_{t-j} + \sum_{j=1}^{n2} b_{ji}\Delta INTEN_{t-j} + \sum_{j=1}^{n3} c_{ji}\Delta EXTEN_{t-j} + \sum_{j=1}^{n4} d_{ji}\Delta OPEN_{t-j} + \theta_1 INTEN_{t-1} + \theta_2 INV_{t-1} + \theta_3 OPEN_{t-1} + \varepsilon_t \quad (1)$$

$$\Delta \ln Exch_t = \lambda_0 + \sum_{j=1}^{n1} e_{ji}\Delta Exch_{t-j} + \sum_{j=1}^{n2} f_{ji}\Delta INTEN_{t-j} + \sum_{j=1}^{n3} g_{ji}\Delta EXTEN_{t-j} + \sum_{j=1}^{n4} h_{ji}\Delta OPEN_{t-j} + \theta_1 INTEN_{t-1} + \theta_2 EXTEN_{t-1} + \theta_3 OPEN_{t-1} + \varepsilon_t \quad (2)$$

$$\Delta \ln OutVOL_t = \lambda_0 + \sum_{j=1}^{n1} k_{ji}\Delta outVOL_{t-j} + \sum_{j=1}^{n2} l_{ji}\Delta INTEN_{t-j} + \sum_{j=1}^{n3} o_{ji}\Delta EXTEN_{t-j}$$

$$+\sum_{j=1}^{n4} p_{ji}\Delta OPEN_{t-j} + \theta_1 INTEN_{t-1} + \theta_2 INV_{t-1} + \theta_3 OPEN_{t-1} + \varepsilon_t \quad (3)$$

$$\Delta \ln EXCHVOL_t = \lambda_0 + \sum_{j=1}^{n1} r_{ji}\Delta EXCHVOL_{t-j} + \sum_{j=1}^{n2} s_{ji}\Delta INTEN_{t-j}$$

$$+\sum_{j=1}^{n3} t_{ji}\Delta EXTEN_{t-j} + \sum_{j=1}^{n4} u_{ji}\Delta OPEN_{t-j} + \theta_1 INTEN_{t-1} + \theta_2 INV_{t-1} +$$

$$\theta_3 OPEN_{t-1} + \varepsilon_t \quad (4)$$

This equation includes both short-run (first-differenced) and long-run (one-period-lagged level) variables. For the short-run coefficients, each lag length n is chosen by minimizing the Akaike Information Criterion (AIC), and each model is estimated at these optimum lags. In the model, $RGDP_t$ is the real gross domestic products per capita, Exchange rate movement is defined as the movement in the rate at which naira exchanges for a unit of US dollar. $INTEN_t$ and $EXTEN_t$ are Intensive margin and Extensive margin of export diversification using Theil diversification or concentration index, $OPEN_t$ is the trade openness which is measured by total trade divided by GDP while Exchange rate and Output volatilities are obtained using ARCH & GARCH model. Data were gathered from different sources including United Nation Conference Trade and Development (UNCTAD), World Trade Organization (WTO) and Central Bank Nigeria.

Majorly, three different measures have been employed to represent volatility of exchange rates. Dell'Ariccia (1999) employs the standard deviation of the first difference of the log real exchange rate while Fernandez and Klassen (2004) measures exchange rate volatility using the moving average standard deviation of the monthly logarithm of real exchange rate. In more recent time, ARCH/GARCH modelling has been popularly employed for modelling volatility, study by Sauer and Sauer and Bohara (2001), and DeVita and Abbott (2004) provide good treatment of the model. In applying the GARCH models to capture the volatility of exchange rates, two steps have been generally considered to be very important. The first step borders on stationarity of the data employed for the GARCH model while the second step focuses on optimal lag selection of the GARCH model. All

of these were appropriately addressed before extracting volatility series from our GARCH model.

In an effort to build our ARDL and VEC on sound econometric foundation and as part of the requirement for these techniques, we subjected our data to unit root tests in order to determine their order of integration and the results are presented in Tables 1 and 2. The results indicate that our variables have a mixed stationarity. The result from Augmented Dickey Fuller unit test in Table 1 shows that all our variables are integrated of order one I(1) excerpt per capita GDP which was stationary at levels. Also, the results from DF-GLS unit root test in Table 2 shows that our variables are of different level of integration I(0) and I(1). Based on this unit root result, ARDL and Vector Error Correction (VEC) model seem to be an appropriate method of model estimation.

After the determination of the stationarity status of our variables, we carried out ARDL bound testing as proposed by Pesaran and Shin (1999) to test for cointegration. According to him, there are two asymptotic critical values: the lower value which assumes that all variables are I(0) and the upper value which assumes that all variables are I(1). If the calculated test statistic goes beyond the upper critical value, then the null hypothesis of "no cointegration" is rejected. If it falls below the lower bound, the null cannot be rejected.

Table 1: Augmented Dickey Fuller unit test

Variables	Level			First Difference		
	Constant	Constant and Trend	None	Constant	Constant and Trend	none
Extensive	-1.579	-4.127	-0.792	-10.660***	-10.554***	-10.683
Intensive	-2.283	-1.119	0.445	-6.1316***	-7.005***	-6.123***
Exchange	1.273	1.078	2.383	-6.221	-6.736***	-5.692***
Per capita	-5.204***	-5.185***	-5.111***			
Openness	-2.250	-1.997	-0.529	-9.8147	-10.026***	-9.913***
CV 1%	-3.4907	-4.0436	-2.5861	-3.4907	-4.0436	-2.586
CV 5%	-2.88790	-3.45118	-1.9437	-2.8879	-3.4511	-1.943
CV 10%	-2.58090	-3.15098	-1.6148	-2.5809	-3.1509	-1.614

Note: *** Significant at 1%,**Significant at 5% and * significant 10%

Table 2: DF-GLS Test Equation

Variables	Level		First Difference	
	Intercept	Intercept and Trend	Intercept	Intercept and Trend
Extensive	1.428	-2.021	-2.295**	-4.677***
Intensive	-1.119	-2.021	-2.295**	-4.677***
Exchange	-1.274	-1.767	-8.033***	-8.232***
Per capita	-2.673***	-2.875*	-7.662***	-8.229***
Openness	0.396	-1.493	-2.354**	-3.110**
CV 1%	-2.593	-3.648	-2.593	-3.648
CV 5%	-1.944	-3.087	-1.944	-3.087
CV 10%	-1.614	-2.794	-1.614	-2.794

Note: *** Significant at 1%,**Significant at 5% and * significant 10

Also, if the statistic falls within the respective bounds, it makes cointegration test inconclusive. The results, as presented in Table 3 show that there is co-integration in the four models estimated for economic growth, Output volatility, exchange rate and exchange rate volatility which make them conformable for ARDL and VEC estimation.

Table 3: Bounds tests Cointegration

Product	F-Statistics	Lower critical value 5%	Upper critical value 5%	Cointegrated
Exchange	10.856	3.79	4.85	Yes
Per capita	8.424	3.79	4.85	Yes
Exchange Vol.	12.9	3.79	4.85	Yes

4.0 Results and Discussions

The results from ARDL model estimation as presented in Tables 4a and 4b have economic growth, exchange rate movement, exchange rate volatility and output volatility as dependent variables. Starting with economic growth in Table 4a, the results show that in the short run both Intensive and Extensive concentration has contemporaneous positive effects on economic growth but only intensive concentration is statistically significant. At lag, both Intensive and Extensive concentration shows statistically significant negative effect on economic growth which basically reaffirms common position in the literature. In long run, the two variables also show statistically significant negative effect on economic growth. This implies that a quarter lag of Export concentration can be inimical to economic growth in Nigeria thus suggests the need for export diversification in the country.

The results from Table 4b show that Intensive concentration will decrease Exchange Rate Movement while Extensive Concentration will increase it contemporaneously. At one period lag, Extensive Concentration show the ability to reduce exchange rate movement and it is statistically significant. In the long run, the two variables demonstrate negative effect on Exchange rate movement but they are not statistical significance and thus suggest export diversification might not be very important to exchange rate movement in Nigeria and this might not be unconnected with management of exchange rate in the country. Also, trade openness shows evidence that it can increase exchange rate movement thus the need for strategic openness.

In the same table, the results show that Intensive Concentration can increase volatility in the short run and long run and this suggests that Intensive margin diversification can reduce exchange volatility in the country. Contrary to this, the results indicate that extensive concentration will reduce exchange rate volatility both in the short run and long while the opposite (Extensive margin Diversification) will increase it. This implies that Nigeria should focus more on its area of comparative advantage and diversify within this area of strength to reduce exchange rate volatility. Also in the results, intensive diversification does not reduce output volatility as expected but extensive diversification does contemporarily in

the short-run but not in the long-run. In addition, openness reduces exchange rate volatility though it is not statistically significant however; the variable contributes significantly to output volatility.

4.1 Model Estimation and Results Discussion

Table 4a: Short run and Long Co-efficient of Economic growth

	$D(GDP_{t-1})$	$D(Inten_t)$	$D(Inten_{t-1})$	$D(Exten_t)$	$D(Exten_{t-1})$	Constant	Inten	Exten	Open
Per Capita Growth	-0.54 (0.01)	13.7*** (0.01)	-15.3*** (0.008)	85.09 (0.53)	-419.6*** (0.03)	325.6*** (0.06)	-1.8 (0.35)	-404.2*** (0.08)	-19.8*** (0.06)

Note: *** Significant at 1%,**Significant at 5% and * significant 10. () Probability value

Table 4b: Short run and Long Co-efficient of Exchange rate Movement, Exchange rate and Output Volatility

	$D(Exch_{t-1})$/ $D(Evol_{t-1})$ & $D(Ovol_{t-1})$	$D(Inten_t)$	$D(Inten_{t-1})$	$D(Exten_t)$	$D(Exten_{t-1})$	Constant	Inten	Exten	Open
Exchange rate movement	-1.04 (0.04)	-1.32 (0.53)	-	208.24 (0.10)	-885.2** (0.0)	-0.83 (0.91)	-1.14 (0.5)	-132.21 (0.6)	30.0*** (0.0)
Exchange rate volatility	-0.04 (0.00)	0.20** (0.08)	-	-20.37*** (0.01)	-	15.3*** (0.01)	1.20** (0.06)*	-20.3*** (0.01)	-0.9 (0.14)
Output Volatility	-0.14 (0.06)	-0.43 (0.3)	-0.6** (0.06)	9.1** (0.09)	-	-	-0.06 (0.3)	-10.3 (0.2)	8.2*** (0.02)

Note: *** Significant at 1%,**Significant at 5% and * significant 10%. ( ) probability value

4.2 Robustness Check

To perform a robustness check on the ARDL model estimated, VECM estimation was performed based on the results obtained from our Bound Co-integration Tests. In this case, our estimation focuses on economic growth and exchange rate movement which are core variables of interest in this study. Also, this robustness check is important to settle some contentious issues in diversification literature. To determine direction of causality between economic growth and trade diversification, VAR Granger Causality was performed. This is very important because of the position of Imbs and Wacziarg (2003) that argued that the level of economic development dictates whether a country would benefit from diversification or not.

The results in Table 5a revealed uni-direction causality between trade diversification (Extensive) and economic growth and the direction is from diversification to growth thus suggesting that a country can always benefit from trade diversification

regardless of their level of economic growth and development. This suggests that the nature of trade diversification has a role play in determining whether the level growth counts for the realization of benefits inherent in diversification. This finding support the position of Olaleye, Edun and Taiwo (2014) and Esu & Udonwa , 2015.

Similarly, the results from VAR Granger Causality as contained in Table 5a show that there is uni-directional Causality between the exchange rate movement and Trade Concentration/Diversification (Extensive) and the direction is from trade diversification to exchange rate movement. This shows that the level of a country's diversification can help in explaining or predicting the movement in exchange rate.

Table 5a: VAR Granger Causality/Block Exogeneity Wald Tests

Dependent variable: D(GROWTH)			
Excluded	Chi-sq	df	Prob.
D(EXTENSIVE)	4.838409	2	0.0890*
D(EXCHANGE)	1.031075	2	0.5972
D(OPEN)	5.522900	2	0.0632*
All	10.34841	6	0.1107
Dependent variable: D(EXTENSIVE)			
Excluded	Chi-sq	df	Prob.
D(GROWTH)	0.822039	2	0.6630
D(EXCHANGE)	2.892781	2	0.2354
D(OPEN)	4.782905	2	0.0915*
All	10.37409	6	0.1098
Dependent variable: D(EXCHANGE)			
Excluded	Chi-sq	df	Prob.
D(GROWTH)	1.429040	2	0.4894
D(EXTENSIVE)	29.98286	2	0.0000***
D(OPEN)	2.764142	2	0.2511
All	35.73947	6	0.0000***

Note: *** Significant at 1%,**Significant at 5% and * significant 10%

The results as presented in Table 5b show bi-directional causality between economic growth and trade diversification (Intensive). This implies that as much as trade diversification can bring about economic growth, the level of economic growth and development can also determine if a country will benefit substantially from trade diversification.

Table 5b: VAR Granger Causality/Block Exogeneity Wald Tests

Dependent variable: D(GROWTH)			
Excluded	Chi-sq	df	Prob.
D(INTENSIVE)	6.522549	2	0.0383***
D(EXCHANGE)	0.201815	2	0.9040
D(OPEN)	5.168118	2	0.0755**
All	12.25434	6	0.0565**
Dependent variable: D(INTENSIVE)			
Excluded	Chi-sq	df	Prob.
D(GROWTH)	9.208962	2	0.0100***
D(EXCHANGE)	4.104314	2	0.1285
D(OPEN)	2.387542	2	0.3031
All	13.07243	6	0.0419**
Dependent variable: D(EXCHANGE)			
Excluded	Chi-sq	df	Prob.
D(GROWTH)	0.663178	2	0.7178
D(INTENSIVE)	1.870633	2	0.3925
D(OPEN)	3.396343	2	0.1830
All	5.211237	6	0.5170

Note: *** Significant at 1%, **Significant at 5% and * significant 10%. ( ) probability value

To investigate the differential effect of intensive and extensive trade diversification/ concentration, we examined variance decomposition component of our VECM and the results are presented in Table 6. As shown from the results, economic growth proxied by per capita growth explains largely its own variance decomposition in short term, medium term and long term which is traditionally expected. This is followed by intensive diversification or concentration in short term and medium term. In the long term, intensive diversification, openness and extensive diversification make substantial contributions but all through the period, Intensive diversification is the largest contributor to variance decomposition of economic growth apart from the growth itself. And, this underlines the importance of trade diversification in the area of comparative advantage for economic growth in Nigeria.

In the same table, the results show that exchange rate movement is largely responsible for its own variance decomposition in the short term, medium term and long term and this is not surprising. Apart from its own contribution, extensive diversification/concentration is about the only variable with substantial contribution to the Variance Decomposition of this important variable in the short term, medium

term and long term. Thus, it is safe to conclude that while Intensive Diversification is important for economic growth, extensive diversification is important exchange rate movement. The implication of this is that for Nigeria to fully benefit from diversification, it must look in both direction of extensive diversification and intensive diversification. With this, the country will be able to withstand external shocks.

Table 6: Variance Decomposition

Variance Decomposition of D (CAPITA)						
Period	S.E.	D(EXTENSIVE)	D(INTENSIVE)	D(CAPITA)	D(EXCHANGE)	D(OPEN)
1	9.764717	0.075449	16.01219	83.91236	0.000000	0.000000
2	10.04047	0.072379	16.11004	81.62371	0.126562	2.067310
5	12.72738	9.579283	12.43059	58.49949	7.815458	11.67517
6	13.05485	9.842857	12.84181	55.72123	10.40075	11.19335
9	13.41049	9.713893	13.15010	53.23974	12.56600	11.33026
10	13.51326	9.603592	12.95131	52.66612	12.46388	12.31510
Variance Decomposition of D (EXCHANGE)						
Period	S.E.	D(EXTENSIVE)	D(INTENSIVE)	D(CAPITA)	D(EXCHANGE)	D(OPEN)
1	10.17140	0.630140	1.665195	0.024723	97.67994	0.000000
2	13.96195	26.26889	0.984605	0.360373	72.23138	0.154750
5	19.53082	21.12986	3.383162	0.361152	74.44653	0.679296
6	20.56831	19.39102	3.770406	0.458984	75.64337	0.736219
9	24.25698	17.41251	3.877557	0.518322	76.58625	1.605366
10	24.98806	17.49389	3.680291	0.562270	76.74174	1.521808

5.0 Conclusion and Policy Implications

The major conclusion from the study is that the much established positive relationship of growth-trade diversification nexus is true for Nigerian economy despite being an oil-based economy. Also, the trade diversification can reduce movement in exchange rate especially extensive diversification thus preventing it from substantial movement that can derail it from long run equilibrium and this will go a long way in bringing about stability in Nigerian economy. This can be regarded as one of the channels through which trade diversification enhances growth. Also, the study confirms that the level of economic growth dictates the extent of benefits a country gets from trade diversification and this is in line with the assertion of (Imbs & Wacziarg, 2003; Olaleye, Edun & Taiwo 2014). The policy implication of

this finding is that intensive diversification in oil and gas can still help the economy to grow while extensive diversification will help to stabilize the exchange rate movement. Thus, the country must diversify in both directions to maximize the benefits inherent in trade diversification, which include stabilization of macroeconomic environment frequently disturbed by exchange rate movement.

Policy recommendations from the study includes first that policy makers should pursue vigorously both intensive and extensive trade diversification in other to propel economic growth. Second, trade diversification can guarantee stable exchange rate for Nigerian economy thus government should open up more sectors of the economy for international transactions and increase number of trading partners across regions of the world.

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A Reassessment of Money Demand in Nigeria

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This paper re-examines broad money (M2) demand and its stability in Nigeria using the Autoregressive Distributed Lag (ARDL) bounds testing procedure. First, the results indicate that a stable long-run relationship exists between M2 and its determinants including GDP, stock prices, foreign interest rates and real exchange rate. Furthermore, stock prices showed a significant and positive effect on the long-run broad money demand, which in some ways reflect increased 'financialization'[3] and integration of the Nigerian economy into the global economic system. Overall, the findings of this study lend credence to the continued relevance of the broad money aggregate, M2, as a benchmark for monetary policy implementation in Nigeria.

Keywords: Money Demand; Stability; ARDL Model; Bounds Test.

JEL Classification: E41, C42.

1.0 Introduction

The discourse on the demand for money in Nigeria has remained active after many years of concerted research and debate on the subject. The decade of the 1970s witnessed pioneering works on the subject by Tomori (1972), Ajayi (1974), Teriba (1974), Ojo (1974) and Odama (1974). These discussions and debates drew a lot of attention in both academic and policy circles at that time and earned the acronym 'TATOO' debate.[4] Since then, new entrants into the discussion have tended to build on the pioneering works of these great Nigerian scholars. This study draws some inspiration from these works. The subject has remained alive globally, owing mainly to the importance of the issues for macroeconomic management and monetary policy in particular. Policymakers need to know always how monetary policy affects the real economy and whether aiming to control money matters for the goal of stabilizing prices. To that extent, knowledge of the demand for money will continue to prove essential.

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[3]Increase in size and influence of financial institutions in an economy.

[4]TATOO is simply a coinage of the first letters of the last names of the pioneers (Tomori, Ajayi, Teriba, Ojo and Odama) of the debate on the demand for money in Nigeria.

Today, some of the policy-related developments that motivated the rigorous investigation of demand for money in Nigeria have not changed substantially. For example, the Central Bank of Nigeria (CBN) in 1974 adopted monetary targeting as the framework for the implementation of monetary policy. One of the key requirements for a successful targeting of monetary aggregates is the stability of money demand (Anoruo (2002), and Khan and Ali (1997)). Knowing the arguments of money demand is essential in the selection of instruments and targets, just as the transmission mechanism of monetary policy depends on the arguments of the demand for money. Till date, the Central Bank of Nigeria has continued to target money as its main monetary policy strategy.[5]

Nevertheless, every fresh attempt at studying the demand for money in Nigeria must be vigorously justified. The demand for money itself is a dynamic phenomenon. The determinants of money demand change over time especially when we consider the growing trends in financial innovation. In the past, many studies had, for example, reported interest rate neutrality in the demand for money function in Nigeria owing to the undeveloped nature of the financial market and narrow range of financial assets, such that rather than substituting between cash and financial assets, economic agents tended to substitute between cash and physical assets.[6] It will be interesting and useful to know if this situation has changed in view of recent milestones in financial deepening. This paper is aimed at reassessing the demand for money in Nigeria in the light of recent developments in the economy including the rapid expansion in incomes, greater number and variety of financial assets, and increased openness of the Nigerian economy. Furthermore, the paper seeks to examine whether equity prices matter for monetary policy formulation in Nigeria.

The rest of the paper is structured as follows: Section two presents a review of

[5]There have been significant refinements over the years especially with the adoption of an interest rate corridor and replacement of the minimum rediscount rate by the monetary policy rate (MPR) in 2006. Notwithstanding these modifications, monetary targeting continues to be an integral part of the Central Bank of Nigeria's monetary policy strategy.

[6]see Ndebbio, 1998.

both theoretical and empirical literature on the demand for money. Section three discusses the data and method of analysis while the estimation and results are presented in Section four. In section five, we present the conclusions and policy implications.

2.0 Literature Review

2.1 Theoretical Framework

The literature on the demand for money, also referred to as the demand for real balances[7], is quite vast. The empirical literature on the demand for money in Nigeria is equally rich. At the theoretical level, the motives for holding money are clearly distinguished; transactions, speculative and precautionary motives. The Keynesian theory identifies all three motives for holding cash balances (Keynes, 1936). Both the post-Keynesian and the classical quantity theories, however, focus on particular motives for holding money. In all, the theories of demand for money essentially rely on the functions of money in explaining the determination of money demand (Teigen, 1971).

Keynes argued that economic agents hold a certain proportion of money for the sake of medium of exchange function, that is, to effect transactions. This motive is viewed as dependent on income. The relationship between the transactions demand for money and income is postulated to be stable. Cash balances are also held to bridge receipts and payments since people are sometimes unsure as to when they will have need to make payments. This motive, which Keynes refers to as precautionary, also depends on the level of income. The third motive for holding money in the Keynesian theory of demand for money is speculative purposes. He argued that individuals hold cash balances in order to speculate or invest. The speculative demand for money is hypothesised to depend on expectations about future (or expected) rates of interest.[8] Post-Keynesians, in particular, Baumol

[7]The demand for money or real balances is that amount of cash balanaces that economic agents are willing to hold at any given time.

[8]Economic agents prefer to hold money when interest rates are low with the expectation that interest rates would rise in the future and the price of bond (the alternative means of holding wealth) would fall.

(1952) and Tobin (1956) indicated that this motive for holding money is also income elastic, in addition to providing greater insights about the role of interest rate in the demand for money. The Baumol-Tobin model explains money holding in terms of transactions demand. Hence, when income increases, the transaction demand for money increases less proportionally. This leads to rise in income velocity of money. Post-Keynesian theories of demand for money include the inventory-theoretic approach and the buffer-stock/portfolio models (for detailed explanation of these theories, see Sriram, 1999). Post-Keynesian theories of demand for money include the Inventory-theoretic approach and the buffer-stock/portfolio models (for detailed explanation of these theories, Sriram (1999). From the forgoing, the demand for real balances increases with the level of income and decreases with interest rate. Zecher (1974) expressed this symbolically as:

$$\frac{M_d}{P} = Y^k I^{-h} \tag{1}$$

$\frac{M_d}{P}$ is demand for real money balances; Y is income, and I is interest rate. k and $-h$ are elasticities with respect to income and interest rate, respectively.

Earlier, the classical school of the quantity theory had made significant imprints on the field of monetary economics. The postulations of the classical thought are represented by the Fisher's equation of exchange and the Cambridge approach.

The Fisher's equation of exchange is symbolically presented as:

$$MV = PT \tag{2}$$

where, M is the quantity of money, V is the velocity of circulation, P is the price level and T is transactions volume.

MV, which is total spending, equals PT (what is purchased) simply implies that money is demanded for transactions sake only. This strict position was later modified in the Cambridge approach also known as the cash balance approach. In this formulation, money is held as part of an individual's wealth and has an opportunity cost. The store of value function of money is emphasised. It nevertheless admits income as a key determinant of the demand for money in addition to the

opportunity cost variable and the rate of interest (Laidler, 1993).

2.2 Empirical Literature

The empirical literature on the demand for money in developing countries is quite vast, with studies that have used Nigerian data contributing a fair share. The earliest studies on the demand for money in Nigeria were; Tomori (1972), Ajayi (1974), Teriba (1974), Ojo (1974), and Odama (1974). These scholars intensely debated the determinants, their relative importance and the stability of the demand for money in Nigeria. Virtually all the studies found income as a determinant of the demand for money in Nigeria. They, however, differed on interest rate. Some of the studies found interest to be insignificant and they defended this finding by arguing that the hugely underdeveloped financial market and the attendant dearth of alternative financial assets provided credence to the result.

Table 1a: Summary of the Empirical Literature on Money demand in Nigeria

Author(s)	Period	Aggregate	Model	Results
Ajayi (1977)	1960-1970	M2	OLS	Demand for money is inelastic with respect to income and price changes expectation. Unstable money demand; Real income and real interest rate.
Arize and Lott (1985)	1960-1983	M1	OLS	Income and expected rate of inflation; control of money stock is essential for price stability
Ajewole (1989)	1973-1986	M1 and M2	McKinnon	Demand for money is influenced by GDP and return to Physical assets. M2 performs much better than M1 in the Nigerian Context. No significant difference between in real money demand when expected and current income are used and interest rates do not significantly influence money demand in Nigeria.
Oresotu & Mordi (1992)	1960-1991	M1 and M2	OLS	GDP, foreign interest rate, domestic interest rate, inflationary expectations and domestic currency exchange rate as the factors influencing money demand function in Nigeria during the period under review.
Hassan, et al (1995)	1976-1988	M2	ECM	Stable demand for money; Cointegration among variables,
(Nwaobi, 2002)	1960-1995	M1 and M2	VAR	Stable demand for money; Income as a suitable scale variable
Anoruo (2002)	1986-2000	M2	ECM/OLS	Stable demand for money; M2 still a relevant monetary policy target; income, M2, real discount rate were co-integrated
Owoye & Onafowora, (2007)	1986-2001	M2	OLS and ECM	Stability of money demand reported; cointegration among real broad money, inflation rate, real income, interest rate and foreign interest rate
Nwafor et al, (2007)	1986-2005	M2	Johansen and julieus Cointegration Test	Money demand function is stable and cointegration among the series was established.

In recent times, many other studies have investigated this same phenomenon and have provided further insights about the arguments and stability of the demand for

money in Nigeria. Some of these studies and their main findings are summarised in Tables 1a and 1b. The earliest studies on the demand for money in Nigeria referred to as the TATOO debate essentially focused on definition of money, income as a key variable and a bit of stability issues (Yamden, 2011). Studies that are more recent have leveraged on the tremendous progress in economic research methodologies and econometrics to shift the debate to a higher level. Rather than dwelling on the traditional variable of money demand suggested by theory, they have sought to identify more efficient proxies for opportunity cost especially. In this wise, variables such as expected exchange rate depreciation and equity yield have emerged as useful proxies for the opportunity cost of holding money in money demand models for Nigeria (see for example Owoye and Onafowora (2007) and Yamden, (2011). Issues such as cointegration (existence of long-run relationship), existence of endogenous structural breaks and stationarity, which the more recent studies have brought on board, have significantly improved model efficiency and results.

To summarise, we have learned from the survey of the empirical literature on the demand for money in Nigeria that income, expected inflation rate, and other proxies of opportunity cost (equity yield, real discount rate, expected exchange rate depreciation) generally perform well in money demand functions using Nigerian data. The particular opportunity cost variable adopted is critical to finding a significant, negative relationship as suggested by theory. In addition, there seems to be some consensus on income as an appropriate scale variable and stability of parameters of the demand for money function. Stable demand for money is especially important as it suggests that targeting monetary aggregates (M2 in particular) is key to boosting economic activity and that they remain a viable monetary policy instrument for Nigeria (Kumar, *et* al. (2010); and Arize and Lott (1985). Interestingly, we note that the income elasticity of money demand tends to be higher when a broad definition of money is used, sometimes even higher than unity (see for example, Hassan, *et* al. (1995); Anoruo, (2002); Owoye and Onafowora (2007); Akinlo (2006)). Studies using other countries' data have similarly reported income elasticity higher than one (see Laidler, 1993). Finally, we note also the presence of endogenous structural breaks even though studies

have differed with respect to the exact point in Nigerian data.

Table 1b: Summary of the Empirical Literature on Money demand in Nigeria (Cont'd)

Author(s)	Period	Aggregate	Model	Results
Kumar, et al (2010)	1960-2008	M1	ECM	Stable demand for money reported; study also identified 1992 and 1986 as the endogenous structural break points
Omanukwue (2010)	1990-2008	M1	Engle-Granger two–stage test for cointegration	Established the existence of long-run relationships among the variables. Weak unidirectional causality from money supply to inflation.
Omotor and Omotor (2011)	1960-2008	M2	ECM	Stable demand for money; study also identified 1994 as the endogenous structural break point
Yamden (2011)	1985-2007	M2, M1	OLS	Stable money demand during most of the sampled years with breakouts in a few years; study found dividend yield significant in both models in addition to income, inflation, and exchange rate.
Nduka,et al (2013)	1986-2011	M2	ECM	Stable demand for money; existence of structural break
Iyoboyi & Pedro (2013)	1970-2010	M1	ARDL/VECM	Empirical results found cointegration relations among narrow money demand, real income, short term interest rate, real expected exchange rate and inflation rate. Real income and intreset rate are significant variables in explaining demand for M1
Doguwa et al (2014)	1992-2013	M2	ECM	Employed the Gregory and Hansen residual based test co-integration method using quarterly data for 1991:1 to 2013:4. Focusing on the impact of financial crisis on the money demand function, they provide evidence of a stable money demand function before and after the recent global financial crisis.
El-Rasheed et al (2017)	1980-2014	M2	ARDL	Monetary uncertainty has significant influence on the demand for money function in Nigeria.

3.0 Data and Methodology

3.1 Data

The data used in this study is quarterly time-series data from 1985Q1-2016Q4.The data were sourced from World Development Indicators published by the World Bank (World Bank, 2016), OECD data bank, the Central Bank of Nigeria's statistics database and the Federal Reserve Bank of St Louis.

3.2 Empirical Model

This study uses an empirical model based on the transaction demand and the opportunity cost of holding money. The money demand model was first introduced by Baumol-Tobin (see Baumol, 1952 and Tobin, 1956)). Their paper found that the transaction demand for money exhibits economies of scale. Hence, when income increases the transaction demand for money increases less than proportionally. Therefore, the model takes the following format as in Baharumshah *et* al. (2009).

$$\frac{m}{P} = f(GDP, fir, Inf, Dir, SP, REER) \tag{3}$$

where m/p is real money stock; GDP is gross domestic product; fir is foreign interest rate; Dir is the domestic interest rate, SP is stock prices, Inf is change in consumer price index and $REER$ is the Real Effective Exchange rate. Several studies have incorporated the exchange rate in the money demand function (see Arango and Nadiri (1981) and Bahmani-Oskooee and Pourheydarian (1990)). Equation (3) is re-written in semi-log form as shown in (4), the model is semi-logged because of the variable that is in percentage i.e. inflation.

$$ln(M)_t = \rho_1 ln(GDP)_t + \rho_2 lnf_t + \rho_3 fir_t + \rho_4 lnDir_t + \rho_5 ln(SP)_t + \rho_6 ln(REER)_t + \varepsilon_t \tag{4}$$

The parameters in equation (4) capture the response of money demand to changes in its determinants. The income elasticity of money demand is expected to be positive. Both domestic and foreign semi-interest elasticity of money demand can be negative or positive depending on the strengths of the income and substitution effect on money balances. The introduction of stock prices in the money demand function is justified by the rapid growth and diversification of the capital market, particularly equities, in the last 10 to 15 years. Increasingly, investment in equities has become a viable alternative form of holding wealth in Nigeria. The REER was used to capture the substitution between domestic and foreign currencies which measure the value of a currency against a weighted average of several foreign currencies) divided by a price deflator or index of costs.

The size of the coefficient of the income variable can take the following forms: if it is equal to unity, $\rho_1 = 1$, the quantity of theory is applicable; furthermore, if the size of the coefficient on the income variable is half, $\rho_1 = 0.5$, the Baumol–Tobin

approach is applicable; finally, if the scale variable is greater than unity, (that is, if $\rho_1 > 1$, money is considered as a luxury good, neglecting wealth effects.

3.3 Econometric Method

This study adopts the Pesaran and Shin (1998) ARDL model. The model is used because of its suitability in modelling a time series particularly in small samples. It has a big advantage in that regardless of the order of the variables (be it in level $I(0)$ or first-difference $I(1)$), it overcomes the unit-root pitfalls in regression, in addition to solving the often present problem of serial correlation in economic times series. Following Pesaran and Shin (1998), the error correction version of the ARDL model is stated as follows:

$$\Delta y_t = \phi + \sum_{i=1}^{k-1} A_1 \Delta y_{t-i} + \sum_{i=1}^{k-1} B_1 \Delta x_{t-i} + \delta_1 y_{t-k} + \delta_2 x_{t-k} + \mu_t \qquad (5)$$

Equation (5) captures the error correction in the ARDL model in which , ϕ is the constant vector parameter, A and B are the short run parameters; y_t captures the endogenous vector variable, x_t is a vector of the other explanatory variables as outlined above and δ_1 and δ_2 are the parameters of the long-run relationship. μ_t is error term, assumed to be serially uncorrelated and homoscedastic.

As noted whilst introducing the ARDL model, all the variables have to be stationary, either in level or at first difference. To check this property before proceeding to the full ARDL model, the study uses the Phillips and Perron (1988) unit-root test.

3.4. ARDL and Bounds Testing Procedure

The Pesaran and Shin (1998) cointegration technique involves a 2-stage procedure in the estimation of the long-run relationship. In the first stage, the existence of cointegration amongst the variables (bounds testing) is tested using the standard Wald or Fisher F-test using equation 3. The null hypothesis is that the coefficients of the lagged regressors in the error correction version of the ARDL model (equation 5) are zero i.e. $H_0 : \delta_1 = \delta_2 = 0$. This null is tested against the alternative hypothesis of $H_1 : \delta_1 \neq \delta_2 \neq 0$. Pesaran and Shin (1998) provide critical values to test the hypothesis, with and without time trend. The critical values

are grouped into "upper" and "lower" bounds, where, the upper bound assumes that all the variables are jointly first-difference stationary i.e. I(1) and the lower bound assumes that all the variables are level stationary or I(0). To reject the null hypothesis, the calculated F-statistic must be above the upper bound critical value. If the calculated F-statistic is found to be below the lower bound, a decision to fail to reject the null hypothesis is required for the model. As a final point, if the calculated F-statistic lies in-between the upper and lower bound, the test result is inconclusive. At this stage knowledge of the order of integration (or time series properties of the variables) is required to proceed. The second stage of estimation can only proceed once cointegration is established among the variables.

At this stage, the short-run and long-run parameters are estimated[9] using the following two equations:

Long-run equation

$$\hat{\delta}_1 y_t + \hat{\delta}_2 x_t = 0; \quad y_t = -\frac{\hat{\delta}_2}{\hat{\delta}_1} x_t \tag{6}$$

obtained from a version of equation (5) where appropriate lags would have been selected for both the dependent and independent variables using any of the information criterion after confirming the existence of long-run relationship in stage one.

Dynamic error correction equation for the short-run coefficients/parameters obtained from the equation below:

$$\Delta y_t = a + \sum_{j=1}^{p} \alpha_j \Delta y_{t-j} + \sum_{j=0}^{q} \beta_{1j} \Delta x_{t-j} + \phi ecm_{t-1} + v_t \tag{7}$$

where $ecm_{t-1} = y_{t-1} - \frac{\hat{\delta}_2}{\hat{\delta}_1} x_{t-1}$ obtained from (6) above; y_t and x_t are as previously defined; β_{1j} are the short-run parameters; ϕ measures the speed of adjustment to a new equilibrium whenever there is a shock. It also provides another means of validating the existence of cointegration or long-run relationship among the variables. It is expected to be negative and significant and less than one in absolute

[9]The lag length and lag criterion are chosen; the criterion could be any of Schwartz, Hannan Quinn or the Akaike. Stability and diagnostic checks are carried out for heteroscedasticity, serial correlation, functional form misspecfication and normality of the data.

value for the model to be stable.

3.5. Stability checks

A stability check is carried out on the model using Brown, *et* al. (1975) model of stability verification. The cumulative sum (CUSUM) and cumulative sum of square (CUSUMSQ) are called out on recursive regression residual. To accept that the model is stable, the plots must fall within 5% critical bounds of significance.

The CUSUM test is based on the cumulative sum of recursive residuals based on the first set of n observations. It is updated recursively and plotted against the breakpoints. If the CUSUM statistic stays within the 5% significance level, the estimated coefficients are said to be stable. A similar procedure is used to carry out the CUSUMSQ that is based on the square of recursive residuals.

4.0 Estimation and Results

This section discusses the empirical results comprising of the preliminary results, unit root test, the bounds testing for cointegration, the long-run and short-run estimates of the model and finally, the stability and diagnostics test results.

4.1 Preliminary results

4.1.1 Summary statistics

Table 2 presents the descriptive statistics of the variables of interest in the study over the period, 1985Q1 to 2016Q4. The standard deviation in the data set range from 0.127 to 21.8176 while skewness ranges from -0.74 to 2.75. The variable with the highest mean is REER with 30.30 and the lowest mean was FIR with 1.63. The Jacque-Bera statistic shows the goodness of fit of the data. From the p-values we can observe the data is not normally distributed as it rejects the null hypothesis of normality.

Table 2: Summary statistics

	M2	GDP	INF	FIR	DIR	SP	REER
Mean	6.894879	4.296955	4.970049	1.634831	4.698228	2.156555	30.30041
Median	6.950176	4.237249	3.065963	1.768597	4.510635	2.294355	22.90882
Maximum	7.678465	4.513010	19.10651	2.748105	8.120378	2.751988	142.1950
Minimum	5.961017	4.127328	0.465995	0.740723	2.271823	1.182588	9.291825
Std. Dev.	0.561085	0.126432	4.684975	0.617615	1.067838	0.466777	21.81765
Skewness	-0.176227	0.456104	1.554344	-0.091923	0.525628	-0.741412	2.751405
Kurtosis	1.743579	1.757067	4.068669	1.621837	4.644152	2.183826	11.73603
Jarque-Bera	9.081696	12.67737	57.63195	10.31003	20.31133	15.27950	568.5285
Probability	0.010664	0.001767	0.000000	0.005770	0.000039	0.000481	0.000000
Sum	882.5445	550.0102	636.1663	209.2583	601.3732	276.0390	3878.453
Sum Sq. Dev.	39.98172	2.030108	2787.522	48.44400	144.8153	27.67086	60453.26
Observations	128	128	128	128	128	128	128

4.1.2 Correlation Matrix

Table 3 presents cross correlations among the variables. The correlation matrix shows positive correlation of M2 with GDP and stock prices and negative correlation with inflation, domestic and foreign interest rates and REER.

Table 3: Correlation Matrix

	M2	GDP	INF	FIR	DIR	SP	REER
M2	1.000000	0.956737	-0.371132	-0.816721	-0.067136	0.947534	-0.264636
GDP	0.956737	1.000000	-0.382151	-0.833793	-0.184160	0.836305	-0.216566
INF	-0.371132	-0.382151	1.000000	0.249987	0.422351	-0.327753	-0.177893
FIR	-0.816721	-0.833793	0.249987	1.000000	0.014483	-0.695317	0.276350
DIR	-0.067136	-0.184160	0.422351	0.014483	1.000000	0.049813	-0.571144
SP	0.947534	0.836305	-0.327753	-0.695317	0.049813	1.000000	-0.291253
REER	-0.264636	-0.216566	-0.177893	0.276350	-0.571144	-0.291253	1.000000

4.2 Unit root test

Unit root examinations were carried out using the Phillips-Perron's (PP test).

Table 4: Unit root test

Variables	PP TEST		
	LEVELS	FIRST DIFF	ORDER of Integration
M2	-1.098	-3.430	I(1)
GDP	0.566	-4.2755	I(1)
INF	-2.623	-5.462	I(1)
SP	-2.499	-4.973	I(1)
FIR	-1.985	-4.298	I(1)
DIR	-2.214	-5.787	I(1)
REER	-3.406	-5.149	I(1)

From the PP unit root test result in Table 4, all the variables are integrated at order one which paves the way for the use of the ARDL bounds testing procedure to test for long-run relationship.

Table 5: Bounds Test

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	4.417477	10%	2.12	3.23
k	6	5%	2.45	3.61
		2.5%	2.75	3.99
		1%	3.15	4.43
Actual Sample Size	121		Finite Sample: n=80	
		10%	2.236	3.381
		5%	2.627	3.864
		1%	3.457	4.943

As stated earlier, the ARDL model approach is implemented in two stages in estimating the long-run relationship. In the first stage, the existence of long-run relationship is tested using the bounds test. The bounds test F-statistic must be greater than the upper bound critical values at 5% or 10%.

The computed F-statistics from the bounds test is 4.417. This value is higher than the upper bound critical value at 3.61 at the 5 per cent level of significance. Hence, the null hypothesis of no-long run relationship can be rejected for the model. In effect, there exists a long-run relationship between the demand for money (M2) and its determinants.

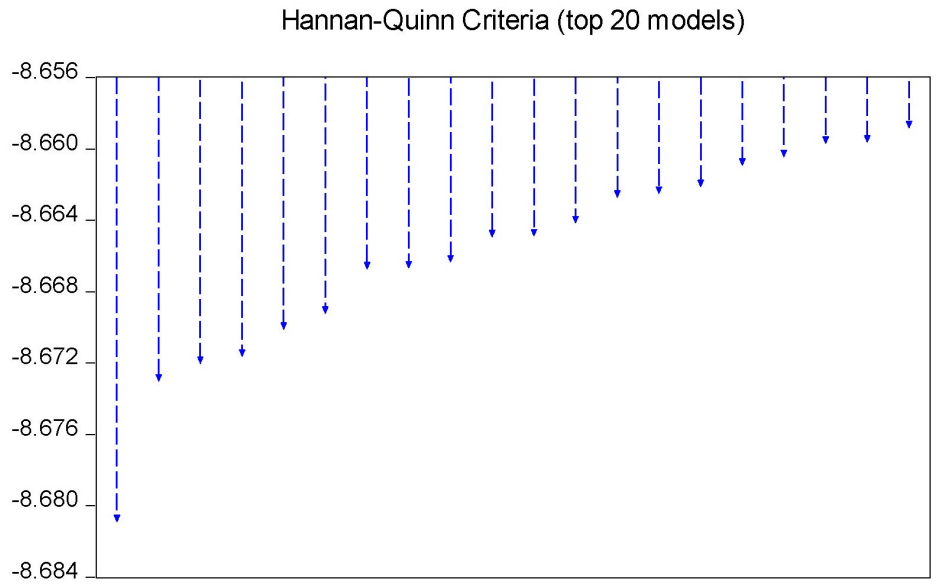

Figure 1: Selection Criteria

Table 6: Long Run Model

Variable	*Coefficient*	*Std. Error*	*T-statistic*	*P-value*
GDP	1.184670	0.650156	1.822133	0.0718**
INF	-0.013414	0.009663	-1.388183	0.1685
FIR	-0.110934	0.108392	-1.023454	0.3088
DIR	-0.024359	0.037573	-0.648318	0.5184
SP	0.616283	0.099097	6.219019	0.0000*
REER	-0.004737	0.002769	-1.710550	0.0906**

Notes: * and ** indicate level of significance at 5% and 10% respectively.

4.3 Long-run and Short-run Models

Table 6 presents the long-run ARDL model for money demand in Nigeria using data from 1985 to 2016. All the coefficients are with correct signs. There is a positive and statistically significant relationship between broad money demand (M2) and GDP as the income elasticity is statistically significant at the 10 per cent level. Hence, an increase in GDP leads to an increase in demand for money as outlined in economic theory. There is also a positive and significant relationship between broad money demand and stock prices. This is because the level of stock prices represents a broad proxy of financial wealth. In the long-run, stock market assets act as a store of value for the monetary aggregate. Both domestic foreign interest rates returned negative coefficients suggesting inverse relationships with broad money demand. By implication, an increase in the foreign interest rate may give rise to a fall in the demand for the local currency (Naira) and increase in the demand for the foreign currency (Dollar). Furthermore, Inflation is negative and statistically insignificant as inflation is negatively correlated to real demand for money. The Real effective exchange rate (REER) is negative and statistically significant at the 5% level. The significance of this indicates the existence of currency substitution in Nigeria.

Table 7: Diagnostic Test

Diagnostic Test	
Serial Correlation	0.464(0.630)
Ramsey Reset	0.380(0.704)
White Test	0.638(0.917)

P-values are indicated in the brackets). Serial correlation test is carried out using LM test for serial correlation of variables, to test for functional form mis-specification Ramsey RESET test is used. Finally, heteroscedasticity is tested using white test. The p-values are presented wiith all showing a failure to reject the null hypothesis for all the tests.

4.4 The Short-Run Model

The dynamic error correction regression associated with the above long-run relationship based on the ARDL approach is reported in Table 7. The model selected is ARDL (3,6,1,6,1,1,7). The coefficients of all lagged first differenced variables in the ARDL model (Short-run coefficient estimates) are shown in Table 8. Not much can be inferred from the short-run model. As expected the error correction term

carries a negative sign which highly significant at the 1% level[10] indicating that M2, GDP, Inflation, Stock Prices, REER and Domestic & foreign interest rates are cointegrated. The absolute value of the coefficient of the error-correction term indicates that about 1.5% per cent of the disequilibrium in M2 demand is counterbalanced by short-run adjustment in each quarter. This indicates that excess money is followed in the subsequent period (next quarter) by a reduction in the level of money balances, which people will hold. Thus, it is important to reduce the existing disequilibrium over time in order to maintain long-run equilibrium.

4.5 Stability Diagnostics

The existence of a stable and predictable relationship between the demand for money and its determinants is considered necessary for formulation and implementation of monetary policy strategies based on intermediate monetary targeting as outlined by Sharifi-Renani (2007). The stability of long-run coefficents is used to form the error-correction term in conjuction with the short-term dynamics. Some of the problems of instablity could stem from inadequate modelling of the shor-run dynamics charaterising departures from the long-run realtionship. Hence it is important to incorporate the short-run dyamics for consistency of long-run parameters. In view of this we apply the CUSUM and CUSUMSQ tests developed by Brown *et* al. (1975).

Analysis of Figure 2 showed that the plots for the CUSUM statistic for M2 are stable and within the boundary. However, the statistic for CUSUMSQ in Figure 3 crosses the critical value line's indicating some instability in M2 money demand. A plausible explanation for this occurrence is the fact that this period coincided with the implementation of a home designed Policy Support Instrument (PSI) programme with the International Monetary Fund (IMF). The Programme set as targets, some thresholds for reserve money and other monetary aggregates, which the CBN was, expected to comply with on quarterly basis, in order to have the support of the Fund in Nigeria's economic and financial reform programmes in

[10]This gives further credence to support the cointegration of the variavles of interest. The value normally lies between 0 and -1 where a value of 1 indicates 100 percent disequilibrium in the money deman function is corrected in the following quarter.

the negotiations leading to the Paris and London Club debt exit in 2005. The objective of the IMF endorsement for the PSI was to provide strong signals to donors, creditors, and investors about the effectiveness Nigeria's economic and financial policies. As expected, the stance of monetary policy during this period was mainly restrictive.

Table 8: Estimated Short Run Money Demand Model: ARDL ECM Approach

Variable	Coefficient	Std. Error	T-statistic	P-value
C	0.017915	0.002991	5.990146	0.0000*
D(M2(-1))	0.659242	0.077539	8.502070	0.0000*
D(M2(-2))	0.177610	0.069136	2.568996	0.0118*
D(GDP)	-0.504133	0.150483	-3.350101	0.0012*
D(GDP(-1))	0.455015	0.175329	2.595211	0.0110*
D(GDP(-2))	-0.030707	0.143330	-0.213249	0.8308
D(GDP(-3))	0.002377	0.142638	0.016661	0.9867
D(GDP(-4))	-0.808778	0.179052	-4.517003	0.0000*
D(GDP(-5))	0.681828	0.157473	4.329797	0.0000*
D(INF)	0.000288	0.000202	1.422116	0.1584
D(FIR)	-0.034068	0.004280	-7.960159	0.0000*
D(FIR(-1))	0.025128	0.005724	4.390161	0.0000*
D(FIR(-2))	0.007939	0.005624	1.411705	0.1614
D(FIR(-3))	0.000105	0.004787	0.021884	0.9826
D(FIR(-4))	0.020018	0.005038	3.973737	0.0001*
D(FIR(-5))	-0.013434	0.004234	-3.173058	0.0021*
D(DIR)	0.001778	0.000782	2.272058	0.0255*
D(SP)	0.009410	0.003880	2.434350	0.0173*
D(REER)	-0.000544	9.27E-05	-6.872199	0.0000*
D(REER(-1))	0.000377	0.000108	3.473265	0.0008*
D(REER(-2))	0.000150	0.000102	1.476926	0.1432
D(REER(-3))	4.87E-05	8.42E-05	0.578383	0.5645
D(REER(-4))	-0.001315	0.000111	-11.79985	0.0000*
D(REER(-5))	0.000914	0.000147	6.210912	0.0000*
D(REER(-6))	0.000288	0.000124	2.333111	0.0219*
ConintEq(-1)	-0.015269	0.002659	-6.743155	0.0000*

Notes: * and ** indicate level of significance at 5% and 10% respectively

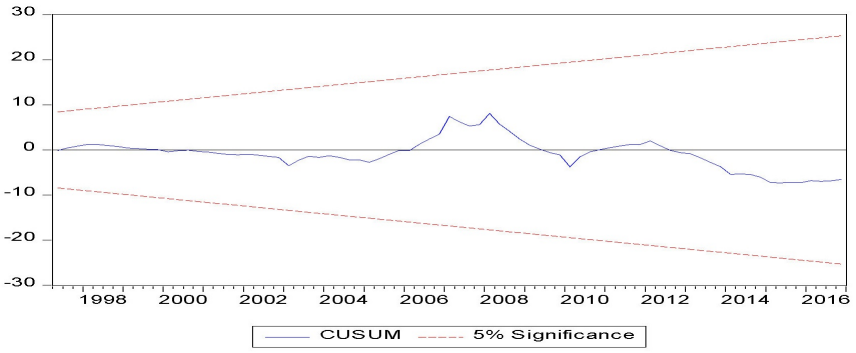

Figure 2: CUSUM Graph

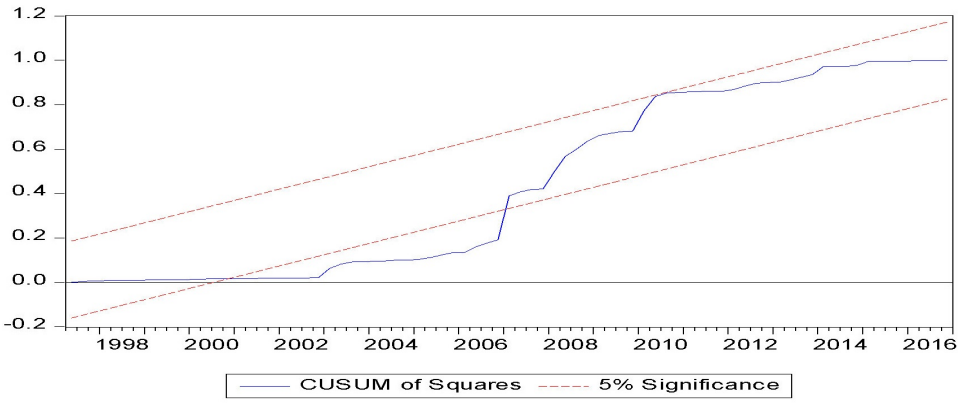

Figure 3: CUSUMSQ Graph

5.0 Conclusions and Policy Implications

The paper sets out to estimate the broad money demand function for Nigeria taking into account the equity market and its impact on money demand. Quarterly observations for the period, 1985Q1 to 2016Q4, were used. The paper adopts the Pesaran and Shin (1998) ARDL bounds testing aproach to determine whether a long-run relationship exist between the variables of interest.

In summary, the results suggest that broad money (M2) remains a credible intermediate target for monetary policy. In the long-run, movements in money demand are related to income, stock prices and foreign and domestic interest rates. The findings of this study are broadly in line with the results in Friedman (1988) and McCornac (1991). From empirical point of view, inclusion of stock prices is important for the stability of M2. These results show that changes in income have significant (positive) short and long-term effects on money; while the variable, stock prices, is positively significant only in long-run. This means that the variable (stock prices) comes into the money demand function for Nigeria as a wealth variable rather than an opportunity cost variable. Inflation is insignificant in the long run, which justifies the short-term orientation of monetary policy. Domestic and foreign interest rates, though properly signed, were statistically insignificant in the long run.

Three policy implications are derived from the findings of this study. First, the

conduct of monetary policy in Nigeria should continue to focus on monetary aggregates, especially their growth rates. This is in view of the established stability of the broad money demand and the positive income elasticity in both the short and the long run. Second, the performance of the Stock prices captured by the All-Share Index in the model suggests that asset prices, particularly equity prices, matter for monetary policy in Nigeria. This is important when viewed against the debate about whether monetary policy should respond to asset price misalignments. In our view, and drawing from this study, the CBN monetary policymakers should begin to pay more attention to asset prices in the conduct of monetary policy. Finally, interest rate performed poorly in the model, and such, we may infer that any instrument that works essentially through interest rates (like the Monetary Policy Rate) will need to be complemented by other instruments to impact the intermediate target (money supply) of monetary policy.

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Appendix

Data Sources:

All data are quarterly for the 1985(1)- 2016(4) period. They were obtained from various sources such as World Development Indicators published by the World Bank (World Bank, 2016), OECD data bank, the Central Bank of Nigeria's statistics database and the Federal Reserve Bank of St Louis. Definition of Variables.

M2 – is broad money supply.

GDP- Is gross domestic Production.

Inflation- Is the inflation rate captured by the consumer price index.

Dir- is the domestic interest rate.

Fir- is the US interest rate.

REER- is the real effective exchange rate.

Unit Root Test.

Augmented-Dickey fuller test.

Given,

$$y_t = \mu + \omega_t + \eta y_{t-1} + \eta_1 \Delta y_{t-1} + ... + \eta_p \Delta y_{t-p} + \varepsilon_t$$

The random walk is obtained by imposing, $\mu = 0$ and $\omega_t = 0$. The random walk drift has $\omega_t = 0$; the trend stationary model ventures both parameters free.

The test statistic to carry out the test is then

$$DF_i = \frac{\hat{\eta} - 1}{StandardError(\hat{\eta})}$$

Based on the statistic,

$$DF_\eta = \frac{T(\hat{\eta} - 1)}{1 - \hat{\eta}_1 - ... - \hat{\eta}_p}$$

It has the advantage that it can accommodate higher autoregressive process in ε_t. Alternatively, by subtracting $y_(t-1)$ from both sides.

$$Deltay_t = \mu_t + \eta^* y_{t-1} + \sum_{j=1}^{p-1} \Pi_j \delta y_{t-j} + \varepsilon_t$$

where

$\Pi_j = -\sum_{k=j+1}^{p}$ and $\eta^* = (\sum_{i=1}^{p} \eta_i - 1)$. The null hypothesis for the Augmented-Dickey fuller is then $\eta^* = 0$ against an alternative of $\eta^* < 0$. If failure to reject the unit root holds, $\eta^* = 0$ then first-difference may be carried out.

$$Deltay_t = \mu_t \omega_t + \eta^* y_{t-1} + \sum_{j=1}^{p-1} \Pi_j \delta y_{t-j} + \varepsilon_t$$

The test is carried out using the joint-hypothesis that $\mu = \omega = 0$.

Phillip's and Perron Test (1988)

The philp-perron's test has been used to improve on the ADF test as it captures finite sample properties.

Given,

$$y_t = \theta_t + \eta y_{t-1} + \eta_1 \Delta y_{t-1} + ... + \eta_p \Delta y_{t-p} + \varepsilon_t$$

where θ_t, may be 0, μ or $\mu + \omega_t$. The (PP-Test) modifies the ADF test outlined above.

$$Z_l = \sqrt{\frac{C_0(e\hat{t}a - 1)}{av}} - \frac{1}{2}(a - C_0)\frac{Tv}{\sqrt{as^2}}$$

$$z_\eta = \frac{T(\hat{\eta} - 1)}{1 - \hat{\eta}_1 - ... - \hat{\eta}_p} - \frac{1}{2}(\frac{T^2 v^2}{s^2}(a - C_0))$$

where,

$$C_0 = [(T - K)/T]s^2$$

$$a = C_0 + 2\sum_{j=1}^{L}(1 - \frac{j}{L+1})c_j$$

where $c_j = \frac{1}{T\sum_{s=j+1}^{T} e_t e_{t-s}}$, $\quad j = 0, ..., p$, that is the j^{th} autocovariance residuals $s^2 = \frac{\sum e_t^2}{T-K}$ and v^2=variance of $\hat{\eta}$.

Null Hypothesis: M2 has a unit root
Exogenous: Constant
Bandwidth: 8 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.098988	0.7149
Test critical values:	1% level	-3.482453	
	5% level	-2.884291	
	10% level	-2.578981	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	8.14E-05
HAC corrected variance (Bartlett kernel)	0.000440

Null Hypothesis: D(M2) has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-3.430390	0.0117
Test critical values:	1% level	-3.482879	
	5% level	-2.884477	
	10% level	-2.579080	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	2.14E-05
HAC corrected variance (Bartlett kernel)	1.98E-05

Null Hypothesis: D(GDP) has a unit root
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.275526	0.0008
Test critical values:	1% level	-3.482879	
	5% level	-2.884477	
	10% level	-2.579080	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	4.04E-06
HAC corrected variance (Bartlett kernel)	4.59E-06

Null Hypothesis: INFLATION has a unit root
Exogenous: Constant
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.623964	0.0908
Test critical values:	1% level	-3.482453	
	5% level	-2.884291	
	10% level	-2.578981	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	1.656813
HAC corrected variance (Bartlett kernel)	4.613833

Null Hypothesis: D(INFLATION) has a unit root
Exogenous: Constant
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-5.462637	0.0000
Test critical values:	1% level	-3.482879	
	5% level	-2.884477	
	10% level	-2.579080	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	1.060381
HAC corrected variance (Bartlett kernel)	1.077181

Null Hypothesis: FOREIGN has a unit root
Exogenous: Constant
Bandwidth: 8 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.985725	0.2928
Test critical values:	1% level	-3.482453	
	5% level	-2.884291	
	10% level	-2.578981	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.008668
HAC corrected variance (Bartlett kernel)	0.035836

Null Hypothesis: D(FOREIGN) has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.298843	0.0007
Test critical values:	1% level	-3.482879	
	5% level	-2.884477	
	10% level	-2.579080	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.003760
HAC corrected variance (Bartlett kernel)	0.003615

Null Hypothesis: DOMESTIC has a unit root
Exogenous: Constant
Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.214452	0.2023
Test critical values:	1% level	-3.482453	
	5% level	-2.884291	
	10% level	-2.578981	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.079905
HAC corrected variance (Bartlett kernel)	0.079905

Null Hypothesis: D(DOMESTIC) has a unit root
Exogenous: Constant
Bandwidth: 18 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-5.787323	0.0000
Test critical values:	1% level	-3.482879	
	5% level	-2.884477	
	10% level	-2.579080	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.061975
HAC corrected variance (Bartlett kernel)	0.039452

Null Hypothesis: SP has a unit root
Exogenous: Constant
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.499546	0.1180
Test critical values:	1% level	-3.482453	
	5% level	-2.884291	
	10% level	-2.578981	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000483
HAC corrected variance (Bartlett kernel)	0.001467

Null Hypothesis: D(SP) has a unit root
Exogenous: Constant
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.973392	0.0001
Test critical values:	1% level	-3.482879	
	5% level	-2.884477	
	10% level	-2.579080	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000297
HAC corrected variance (Bartlett kernel)	0.000308

Null Hypothesis: D(SP) has a unit root
Exogenous: Constant
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.973392	0.0001
Test critical values:	1% level	-3.482879	
	5% level	-2.884477	
	10% level	-2.579080	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000297
HAC corrected variance (Bartlett kernel)	0.000308

Null Hypothesis: REER has a unit root
Exogenous: Constant
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-3.406467	0.0125
Test critical values:	1% level	-3.482453	
	5% level	-2.884291	
	10% level	-2.578981	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000810
HAC corrected variance (Bartlett kernel)	0.002351

Null Hypothesis: D(REER) has a unit root
Exogenous: Constant
Bandwidth: 13 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-5.149594	0.0000
Test critical values:	1% level	-3.482879	
	5% level	-2.884477	
	10% level	-2.579080	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.000540
HAC corrected variance (Bartlett kernel)	0.000483

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	1.256482	Prob. F(41,79)	0.1913
Obs*R-squared	47.75980	Prob. Chi-Square(41)	0.2172
Scaled explained SS	71.03775	Prob. Chi-Square(41)	0.0025

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	2.081201	Prob. F(2,77)	0.1317
Obs*R-squared	6.205467	Prob. Chi-Square(2)	0.0449

Can Islamic Banking and Finance Spur Financial Inclusion? Evidence from Sub-Saharan Africa

Musa Abdu[1], Adamu Jibir[2], Salihu Abdullahi[3] and Aliyu A. Rabi'u[4]

This study examined the effect of introduction of Islamic banking and finance on financial inclusion in Sub-Sahara Africa (SSA). To achieve this objective, the study applied Probit, Tobit and Juhn-Murphy-Pierce decomposition to estimate model of financial inclusion. The study used World Bank's Global Financial inclusion index (Global Findex) dataset of 2015. The findings revealed that the introduction of Islamic banking and finance system in some Organization of Islamic Cooperation (OIC) countries in SSA enhanced financial inclusion in the sub-region. The study also uncovers that households from OIC with Islamic banking and finance are more likely to be financially included than their counterparts in OIC countries without Islamic banking and finance. Further, there are other factors that play an important role in determining the probability of financial inclusion in the region. Inter alia, these factors include age, gender, income level and level of education. The policy implication of the findings is that introducing Islamic banking and finance is necessary for spurring financial inclusion in OIC of SSA.

Keywords: Financial inclusion; Islamic banking; Juhn-Murphy-pierce; OIC; Sub-Saharan Africa; Tobit.
JEL Classification: G10; G20; Z12; C14; O55; C35.

1.0 Introduction

Sub-Saharan Africa (SSA) is believed to be the region hosting larger proportion of poor people in the world. It has an estimated population of over 960 million people. Majority of the people in SSA are living in abject poverty with daily income of less USD2 per day. Financial exclusion is assumed to be one of the major factors contributing to poverty, unemployment and low level of growth and development in most SSA countries (World Bank, 2015a). Conventional financial institutions have failed in providing financial services and opportunities to the poor households and micro enterprises. These can be attributed to banks' bureaucratic processes and unending requirements, and sometimes the households and firms especially

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Muslims cannot patronize their services due to interest-led transactions, which is prohibited according to Islamic law (Ahmed, 2010; Arouri, Ameur, Jawadi, Jawadi and Louhichi, 2013; El Qorchi, 2005; Beck, Demirguc-Kunt and Merrouche, 2013). Besides that, the risk sharing feature of the Islamic banking and finance allows longer term loans and efficiency between parties which leads to more return on capital (Chong and Liu, 2009).

Islamic banks are money-making financial intermediaries much like conventional banks, but in order to meet the requirements of Islamic law (Shariah), they must adhere to four major principles. A prohibition on charging interest is the primary difference between Islamic banks and conventional banks, derived from the notion that charging interest is a form of exploitation and inherently inconsistent with Islamic values of fairness; Islamic banks are also prohibited from speculation, in the form of risky or uncertain business ventures, and from financing haram activities. Finally, Islamic banks are compelled to donate part of their profits to benefit society in the form of zakat (Imam and Kpodar, 2010). Islamic banking and finance has emerged in the recent years as an alternative, effective and viable tool for providing financial services and development worldwide, including non-Muslim countries. There are solid evidence that Islamic finance has become an integral part of the global financial system and that it has the potentials of solving the problem of poverty and low economic growth through financial inclusion especially in poor income countries (World Bank, 2015b). Financial inclusion through providing access to financial services will stimulate the independence and self-development of poor households and micro enterprises. Additionally, providing easy access to finance is considered as a giant step in connecting the poor section of the society to a larger and broader world (Imboden, 2005).

Available statistics by World Bank (2015c) suggests that there has been substantial progress in increasing financial inclusion in the world for about 62 percent of adults are financially included in 2014 as against 51 percent in 2011. Nonetheless, World Bank (2015c) reports that about 2 billion adults were financially excluded in 2014 and 17 percent of them were from Sub-Saharan Africa (SSA). Again, 5 percent of the financially excluded adults cited religious reasons or beliefs as their

justification for financial exclusion and majority of these adults are expected to be Muslims (World Bank, 2015c; Zaher and Hassan, 2001). The rate of financial exclusion due to religious reason is even higher in SSA for it stands at 6.8 percent as depicted in figure 2. In view of this scenario, Islamic system of Banking and finance could be very effective in enhancing financial inclusion, especially in Muslims dominated countries.

Although, there is proliferation of studies on the role of Islamic finance on financial inclusion in the recent years, such as Mohieldin, Iqbal, Rostom and Fu (2012); Demirguc-Kunt, Klapper and Randall (2013); Naceur, Barajas and Massara (2015); Leon and Weill (2016); and Zulkhibri (2016) among others but there are at best too scanty studies that specifically focused on SSA countries despite the importance of the region in the world and fast development and growing awareness of Islamic finance in the region. This prompted the need to unveil the impact of Islamic financial services in reducing financial exclusion in the region.

The objectives of this study are twofold: firstly, to explore empirically whether Islamic finance has contributed in enhancing the probability of financial inclusion in SSA countries, and secondly, the study sought to examine the gap that may exist between the OIC countries with Islamic banking and finance and those without in SSA in the probability of financial inclusion. These objectives were achieved by employing Probit, Tobit regression models and Juhn-Murphy-Pierce decomposition technique.

The paper is divided into five sections, following the introduction, section 2 presents stylised facts of financial inclusion in SSA and review of related literature is undertaken; section 3 focuses on methodology and sources of data; while section 4 presents the result and findings of the study. Section 5 concludes the study with recommendations for policy action.

1.1 Stylised Facts of Financial Inclusion in Sub-Saharan Africa

In Figure 1 there is the depiction of the distribution of financial inclusion in SSA using the core indicators of financial inclusion. The figure suggests that only 27.7

percent of the households surveyed have bank accounts at financial institutions in SSA which is higher than 20.93 percent in OIC member countries in SSA. This implies that religious (Islamic) belief, perhaps, serves as a constraint to financial inclusion in the OIC countries of the region.

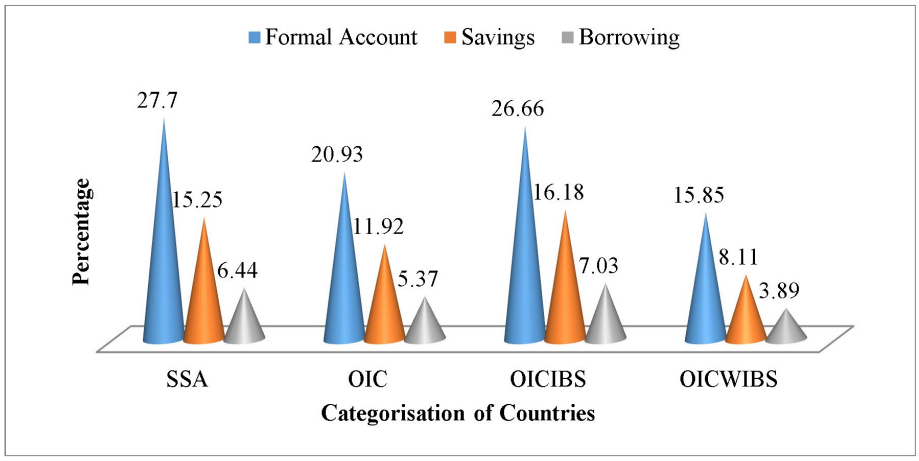

Figure 1: Distribution of Financial Inclusion

This is so, considering that among the OIC countries there are those without Islamic banking and finance. This could be subsequently confirmed when the OIC countries were separated into OICIBS and OICWIBS. The rate of financial inclusion in OIC countries with Islamic Banking and Financial System (OICBS) (26.66 percent) is higher than that of OIC without Islamic banking system (15.85 percent) in the region. It is becoming clearer that religious factor may be at work in determining the probability of financial inclusion in OIC countries in SSA. The same distribution is obtainable when other indicators (saving in financial institution and borrowing from financial institutions) are considered in Figure 1. It could be inferred that financial inclusion is generally low in SSA and lower in OIC countries of the region. However, OICIBS shows some level of progress.

Figure 2 reveals the distribution of households who are financially excluded due to religious reason. For instance, 6.8 percent of the households surveyed in SSA cited religious reason as their constraint to financial inclusion while 9.71 percent of the households among the households surveyed in OIC of the region also cited religious reason for their financial exclusion.

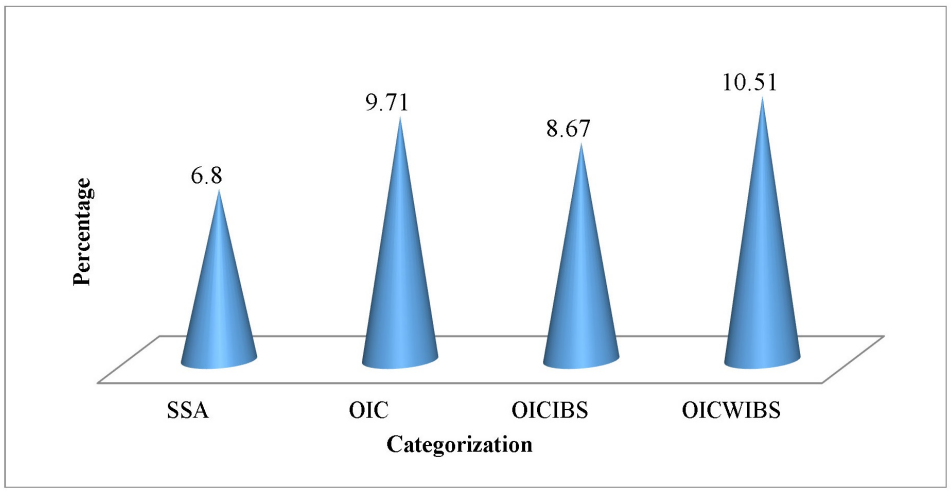

Figure 2: Distribution of Religious Reason for Financial Enclusion

Again, the rate of religious constraint is lower in OICIBS (8.67 percent) than in OICWIBS (10.51), though the gap is not very significant. It is indicated that even with the introduction of Islamic banking and finance system in some countries, certain households cited religious reason for the financial exclusion. This implies that there may be lack of awareness of the importance or existence of Islamic banks.

2.0 Literature Review

2.1 Theoretical Framework

Islamic banking and finance has become increasingly widespread over the past three decades, particularly in OIC countries. This has spawned volume of studies in the area by academics, researchers and interest groups.

The most cited theories of financial inclusion are free market model and theory of asymmetry of Information. Free market model is an offshoot of classical economic theory which proposes that the nature and structure of market is the main determinant of health condition of any economy. The model argues that a deregulated economy tends to be more 'Pareto optimal' than otherwise, and that any government intervention through policies distorts the market thereby taking the economy off the track that could to lead to Pareto optimum (Aboody and Baruch, 2000; Garmaise and Natividad, 2010). In connection, a deregulated financial system

tends to enhance financial inclusion as deregulated financial institutions actively engage in any legitimate transactions that could maximize shareholders' wealth (Boyce, 2000; Chavan, 2008 and Philip, 2014).

By so doing, they could offer any financial product or service (including Islamic banking and financial services) that customers demand so much for irrespective of tribal, religious and regional affiliations of the customers. However, a regulated financial system tends to cause financial exclusion as they are restricted by government policies and as such; they may not provide a variety of financial products. Also, the theory of asymmetry of information postulates that the imperfection of information about the characteristics of potential borrowers and lenders could be the major source of financial exclusion. Information is imperfect or asymmetric if one party to a transaction has more information than the other.

The persistence of this condition could deleteriously affect the economic transactions and may result in total denial of financial products to certain groups in the economy (Philip, 2014). In connection to this study, Islamic financial services could be available in the economy but due to imperfect information about the availability, accessibility and affordability people may not access and use such financial products. The theory of asymmetry of information serves as the theoretical framework of this study given that it is the micro-foundation of free market model. It is chosen as it addresses the major problem of Islamic financial system in SSA, which is ignorance or lack of awareness of the principles of Islamic banking and finance in the region. For instance, Al-Jarhi (2016) used the asymmetric model as a basis to develop an Islamic economic theory for financial regulation, specifically on Islamic debt instruments (which are one of the measures of financial inclusion). Kömling (2014) applied the model to explain profit-and-loss-sharing contract in Islamic finance.

2.2 Empirical Literature

The nexus between finance and economic activities has long been established in economic literature. Economic development of a country is driven by level of connectivity and performance of the financial system. Although Islamic banking and

financial system emerged and evolved over the last 40 years; there are scanty studies on the effect of Islamic banking and financial system on financial inclusion. Again, most of the available studies were carried out in the Middle-eastern region of the world. For instance, Zulkhibri (2016) studies the relationship between Islamic finance and financial inclusion using data obtained from financial industries in Muslim countries. The study found that despite the growth in Islamic finance in the recent past, there are still many individuals that are financially excluded. Contrarily, Usman and Tasmin (2016) using documented evidences reveal that Islamic finance has contributed immensely in enhancing financial inclusion through human empowerment, increased financial services and financial windows.

Furthermore, Ali (2015) examines the role of Islamic microfinance in enhancing access to finance in Muslim countries and the findings show that Islamic microfinance has gone long a way in making financial services available to people particularly those that are initially excluded. In another study by Naceur, Barajas and Massara (2015) on the relationship between the development of Islamic banking and finance and financial inclusion in OIC countries and their findings reveal that there is a significant nexus between Islamic finance and financial inclusion at both individual and firms level. Similarly, Mohieldin, Iqbal, Rostom and Fu (2012) investigate the impact of Islamic banking and finance on financial inclusion in OIC countries and found that Islamic finance plays a significant role in enhancing financial inclusion, redistribution of income and building a healthy economy in most OIC countries.

Using a panel data for developing and emerging economies, Leon and Weill (2016) examine the role of Islamic banks in promoting access to credit. The result indicates that Islamic banking and finance has not contributed significantly in promoting financial inclusion compared to conventional banks. On the other hand, where there is limited number of conventional banks, the contribution of Islamic banks is found to be positive. Similarly, Bhattacharaya and Wolde (2010) reveal that lack of access to credit is one factor driving down growth in Middle East and North Africa (MENA) countries relative to the rest of the world. It is also argued in the literature that availability of financial services may not necessarily induce financial inclusion, this is because some people may voluntarily exclude themselves

from the financial services due to religious or cultural reasons and, sometimes, due to ignorance (Beck, Demirguc-Kunt and Peria, 2008).

In another study by Bose, Bhattacharya and Islam (2016) on the financial inclusion disclosure among Bangladesh's banks using data spanning between 2008 and 2013. Their findings indicate that the level of financial inclusion has a positive relationship with the size of banks, growth opportunities, institutional investors and region based branches. On the other hand, the percentage of female directors and firms' age are negatively related with the level of financial inclusion disclosures.

Moreover, Morrissey (2012) investigates the effect of Islamic banking and finance on financial outcome in Gulf Cooperation Council (GCC) countries and found evidence that Islamic banking has a positive and significant impact on private savings of individuals. Demirguc-Kunt, Klapper and Randall (2013) investigate the role of Islamic finance on financial inclusion. The study reveals that adult Muslims are significantly less likely to own a formal account than non-Muslims. On the other hand, the study found no evidence that Muslims are less likely to report formal or informal borrowing. Additionally, they found that Muslims are most likely to report religion as a barrier than non-Muslims. Again, Sain, Rahman and Khanam (2016) examine financial exclusion among minority Muslims in Australia. They reported that financial exclusion remains a serious problem among Muslims due to little windows for Islamic finance and products in Australia.

There are some studies that indirectly assessed the role of Islamic banking and finance in improving financial inclusion. This is so because the studies investigate the effect of Islamic banking and finance on investment, portfolio diversification, susceptibility to financial crisis and degree of uncertainty in relation to conventional banking, which all are related to financial inclusion. For example, Arouri, Ameur, Jawadi, Jawadi and Louhichi (2013) using VAR model established that Islamic finance industry is less affected by financial crisis than conventional one; investment in Islamic products generates high returns, and portfolio that include Islamic products are less risky than conventional one. Thus, Islamic financial system could serve as an alternative to conventional financial system, and con-

sequently Islamic finance enhances financial inclusion. Likewise Beck, Demirguc-Kunt and Merrouche (2013), in their cross-country comparative study of Islamic versus conventional banking, indirectly confirmed that Islamic financial system can spur financial inclusion. The study specifically found out that although Islamic banks are less cost-effective than conventional ones, they have a higher intermediation ratio, higher asset quality and better capitalization. Again, Gheerart (2014), using Islamic Finance Recording and Sizing Tool (IFIRST) data, ascertained that the development of Islamic banking in Muslim countries bring about a higher banking sector development as measured by amount of private credit or bank deposits scaled to GDP.

There are other studies that generally analysed the major determinants of financial inclusion. The studies mostly observed that (on demand-side) age, income level, gender (male), educational level, distance to financial institutions, lack of documentation, etc. were the major determinants of financial inclusion (Abdu, Buba, Adamu and Muhammad, 2015; Akudugu, 2013; Tuesta, Sorensen, Haring and Camara, 2015; and Fungcova and Weill, 2012). On the supply-side, the studies suggested that branches, ATMs, market size, economic growth (Naceur, Barajas and Massara 2015 and Tuesta, Sorensen, Haring and Camara, 2015).

There are also studies that examine the influence of Islamic law on the operations of Islamic banking and finance. For example, Chong and Liu (2009) examine the operation of Islamic banking in Malaysia within the framework of Islamic law and the results show that their activities are not significantly different from the conventional bank. The study further reveals that only negligible portion of Islamic banks are strictly using profit and loss sharing paradigm and that most Islamic banks are not interest-free. Similarly, Dasuki and Abozaid (2007) show similar evidence that there is no significant difference in the operation of Islamic and conventional banks. In another study by Samad (2004) on the comparison between performance of Islamic banks and conventional banking system in Bahrain, the result reveals that there is no noticeable variation between Islamic and conventional banks with respect to profitability and liquidity. Ahmed, Rehmn and Humayoun (2011) investigate the role of Islamic law in the operations of Islamic banks in

Pakistan. The study shows that Islamic law strongly influence the activities of Islamic banks in Pakistan. Further, Khan (2010) posits that after three decades of the introduction of Islamic banking system, there remains a substantial divergence in application of islamic law in the operations of islamic banks as they are functionally indistinguishable with the conventional banks. The study indicates that although in some cases, the central banks guarantee the operation of Islamic banks in a manner that is not fully in compliance with Islamic law. In another study Chen and Masih (2017) reveals that Islamic finance and banking services is significantly difference from the conventional banking system more especially in the area of profit and loss between parties. Dasuki and Abdullah (2007) also found similar evidence that Islamic banks differs in their operations and are highly preferred in Malaysia because of religious belief, quality and efficient services and social responsibility programs.

It is noted from the literature reviewed above that there are few studies that examined empirically and theoretically the role of Islamic banking and finance in providing financial services. Despite the increasing awareness and expansion in their services but studies on this area seems to be rare. More importantly, there are too scanty studies (if any) on SSA.

This study was motivated by the works of the Mohieldin, Iqbal, Rostom and Fu (2012) and Naceur, Barajas and Massara (2015). Though this study appears similar to the latter study, it does differ from Naceur *et al.* (2015) in a number of aspects. First, this study focuses only on SSA so as to take care of socioeconomic, demographic and political peculiarities across the continents and continental subregions. Second, this study uses methodology that is entirely different from that of Naceur *et al.* (2015). For example, this study uses dependent variables like savings at and borrowings from formal financial institutions, and constructed a score of financial inclusion over and above just having bank account as used by Naceur *et al.* (2015). With regard to methodology, this study uses probit and tobit techniques to estimate the models. Specifically, the study applies the technique of Juhn-Murphy-Pierce decomposition to quantitatively compute the gap. Therefore, this study contributes to literature by covering the above lacuna identified in literature.

3.0 Methodology

3.1 Source of Data and Variables' Measurement

To realize its objectives, this study used the 2014 World Bank's Global Financial inclusion (Global Findex) dataset by World Bank (2015c). This dataset focuses on such financial inclusion issues as households' ownership of bank account at, savings at and borrowings from, financial institutions, across 142 countries of the world and 34 of them are from Sub-Saharan Africa. There are also 17 OIC countries in SSA and out of them 8 are OIC with Islamic banking and finance (see Table 2 in appendix). The dataset contained information like age, gender and income level of households surveyed. Using this source of data, four core indicators of financial inclusion have been constructed which include *dummies for formal bank account, formal savings and formal borrowing* as well as *overall index* of financial inclusion. The overall index is constructed by summing dummies for formal bank account, formal savings and formal borrowing, divided by three (number of variables). This is based on broad measure approach of technological capabilities index theoretically developed by Lall (1992), and modified by Mahendra, Zuhdi and Muyanto (2015) in their efforts to develop broad measure of innovation. Like Mahendra, Zuhdi and Muyanto (2015), this study did not normalise the index, instead it divided the sum of their dummies by their number.

3.2 Estimation Techniques

This study applied three techniques of analysis to realize its cardinal objectives. The techniques include binary probit regression model, tobit regression model and Juhn-Murphy-Pierce decomposition. Binary probit regression has been used in estimating the determinants of households' likelihoods to own formal bank account, make formal savings and borrowings. This model is so chosen since the dependent variables are all binary dummies. The binomial probit is an estimation technique for equations with dummy dependent variables that avoids the unboundedness problem of the linear probability model by using a variant of the standard normal cumulative distribution function (Studenmund, 2011). The binary probit model is specified in equation (1):

$$\Pr(i = 1/Y = y) = \Phi(\beta_0 + \beta_1 X_i + \beta_2 D_i + \varepsilon_i) \tag{1}$$

Where $Pr(i)$ is the propensity for the household i to own formal bank account, make formal savings and borrowings; and $\Phi(\cdot)$ is the standard normal cumulative distribution function (cdf). x_i is a vector of households' characteristics and income level of the households. Di is a dummy for OIC or OIC with Islamic banking and finance system.

Given that $\Phi(\cdot)$ is a standard normal cumulative distribution function, the probit distribution function takes the form of equation (2):

$$Prob\left(y_i = 1\right) = \Phi\left(X_i\beta\right) = \int_{-\infty}^{X_i\beta} \frac{1}{\sqrt{2\pi}} \exp\left(\frac{z^2}{2}\right) dz \tag{2}$$

The standard normal transformation $\Phi(\cdot)$ restricts the probability to fall between 0 and 1.

In order to estimate the determinants of overall index of financial inclusion; Tobit regression model would be used since the dependent is left-censored at 0 and right-censored at 1. As an extension of the probit model, Tobit model is applied to correct for the possible sample bias in the observation (Bhattarai, 2016). Thus, the model is specified as in equation (3) below:

$$fin_i^* = \beta_o + \beta_1 x_i + \beta_2 D_i' + \varepsilon_i \tag{3}$$

where $fin_i = 0$ if $fin_i^* \leq 0$ and $fin_i = fin_i^*$ if $fin_i^* > 0$.The definitions of the variables remain as in equation (1).

Juhn-Murphy-Pierce decomposition technique is adopted in order to estimate the actual gap in financial inclusion between OIC with Islamic banking and OIC without Islamic banking in SSA. Juhn, Murphy and Pierce (1993) first proposed this technique for estimating wage inequality, and thus, the econometric setting of the model is specified as in equation (4):

$$\overline{fin}_{IBS} - \overline{fin}_{WIBS} = (\overline{X}_{IBS} - \overline{X}_{WIBS})\beta_{IBS} - \overline{\theta}_{WIBS} = (\overline{X}_{IBS} - \overline{X}_{WIBS})\beta_{IBS}$$

$$-\overline{\theta}_{WIBS} * \sigma_{IBS} \tag{4}$$

The first term on the right-hand side of equation (4) corresponds to that part of the differential in financial inclusion attributable to the group differences in the observed characteristics (quantity or endowment effect), while the second and third terms correspond to the difference in coefficients (the prices effect) and differences in unobservable prices and quantities, i.e, the discriminatory or "unexplained" component of this decomposition respectively. Where θ is a standard residual with mean zero, unitary variance; β is a vector of parameters of explanatory variables (productive characteristics); and σ is a standardised residuals, i.e. the quantity of the not observed productive abilities multiplied by the yield of these abilities.

4.0 Results and Discussions

In the appendix, Table 1 reports the definitions of variables, which shows that all the variables are discrete ones with the exception of age. Table 2 presents the categories of countries in SSA: non-OIC, OICIBS and OICWIBS countries. Table 2 reveals that there are 17 non-OIC countries, 8 OIC countries with Islamic banking and finance, and 9 OIC countries without Islamic banking and finance in the dataset.

Table 3a reports the coefficients of determinants of probability of financial inclusion (own bank account, savings and borrowings). Model of formal bank in table 3a shows that age, level of education, gender, income and being an OIC, are the significant determinants of probability to own bank account at formal financial institution in SSA.

Table 3a: Probit Model on Financial inclusion in SSA

	Formal Bank Account	Savings	Borrowings
VARIABLES	Coefficient	Coefficient	Coefficient
Age	0.0660***	0.0666***	0.0757***
	(0.00288)	(0.00361)	(0.00480)
Age-squared	-0.000609***	-0.000657***	-0.000790***
	(3.43e-05)	(4.42e-05)	(5.86e-05)
Male	0.0891***	0.0774***	0.00674
	(0.0163)	(0.0186)	(0.0229)
Secondary	0.816***	0.678***	0.312***
	(0.0180)	(0.0209)	(0.0259)
Tertiary	1.397***	1.131***	0.652***
	(0.0365)	(0.0362)	(0.0420)
Income level	0.192***	0.201***	0.110***
	(0.00605)	(0.00724)	(0.00868)
OIC	-0.422***	-0.278***	-0.150***
	(0.0163)	(0.0186)	(0.0229)
Constant	-2.977***	-3.448***	-3.563***
	(0.0605)	(0.0751)	(0.0990)
Prob > chi^2	0.0000	0.0000	0.0000
Pseudo R^2	0.1801	0.1532	0.0750
Log pseudolikelihood	-15918.242	-11813.288	-7225.532
Observations	32,904	32,658	32,681

Robust standard errors in parentheses *** *indicate significances levels at 1%*

The introduction of age-squared in the models is to capture non-linear effect of age on financial inclusion. Model of savings in the table shows that level of education, especially tertiary education, is the major determinant of probability of making formal savings, followed by OIC, income level, male gender and age. Model of borrowings in the table finally reports that age, level of education, income and being an OIC, are the significant determinants of households' likelihood to borrow from financial institutions. The significant determinants are reported in all the models to be statistically significant at 1 percent level of significance.

Model 1 in Table 3b reveals that as the age of household increases the probability of owning formal bank account rises by 2.04 percentage point until certain age limit beyond which the probability reduces by 0.02 percentage point when the age increases. In other words, age-squared suggests that age (old age) has negative non-linear effect on probability of owning formal bank account because as the individuals get old they may not be productive enough to generate resources to own bank account. Again, as households move from an income level to the higher one

their likelihoods to own formal bank account increases by 5.95 percentage point. Households with secondary and tertiary education are more likely to own formal bank account by 26.1 and 51.3 percentage points than those with primary or less education respectively. Being male household improves the likelihood of owning formal bank account by 2.75 percentage point than otherwise.

Table 3b: Marginal Effects of Probit Model on Financial inclusion in SSA

	Formal Bank Account	Savings	Borrowings
VARIABLES	Coefficient	Coefficient	Coefficient
Age	0.0660***	0.0666***	0.0757***
	(0.00288)	(0.00361)	(0.00480)
Age-squared	-0.000609***	-0.000657***	-0.000790***
	(3.43e-05)	(4.42e-05)	(5.86e-05)
Male	0.0891***	0.0774***	0.00674
	(0.0163)	(0.0186)	(0.0229)
Secondary	0.816***	0.678***	0.312***
	(0.0180)	(0.0209)	(0.0259)
Tertiary	1.397***	1.131***	0.652***
	(0.0365)	(0.0362)	(0.0420)
Income level	0.192***	0.201***	0.110***
	(0.00605)	(0.00724)	(0.00868)
OIC	-0.422***	-0.278***	-0.150***
	(0.0163)	(0.0186)	(0.0229)
Constant	-2.977***	-3.448***	-3.563***
	(0.0605)	(0.0751)	(0.0990)
Prob > chi^2	0.0000	0.0000	0.0000
Pseudo R^2	0.1801	0.1532	0.0750
Log pseudolikelihood	-15918.242	-11813.288	-7225.532
Observations	32,904	32,658	32,681

Robust standard errors in parentheses *** *indicate significances levels at 1%*

Finally, households from OIC countries in SSA are less likely to own formal bank account by 13.10 percentage point than otherwise. Model 2 in table 3b shows that as the age of household increases the likelihood to save at financial institutions rises by 1.29 percentage point. Age-squared (non-linear effect) implies that at an old age, the probability of making savings at financial institutions reduces by 0.01 percentage point. Again, as households move from an income level to the higher one their likelihoods to save at financial institution increases by 3.90 percentage point. Households with secondary and tertiary education are more likely to make savings at banks by 14.2 and 34.5 percentage points than those with primary or

less education respectively. Being male household improves the likelihood of making formal savings by 1.50 percentage point than otherwise. More importantly, the model reveals that households from OIC in SSA are less probable to save at financial institutions by 5.42 percentage point than otherwise.

Model 3 in Table 3b indicates that as the age of household increases the probability to borrow from financial institutions goes up by 0.80 percentage point. Age-squared (non-linear effect) again indicates that as the age of old people increases the chances of borrowing from financial institutions falls 0.01 percentage point. This may be due to the influence of retirement. Households with secondary and tertiary education are more likely to borrow from banks by 3.47 and 10.80 percentage points than those with primary or less education respectively. As income increases from one level to a higher level, the possibility to borrow from financial institutions improves by 1.16 percentage point while households from OIC in SSA are less probable to borrow from financial institutions by 1.59 percentage point than otherwise. The models are correctly specified as nonlinear given the significance of hat-square. The models have also strong prediction power as they accurately predicted the rates of financial inclusion in SSA.

Table 4a reports the impact of Islamic banking and finance on the probability of financial inclusion in OIC countries of SSA. The table indicates that level of education; OICIBS, income level, male gender, and age (both youthful and old) are the significant determinants of chances to be financially included. However, male gender is insignificant in a model of borrowings. Table 4b presents the marginal effects of variables in the models capturing the impacts of Islamic banking and finance on indicators of financial inclusion.

Table 4a: Probit Model on Impact of Islamic banking & Finance in OIC

	Formal Bank Account	Savings	Borrowings
VARIABLES	Coefficient	Coefficient	Coefficient
Age	0.0769***	0.0821***	0.0697***
	(0.00487)	(0.00616)	(0.00685)
Age-squared	-0.000744***	-0.000830***	-0.000725***
	(5.89e-05)	(7.61e-05)	(8.27e-05)
Male	0.161***	0.123***	0.0468
	(0.0245)	(0.0286)	(0.0341)
Secondary	0.811***	0.686***	0.289***
	(0.0274)	(0.0322)	(0.0388)
Tertiary	1.236***	0.978***	0.450***
	(0.0496)	(0.0522)	(0.0636)
Income level	0.197***	0.200***	0.0860***
	(0.00910)	(0.0110)	(0.0125)
OICIBS	0.221***	0.287***	0.222***
	(0.0243)	(0.0284)	(0.0344)
Constant	-3.748***	-4.198***	-3.620***
	(0.101)	(0.127)	(0.142)
Prob > chi^2	0.0000	0.0000	0.0000
Pseudo R^2	0.1817	0.1657	0.0645
Log pseudolikelihood	-7127.565	-5121.2483	-3289.4316
Observations	16,975	16,799	16,816

Robust standard errors in parentheses *** indicate significances levels at 1%

It is clear in the models of Table 4b that households from OIC with Islamic banking and financial system (OICIBS) have more chances of owning formal bank account, make formal savings and borrowings by 5.51, 4.36 and 2.07 percentage points than those from OIC without Islamic banking and finance system (OICWIBS), respectvely. The models in table 4b are correctly specified as nonlinear given the significance of hat-square. The models have also strong prediction power as they accurately predicted the rates of financial inclusion in SSA.

Table 4b: Marginal Effects of Probit Model on Impact of Islamic banking & Finance in OIC

VARIABLES	(1) Formal Account	(2) Savings	(3) Borrowing
Age	0.0191***	0.0123***	0.00641***
	(0.00117)	(0.000871)	(0.000590)
Age-squared	-0.000185***	-0.000124***	-6.68e-05***
	(1.43e-05)	(1.09e-05)	(7.23e-06)
Male	0.0396***	0.0183***	0.00430
	(0.00599)	(0.00420)	(0.00311)
Secondary	0.222***	0.119***	0.0286***
	(0.00776)	(0.00608)	(0.00407)
Tertiary	0.429***	0.245***	0.0580***
	(0.0189)	(0.0179)	(0.0108)
Income Level	0.0488***	0.0299***	0.00792***
	(0.00220)	(0.00158)	(0.00114)
OICIBS	0.0551***	0.0436***	0.0207***
	(0.00610)	(0.00440)	(0.00327)
_hat	.3267765***	.2083595***	.2164925***
	(.0114237)	(.0133532)	(.0307964)
_hatsq	.0490411***	.0240866***	.0382631***
	(.0062992)	(.0052167)	(.0093046)
Obs Predicted	.2093667	.1192333	.0536394
Predicted Pr(x-bar)	.1647108	.0806661	.0434012
Prob > chi2	0.0000	0.0000	0.0000
Pseudo R2	0.1817	0.1657	0.0645
Observations	16,975	16,975	16,975

Robust standard errors in parentheses *** indicate significances levels at 1%

Table 5 presents Tobit model results on the determinants of overall financial inclusion in SSA. Model 1 (or model 2) in Table 5 suggests that as the level of income goes up from one level to the higher one, the possibility of being financially included improves by 12.3 (or 13.3) percentage point than otherwise.

The models reveal that age (young and old), male gender, levels of education income level, religious beliefs, and introduction of Islamic banking and finance are the significant determinants of overall financial inclusion in the region. The variables are all significant at 1 percent level of significance. Model 1 and Model 2 in the table indicate that as age increases the probability of overall financial inclusion increases by 4.66 and 5.74 percentage points respectively. Also, age-squared (non-linear effect) suggest that at an old age, the probability of overall financial inclusion reduces by 0.044 and 0.056 percentages, respectively as the age increases. It can also be seen from models 1 and 2 that being a male make the probability of overall financial inclusion to rise by 4.57 and 9.00 percentage point

respectively, than otherwise. Households with secondary education are likely to be more financially included by 49.90 and 53.10 percentage points, respectively, while households with tertiary education are likely to be more financially included by 81.60 and 77.40 percentage points, respectively than those with lower levels of education respectively.

Model 1 in Table 5 signifies that households from OIC in SSA are less probable to be financially included by 24.4 percentage point than those from non-OIC countries in the region. This signals the influence of religion in the model. Finally, the introduction of Islamic banking and finance in OIC countries of SSA (OICIBS) makes the households in the countries to be more likely to be financially included by 17.60 percentage point than OIC without Islamic banking and finance in the region as shown in model 2 of Table 5.

Table 5: Tobit Model on Determinants of Financial inclusion in SSA

VARIABLES	(1) SSA	(2) OIC (SSA)
Age	0.0466*** (0.00183)	0.0574*** (0.00331)
Age-squared	-0.000443*** (2.18e-05)	-0.000564*** (4.01e-05)
Male	0.0457*** (0.00999)	0.0900*** (0.0166)
Tertiary	0.816*** (0.0192)	0.774*** (0.0299)
Secondary	0.499*** (0.0112)	0.531*** (0.0185)
Income Level	0.123*** (0.00380)	0.133*** (0.00620)
OIC	-0.244*** (0.0100)	
OICIBS		0.176*** (0.0165)
Constant	-1.905*** (0.0396)	-2.576*** (0.0706)
Sigma	0.689*** (0.00587)	0.751*** (0.00981)
_hat	1.062736*** (.0185388)	1.220212*** (.0378308)
_hatsq	.1257177*** (.0240115)	.247701*** (.0333219)
Prob > chi2 Pseudo R2 Observations	0.0000 0.1487 32,525	0.0000 0.1468 16,713

Robust standard errors in parentheses *** indicate significances levels at 1%

To establish the actual gap in financial inclusion between OICIBS and OICWIBS in SSA, Juhn-Murphy-Pierce Decomposition models have been estimated and presented in Table 6. In terms of formal account, there is 10.81 percentage point gap in financial inclusion between OICIBS and OICWIBS. This means OICIBS have 10.81 percentage point higher chances of owning bank accounts at financial institutions than OICWIBS in SSA.

Differences in observable factors (quantity effect) contributed 5.88 percentage point to the gap (55 percent of the total gap). This implies when explanatory variables of the model (observable factors) like age, gender, educational level and income level were equally distributed between OICIBS and OICWIBS in SSA, the gap would be reduced by 55 percent. Otherwise the gap continues to widen by same proportion. Again, variation in unobservable factors (price effect) contributed 4.82 percentage point to the gap (44 percent of the total gap). Price effect refers to changes in variables or factors not included in the model, and, in this case, they imply that should there be an equal distribution of the observable factors between the two groups, a gap of 4.82 percentage point would still exist between them. This could be as a result of discrimination of financial institutions on the basis religious affiliations (Islamic versus conventional financial institutions) in the region. Finally, the interaction between price and quantity effects contributed 0.11 percentage point to the gap. With respect to overall index of financial inclusion, there is 7.27 percentage point gap in financial inclusion between the groups. Difference in quantity effect contributed 3.45 percentage point to the gap (48 percent of the gap) while price or discrimination and interaction of price and quantity effects contributed 3.75 (51 percent of the gap) and 0.10 (1 percent of the gap) percentage points to the gap respectively.

Table 6: Juhn-Murphy-Pierce Decomposition of Financial inclusion inequality in OIC, SSA

	Formal Account	Savings	Borrowing	Overall Index
Total Difference (T)	.10813415	.08033823	.03144093	.07269332
Observable Factors (Quantity Effect)	.05880389	.03565695	.0093402	.03458653
Unobservable Factors (Price Effect)	.04824332	.04388021	.02159058	.03748162
Interaction between quantity and price Effects	.00108694	.00080108	.00051016	.00062517

With respect to formal savings and borrowing, Table 6 reveals that there exist 8.03 and 3.14 percentage point gaps between OICIBS and OICWIBS in SSA. Variation in observable factors contributed 3.57 (44 percent of the gap) and 0.93 (30 percent of the gap) to differences in formal savings and borrowings between OICIBS and OICWIBS in SSA respectively. Differences in unobservable factors contributed 4.39 (55 percent of the gap) and 2.16 (67 percent of the gap) percentage points to variations in formal savings and borrowings between OICIBS and OICWIBS in SSA respectively. Finally, the interaction between price and quantity contributed 0.08 (1 percent of the gap) and 0.05 (3 percent of the gaps) percentage point to the gaps in formal savings and borrowings between OICIBS and OICWIBS in SSA respectively.

Given that discrimination contributed largely to the differences in the measures of financial inclusion, it may be concluded that Islamic belief is the major unobservable factor responsible for the discrimination. This is further made clear by the fact that discrimination contributed the most to the inequalities in formal savings and borrowings between OICIBS and OICWIBS in SSA because interest is receivable on savings and it is payable on borrowings at conventional financial institutions. However, prohibiting paying or receiving interest is the major difference between Islamic and convention financial institutions.

It is quite obvious from the above analysis that so many factors play significant roles in determining or spurring financial inclusion in SSA. Among others, a religious belief especially Islamic one determines the probability of financial inclusion

negatively. This is so because Islam clearly prohibits interest-based and unethical transactions. However, the introduction of Islamic banking and finance system in some OIC countries in SSA improves financial inclusion. Nonetheless, the gap in financial inclusion or religious constraint between OICIBS and OICWIBS is still negligible meaning despite the introduction of Islamic banking and finance system; some households in OICIBS are still financially excluded due to religious constraint. This implies that introducing Islamic banking and finance system in OIC is necessary but not sufficient conditions; that there is need for mass awareness creation on bounties of the system given the positive significance of level of education in the models. Given the fact that quantity effect contributed largely to the gap; this means there is also need for institutional re-arrangement in the process of introducing Islamic banking and finance system in an OIC country, that is, such institutions should be strategically established in regions where their services are in much demand.

The findings of this study disagreed with those of Naceur, *et al.* (2015) that there is weak evidence that Islamic banking enhances financial inclusion. However, the findings of this study agreed with those of Mohieldin, et al (2012) though the latter study is supply-side oriented study using redistributive instruments such as Zakah, adaqat, Waqf, and Qar-al-asan. Thus, this study contributes to the existing literature by focusing particularly on SSA given socioeconomic, demographic and political peculiarities of the region and using entirely different theoretical and methodological frameworks.

5.0 Conclusion and Policy Implications

The primary goal of this study remains to empirically answer the question that: Can Islamic banking and finance spur financial inclusion in SSA? To scientifically realize the objective, the study used Probit and Tobit regression techniques and Juhn-Murphy-Pierce decomposition technique to analyse Global Financial inclusion (Findex) data collected by World Bank, (2015c). The study arrived at some stylized facts about financial inclusion in SSA. First, the study established that households from OIC member countries in SSA are less likely to be financially included than their non-OIC counterparts. This suggests that religion (Islamic doc-

trine) constrains households from being financially included in those OIC countries. Secondly, the study also uncovers that households from OIC with Islamic banking and finance are more likely to be financially included than their counterparts in OIC without Islamic banking and finance. This implies that the introduction of Islamic banking and finance system in some OIC countries in SSA spurs financial inclusion in the region. Lastly; other factors play important role in determining financial inclusion in the region. These factors include youthful and old age, male gender, income level and most importantly is the level of education, of households.

The policy implications of the study is that although introducing Islamic banking and finance system in OIC is necessary condition for enhancing financial inclusion in OIC of SSA but it is not sufficient condition. Policymakers and financial regulators have herculean task by way of engaging in mass awareness creation given the low level of education in SSA. There is also need for institutional re-arrangement in the process of introducing Islamic banking and finance system in OIC of SSA. By this, we mean such institutions should be strategically established in regions where their services are in much demand. This has been empirically backed given that endowment or price effect contributed largely to the gap in financial inclusion between OICIBS and OICWIBS in SSA. In same vein, enhancing financing inclusion would help SSA in realizing their foremost dream of reducing poverty in the region.

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Appendix

Table 1: Definitions of Variables in the Models

Explanatory Variables	Definition
Age	Age in years of the households
Agesqr	Age-squared of the Households
Male	Dummy taking the value of 1 for male household and 0 otherwise.
Income Level	Ordinal Dummy taking the value of 1 for the poorest households, 2 for the poor households, 3 for the middle-income households, 4 for the rich households and 5 for the richest households.
Primary/Less	Dummy taking the value of 1 for household with primary or less education and 0 otherwise.
Secondary	Dummy taking the value of 1 for household with secondary education and 0 otherwise.
Tertiary/more	Dummy taking the value of 1 for household with tertiary education or more and 0 otherwise.
SSA	Dummy taking the value of 1 for household from Sub-Saharan Africa and 0 otherwise.
OIC	Dummy taking the value of 1 for household from Organization for Islamic Cooperation countries in Sub-Saharan Africa and 0 otherwise.
OICIBS	Dummy taking the value of 1 for household from Organization for Islamic Cooperation countries with Islamic banking and finance in Sub-Saharan Africa and 0 otherwise
OICWIBS	Dummy taking the value of 1 for household from Organization for Islamic Cooperation countries without Islamic banking and finance in Sub-Saharan Africa and 0 otherwise

Source: Authors' construction

Table 2: Categories of Sub-Saharan African Countries in the Findex

Non-OIC SSA	OICIBS	OICWIBS
Angola,	Burkina Faso	Benin,
Botswana,	Cameroon,	Chad
Burundi,	Cote d'Ivoire	Gabon
Democratic Republic of Congo	Mauritania	Guinea,
Congo, Republic, Ethiopia	Nigeria,	Mali
Ghana, Kenya, Madagascar	Senegal	Niger
Malawi, Mauritius, Namibia,	Sudan	Sierra Leone
Rwanda, South Africa	Uganda	Somalia,
Tanzania, Zambia & Zimbabwe		Togo

Source: Authors' construction

Impact of Energy Consumption on Poverty Reduction in Africa

Innocent Okwanya[1] and Patricia O. Abah

This study investigates the impact of energy consumption on poverty reduction in a panel of 12 African countries over a period of 1981-2014. Using the Fully Modified Ordinary Least Square (FMOLS) method, the study shows that a long-run negative relationship exists between energy consumption and poverty level, which underscores the importance of energy in poverty reduction in the selected African countries. The result also indicates that other variables such as capital stock and political stability have significant effect on poverty implying that these factors play critical role in reducing poverty. Furthermore, the granger causality test shows that a short-run unidirectional causality runs from energy consumption to poverty. The findings clearly suggest that increasing energy consumption leads to a decline in poverty level. The study therefore recommends that the government in the selected countries should improve infrastructure and maintain political stability in order to maximize the effect of energy consumption on poverty reduction.

Keywords: Energy Consumption, Panel Causality, Panel Cointegration, Poverty level.
JEL Classification: I32; Q43.

1.0 Introduction

Undoubtedly, energy plays an important role in economic development especially in economies with high economic growth rate. Most scholars agreed with the position that increased energy consumption is a panacea to poverty and a tool for sustaining and enhancing economic growth particularly in developing nations (Abdur and Khorshed, 2010; Boardman and Kimani, 2014; Legros et al. 2009). Based on this premise, most policy makers tend to advocate for increased supply of energy and borrowing to meet the capital requirements, energy demand and aspirations of their citizens. The rate of investments in modern energy, especially in developing countries increased by 10 percent between 2010 and 2014 in a bit to increase the supply of energy, access rate to modern energy within the same period increased by 2 percent (World Bank, 2016). It is expected that, with such level of investments in energy, there will be a drastic increase in economic growth

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that will lead to decline in poverty level. However, despite the increased investment in energy and increased access to modern energy, about 1.7 billion people (18 percent of the world's population) still live below the World Bank's poverty line (World Bank, 2014). Unfortunately, most of the increase in poverty occurred in developing and emerging countries where investment in modern energy grew at 1.8 percent over the past 10 years, still leaving these economies with about 1.3 billion people in absolute poverty (World Bank, 2015). While many scholars tend to assume that energy consumption reduces poverty; on the contrary, increased energy consumption does not decrease poverty rate in Africa because energy consumption does not always translate to economic growth.

This paper argues that increased energy consumption is a necessary but not a sufficient condition in reducing poverty in developing countries. Certainly, energy such as electricity is needed in providing services that could enhance the living condition of the poor such as lighting, cooking and in providing power for some small scale industries, but it does not follow that even when such energy is made available, it will have a significant impact on the income of the poor. For such to happen, Gavin, Stefan and Michael (2013) argued that mechanism must be in place to transform energy into useful ventures. Such transformation is possible if constraints that inhibit the effective use of energy, such as lack of knowledge and skills, poor infrastructural facilities, political instability, inequality, poor business environment are removed. Neglecting these factors will not only affect the rate at which energy is transformed into economic activities but also affect gross domestic product (GDP)-energy relationship and consequently determine whether or not energy consumption will have sustainable impact on the citizens of a nation. There is, therefore, the need to pay close attention to factors that tend to affect energy-GDP relationship. This study paid attention to two of these factors-capital stock and political stability- which are issues of concern prevalent in most African countries.

In Africa the concept of energy-GDP nexus that explains the causal link between energy consumption and economic growth is better understood when extended to include the effect of this relationship on poverty level. Although many scholars

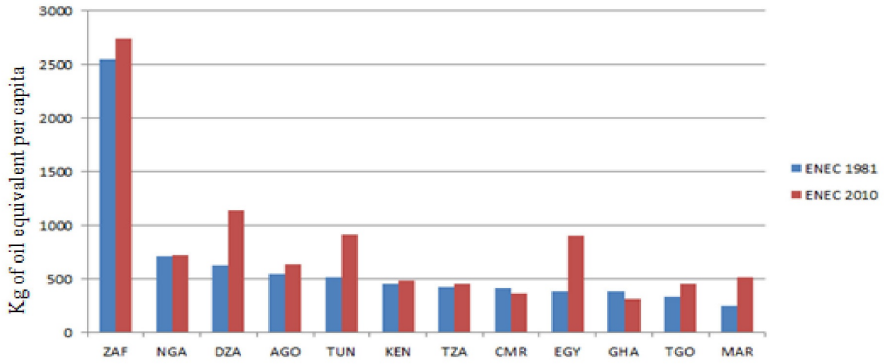
seem to agree on the role of modern energy in human development, the disagreement on causal link between energy consumption and economic growth and by extension the role of energy in poverty reduction still remains. For instance, some scholars found a unidirectional causality between energy consumption and economic growth (Masih and Masih, 1997; Fatai, 2004; Wolde-Rufael, 2005). Others such as Morimoto and Hope (2004) and Lee and Lee (2010) found bidirectional causality between energy consumption and economic growth; while others argued that energy consumption has a neutral impact on economic growth (Ghali & El-Sakka, 2004; Lee and Chien, 2010). These disagreements on the place of energy consumption and economic growth in poverty reduction among scholars underscore the fact that policies to increase investment in energy in poverty reduction should be carefully designed and implemented.

This study examines the link between energy consumption, poverty level, political stability, capital stock and GDP across 12 African countries. The contribution of this study is in two folds: first, it examines the effects of energy consumption, capital stock, political stability and GDP on poverty across selected African countries. Capital stock in terms of infrastructures and political stability are essential for energy consumption to be translated to growth and poverty reduction (Lee & Chien, 2010; Tang & Abosedera, 2014). The fully modified OLS is used to establish this long-run relationship because it takes into account integration and cointegration properties of the variables, also correct the problem of serial correlation and heterogeneity that may arise from using panel data. Secondly, we ascertain whether energy consumption translate to poverty reduction among 12 selected African countries. Previous studies paid little attention to whether energy consumption translates to reduction in poverty. Taking insight from the work of Foster and Tre (2000) who studied the impact of energy intervention on the poor in Guatemala, the study assumed that poverty in most Africa countries could have indirect link with energy consumption. The panel VECM is therefore used to investigate the short-run and long-run causal effect of this relationship. The variance decomposition is used to ascertain the rate at which energy consumption translate to poverty reduction. The remainder of this study is as follows: section 2 provides some sylized facts while section 3 reviews theoretical and empirical lit-

erature, section 3 is a discussion on the methodology used, section 4 shows the empirical results and section 5 is the conclusion and policy implications.

2.0 Some Stylized Facts on Energy Consumption and Poverty in Selected African Countries

To give a clear understanding of the situation in the selected countries we describe the basic characteristics of economic growth, poverty rate and energy consumption. The countries were selected from five region of Africa. The 12 countries are Ghana, Nigeria, Tanzania, Egypt, Morocco, Togo, Tunisia, South-Africa, Algeria, Kenya, Cameroon and Angola. First, we compared the per capita energy consumption among the selected African countries for the period of 1981 and 2010. The bar charts of energy consumption of the two periods are depicted in Figure 1.



Note: the abbreviations for the countries are; ZAF = South Africa, NGA = Nigeria, DZA = Algeria, AGO = Angola, TUN = Tunisia, KEN = Kenya, TZA = Tanzania, CMR = Cameroon, EGY = Egypt, GHA = Ghana, TGO = Togo and MAR = Morocco

Figure 1: Energy consumption in Selected African Countries, 1981 and 2010

As shown in Figure 1, energy consumption increased for the periods 1981 to 2010 in the selected countries except for Cameroon and Ghana where the per capita energy consumption decreased. The graph also shows that there is significant increase in per capital energy consumption in Algeria, Tunisia, Egypt and Morocco while South Africa, Nigeria Angola, Kenya, Tanzania and Togo have a moderate increase in energy consumption. The increase in energy consumption in almost all the countries suggests the importance placed on energy by these countries.

Despite the fact that energy consumption increased over the years in some of these countries, it is important to examine whether the increase in energy consumption translated to poverty reduction. This is because increased energy consumption may lead to economic growth but does not necessarily translate to reduction in poverty has is common in most African countries even though reducing poverty may constitute the main objective of most governments in Africa. Apart from the indirect effect of energy consumption on poverty rate, there are measures that have been taken among these countries that tend to link energy consumption directly to poverty reduction in the selected countries. For instance, the government in some of the countries subsidized the price of energy consumed and also ensures access to energy by citizens. We compare energy consumption and poverty rate among the selected countries using fitted line correlation for 1981 and 2010. The outcome is presented in the Figure 2 and 3.

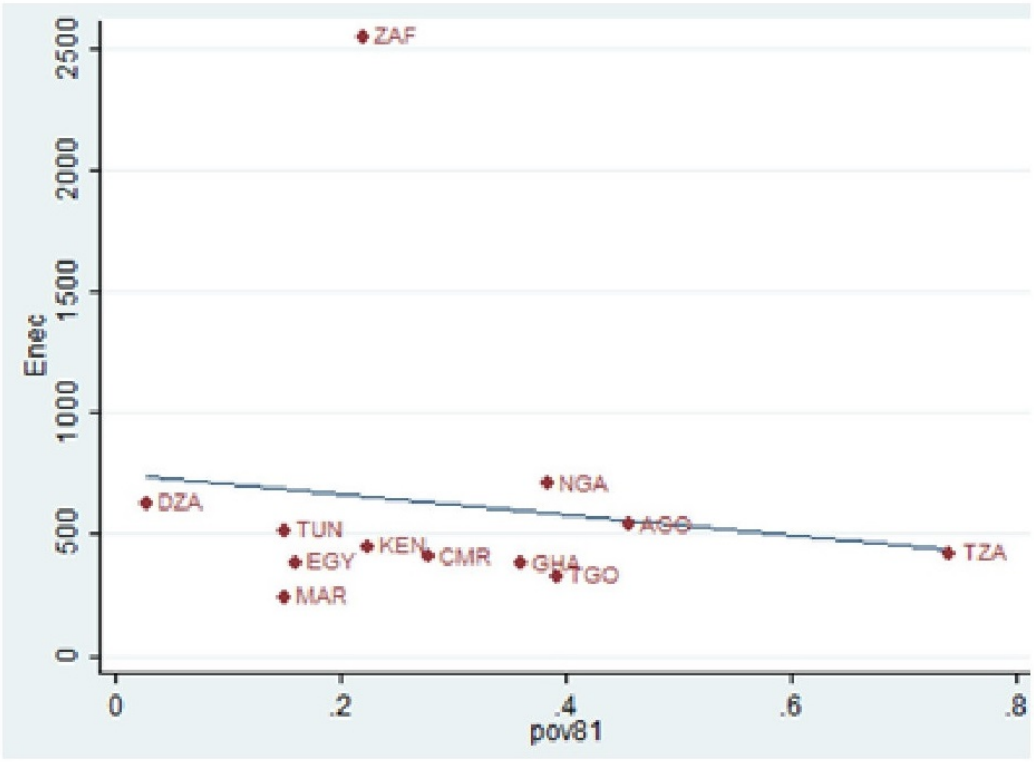


Figure 2: Energy Consumption and Poverty Rate,1981

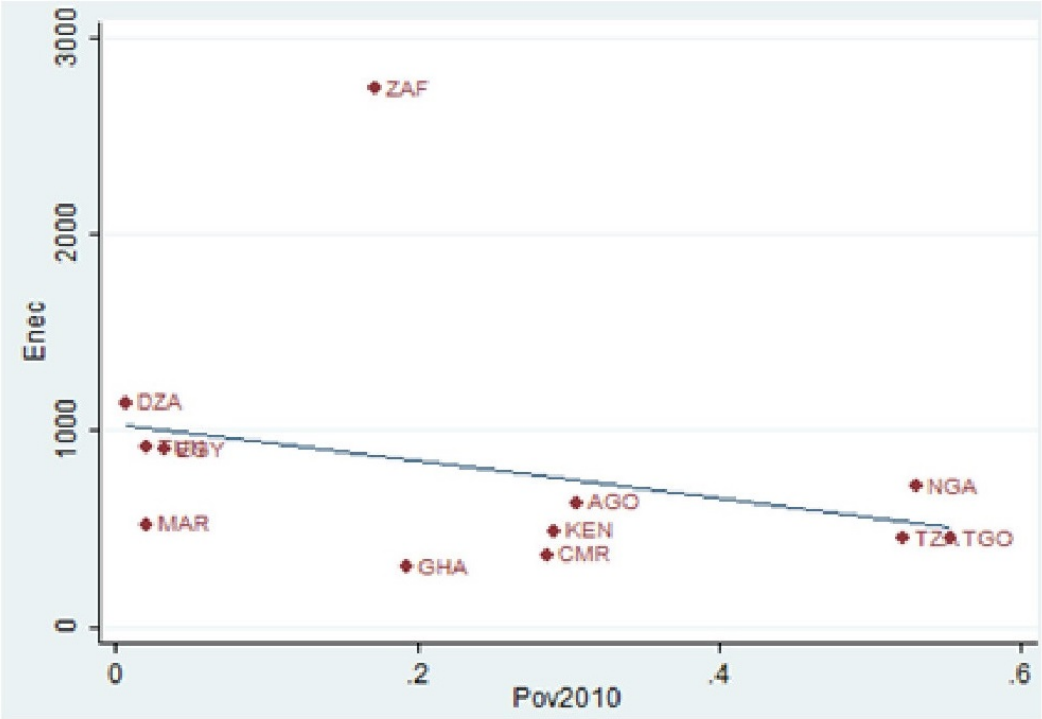


Figure 3: Energy Consumption and Poverty Rate,2010

Figures 2 and 3, as obtained from WorldBank Development Indicator (WDI) show the relationship between energy consumption and poverty in the selected countries for the period 1981 and 2010 respectively. Comparing the outcome from the two graphs suggest that countries that have increased energy consumption actually witness decrease in poverty rate - although this was not the case for countries like Nigeria and Togo that experienced an increase in poverty despite increase in energy consumption. Lastly on the stylized facts, we compare the average values of energy consumption, per capita income and poverty rate in these countries.

Table 1 shows the average values of energy consumption, real GDP and poverty rate of the countries base on their region. The results show that poverty rate is low among the North Africa countries. Unsurprisingly, the low level of poverty is associated with high GDP and energy consumption for the selected North African countries. The table also indicates that poverty rate is highest among West African countries. As expected, apart from Nigeria the energy consumption and income of these countries is quite low relative to those of the North African countries.

Some countries like Angola and South Africa clearly negate the classical assumption that high energy consumption and GDP reduces poverty rate as posited in the literatures. What this implies is that the growth process in some of the African countries had not been pro-poor or in some cases the proper mechanism needed to transmit the growth process to poverty reduction has not been adequately put in place for energy-GDP process to be transmitted to poverty reduction in some of these countries. Rauniyar and Kanbur (2010) and Jaumotte, Lall and Papageorgiou (2008) for instance, argued that growth become inclusive when there is improved capital stock that will ensure equitable distribution of resources.

We acknowledge the facts that there are some reservations when it comes to linking the growth process of nations to poverty reduction. The reservations arise not just from the differences in the view points and discipline of scholars but also from the strength of institutions of countries and socio-cultural ideologies that tend to affect the will of some government to give proper attention to poverty reduction. Such idiosyncrasies that exist among these nations, although important, tend to affect policies necessary to provide the required nexus between energy consumption, GDP and poverty. In as much as we do not just want to assume this away, the study addresses this fact by accounting for the heterogeneity that exists among the countries.

Table 1: Energy Consumption and Poverty Rate, 2010

Region	Countries	Average Energy Consumption	Average Real GDP (in millions USD)	Average Poverty Rate
Central Africa	Cameroon	393.24	62,761.16	0.31
	Angola	538.45	247,960.15	0.47
East Africa	Kenya	452.18	116,519.81	0.26
	Tunisia	717.92	213,266.35	0.07
	Tanzania	407.44	48,551.20	0.69
North Africa	Egypt	662.73	409,492.8	0.08
	Algeria	931.91	972,343.96	0.03
	Morocco	359.68	443,367.27	0.08
South Africa	South-Africa	2698.48	924,832.89	0.26
West Africa	Ghana	341.21	43,874.9	0.33
	Nigeria	731.68	337,305.8	0.55
	Togo	392.95	13,763.62	0.52

Source: World Bank Indicator [WDI], (2016)

3.0 Literature Review

3.1 Theoretical Framework

Energy plays a very important role in the growth process of most economies (Fatih, 2007; Akinlo, 2008). This postulation is based on the theory of economic growth and natural resources propounded by Solow (1956). The theory argued that natural resources such as capital, labour and land are important factors of production and play significant roles in economic growth. Starting with the pioneering work of Kraft and Kraft (1978) who established the relationship between economic growth and energy consumption, energy is argued to be one of the main drivers of modern economy especially across countries that have witnessed rapid growth in recent years. Many other empirical studies have assessed the effect of energy consump-

tion on economic growth (Asafu-Adjaye 2000; Wolde-Rufael, 2006). Most of the studies focused on the causality between energy consumption and economic growth (Asafu-Adjaye, 2000; Chontanawat, Hunt & Pierse, 2008; Apergis & Payne, 2010; Ozturk, Ashan & Kalyonau , 2010; Apergis & Payne, 2010; Aziz, 2011).

Recent theoretical conjectures have tried to link energy consumption with poverty. Among such studies are Foster and Tre (2000) and Barnes, Khandker and Samad (2010). The concept of linking energy consumption to poverty is anchored on the energy transition theory. The proponents of the energy transition theory such as Hosier and Dowd (1987) and Leach (1992) linked the nature of energy consumed to income. The theory explains that the type of energy consumed by a nation strongly depends on the level of per capita income. Drawing from consumer theory, the theory posits that as income increases, energy consumers tend to transit from traditional or inferior energy to modern energy due to ease of use and comfort. The theory holds that there is a direct link between level of income and energy consumption; high income countries tend to consume more quality energy than poor countries. This study, like previous studies, rests on the energy transition theory and which maintains that poor access to modern energy limits a nation's potentials to reduce poverty and ensure sustainable growth. This is because access to energy is central to any poverty reduction drive (Pachauri & Spreng, 2004) as energy deprivation inhibits production and limits level of economic activities (Kaygusuz, 2011 and Sovacool, 2012).

3.2 Empirical Literature

The empirical literature reviewed in this study are divided into two strands: the first strand of literature examines the relationship between energy consumption and economic growth. The second strand of literature focuses on whether energy consumption affects poverty and standard of living.

Many studies had attributed economic growth to increased energy demand (Mahadevan and Asafu-Adjaye, 2007); others argued that energy consumption increases growth. For instance, Chontanawat, Hunt and Pierse (2008) studied energy consumption and economic growth across 100 countries. Using Granger causality,

they found that the proportion at which causality runs from energy to GDP is higher in developed countries than in developing countries. Ozturk, Ashan and Kalyonau (2010) studied the relationship between energy consumption and economic growth across 51 countries using panel causality. They group the nexus effect of energy-GDP relationships of countries based on their level of income. The study found a unidirectional causality that runs from GDP to energy consumption for low income countries while a bidirectional causality exist for middle income countries. Mahadevan and Asafu-Adjaye (2007) studied the relationship among energy consumption, economic growth and prices in 20 developed and developing countries. Using panel vector error correction model (VECM) the study found that, bidirectional causality exist between economic growth and energy consumption in developed economies both in the short and long run, while a unidirectional causality flows from energy consumption to economic growth in the short-run. Another interesting result of this study is that the elasticity response in terms of economic growth from an increase in energy consumption is larger in developed countries than in developing countries.

Similar studies conducted in some Africa of individual countries also found related results: Wolde-Rufael (2006) test the long-run and causal relationship between electricity consumption per capita and real gross domestic product (GDP) per capita for 17 African countries for the period 1971-2001. The study employed cointegration test proposed by Pesaran et al (2001) and the granger causality test proposed by Toda and Yamamoto (1995). The result of the study shows a long-run relationship between electricity consumption per capita and real GDP per capita for only 9 countries and Granger causality for only 12 countries. Study also found a unidirectional causality running from real GDP to electricity consumption for 6 countries. It found a unidirectional causality running from electricity consumption to GDP and bi-directional causality for the remaining 3 countries. Okafor (2012) examined the causal relationship between energy consumption and economic growth in Nigeria and South Africa. Employing the Hsiao's Granger causality approach, the study found that economic growth causes total energy consumption in South Africa while energy consumption causes economic growth in Nigeria. Similar study by Kahsai, et al. (2012) tested the relationship between

energy consumption and economic growth in sub-Saharan Africa using a panel cointegration approach. Their findings showed that there is no causal relationship between GDP and energy consumption in low income countries in the short-run while a strong causal relationship running in both directions is found in the long-run.

Orhewere and Henry (2011) studied energy consumption and economic growth in Nigeria. They investigated the causality between GDP and energy consumption in Nigeria. Using the vector error correction techniques they found a unidirectional causality from electricity consumption to GDP both in the short-run and long-run. Abdur and Khorshed (2010) also studied the nexus between electricity generation and economic growth in Bangladesh using granger causality. They found a unidirectional causality that flows from electricity generation to economic growth. The results of these studies underscore the importance of energy in economic growth.

Ouedraogo (2013) studied energy consumption and economic growth among Economic Community of West African States (ECOWAS). The study tested the long-run relationship between energy consumption and economic growth rate across fifteen of the ECOWAS members from 1980 to 2008. Using the panel cointegration techniques and granger causality, the results of the study show that GDP and energy consumption move together in the long-run. The study also found a unidirectional causality that runs from energy consumption to GDP in the long-run and from GDP to energy consumption in the short-run.

Despite studies that shows GDP-energy relationship, most energy economists have not yet agreed on the relationship between energy and economic growth. In general, studies have found three forms of energy-GDP relationship: first, a unidirectional causality that flows from energy to GDP which implies that energy is vital for economic development (Fatai, Oxley and Scrimgeour, 2004; Morimoto and Hope, 2004; Yoo, 2006). The second is a unidirectional causality that flows from GDP to energy, which means that energy is only needed for economic activities (Oh and Lee, 2004; Soytas and Sari, 2003). Thirdly, is the possibility of no causality between energy and GDP, which implies that energy does not have

any impact on economic activities (Masih and Masih, 1997; Asafu-Adjaye, 2000). Overall, since the relationship between energy consumption and GDP affects policy options; the transmission mechanism to which energy consumption affects the poor and its interaction with other factors should be understood in the context of individual country's or regional economic structure.

The second strand of literatures found their basis in the endogenous growth theory which posits that other factors apart from capital, labour and energy are needed to enhance GDP growth of a nation. The proponents of the endogenous theory (such as Romer, 1986; Lucas, 1988; Baro, 1990) seek to explain the causes of growth that is left unexplained by the traditional concept of production. The theory laid emphasis on human capital development, infrastructure and research. The theory maintained that the government can improve efficient allocation of resources if there is increased investment in human capital, build a knowledge based institutions, provide environment that is conducive for local and foreign investment.

Just like energy-GDP relationship, the study of energy and poverty is becoming a paramount issue among energy economist because energy poverty could be a catalyst for unrest and instability (Basilian and Yumkella, 2015). According to Pachauri, et al. (2004) high level of poverty affects the pattern of energy consumption in terms of the quantity and quality of energy. The poor are always prone to the use of traditional and inefficient energy sources such as wood and coal which are unlikely to increase economic growth. Few studies have assessed the effect of energy consumption on poverty (Gertler, et al. 2011) most of the studies focused on theoretical relationship between energy and poverty (Short, 2002). Only few examine the magnitude of the impact of energy consumption on poverty. Meikle and Bannister (2003) for instance, studied the linkages between energy and poverty in poor urban households in Indonesia, Ghana and China. The study found that the poor are more vulnerable to shocks in the energy market.

Gertler, et al. (2011) studied the nexus between poverty, growth and the demand for energy. Using a panel analysis, they found that the demand for energy increases among countries that are pro-poor than among countries that are not.

They argued that not taking into consideration the pro-poor growth could grossly underestimate future energy use. When households' incomes go up, so is their demand for energy because they buy energy using assets. The speed at which households come out of poverty affects their purchase decisions. Improving the income of the poor increases their demand for energy. Filho and Hussein (2012) examine the link between energy availability and improvement in the standard of living. They found that the living standard is likely to improve with increased availability of modern energy. They pointed out that rural area stands to benefit more with increased availability of renewable energy technologies. The study used a comparative analysis, which tends to be subjectively bias. In this study we however, employed a more statistical method of analysis by employing the VECM method to assess the causal link between energy and poverty.

Darby (2011) argued that energy should not just be viewed as a commodity or an ecological resource but also a social necessity capable of increasing the social and economic wellbeing of people. According to the author, adequate energy supply to some extent affect economic growth and in some cases may determine the level of development, socio-cultural and economic ideology governing a nation. Fatih (2007) also pointed out that strong political will in the improvement of the general welfare of citizens is the main strategy to reducing poverty but not neglecting energy supply. Such improvement in the welfare of the citizens comes via increase in public and private investment in infrastructures and human capital, which serves as a prerequisite to efficient energy use. In this regard, Stern (2003) argued that innovation and energy efficiency, energy quality and shift in the composition of energy input are intervening factors affecting the relationship between energy and economic growth. According to Hodgson (2000), institutional factors play a big difference between developed and developing economy. Countries with strong institutions tend to have strong infrastructural base, provide reliable economic and political environment necessary for economic growth. Although other factors apart from energy may account for the differences in the impact of energy consumption on poverty reduction, this study tend to examine two of these factors by assessing the link between energy consumption, poverty, political stability, capital stock and GDP across 12 African countries.

Apart from institutional factors, studies have tried to identify channels through which economic growth affects poverty rate. Fields (2001) for instance, pointed out that growth can translate to poverty reduction when there is adequate physical capital, increase human capital, rule of law, competitive markets, openness to trade and investment, low inequality and increased agricultural activities. Kraay (2006) pointed out that the pattern to which growth can affect the poor is specific to countries but in generic terms economic growth can only reduce poverty when growth is pro-poor. They pointed out that in Africa one main channel to transmitting growth to the poor is improving the agricultural system. Agriculture still remain the highest employer of labour especially the poor. Juzhong et al (2009) categorized the channels to which growth affect poverty reduction into three main channels: direct channels which involves expenditure on education and infrastructures; the market through labour and finance; and government policy through trade openness and government subsidies.

Past studies contribute to our understanding of the relationship between energy consumption and economic growth, but less attention has been on whether energy consumption translates into poverty reduction. Earlier studies by Foster and Tre (2000) and Barnes, Khandker and Samad (2010) linked energy consumption to poverty in Guatemala and Bangladesh respectively. This study contributes to knowledge by examining the effect of energy consumption on poverty rate within selected African countries. This study intends to push this argument further by assessing the impact of variables such as capital stock and political stability so as to determine the place of energy consumption in poverty reduction especially among African countries. As indicated in the literature, addition to GDP we included two variables in the estimation of the energy poverty relationship as control variables. In this paper we argue that if energy consumption does not affect poverty level in some countries then policies towards increasing investment on energy supply to reduce poverty will only achieve infinitesimal success. Rather, such investments and policies should be redirected into projects and programs that will provide solid economic structures that will enhance sustainable economic development. As argued by Acemolu (2011) it is only when we understand the fundamental causes of the

differences in development across countries can we then avoid platitude recommendations such as government should increase energy supply so has to reduce poverty.

4.0 Methodology

This study focuses on the relationship among GDP, energy consumption, poverty level, and political stability. Data used for this analysis were collected from (World Bank Indicator [WDI], 2016). The variables used for this analysis are annual data on energy consumption (kg of oil equivalent per capita), GDP at constant 2011 national prices (in million 2011 US$), political stability (measured by the perception that government will be destabilized by domestic violence or terrorism). The World Bank indicator measures political stability using the stability index consisting of factors like mass civil protest, politically motivated aggression, instability within political regime and instability of political regime. The political stability of a country is weak if the stability index is close to -2.5 and strong if the index is close to 2.5. The economic variable for growth is measured by the growth in the real GDP. Poverty is proxied by the head count of people living below the international poverty line of US$1.25 a day. This follows the application of poverty rate as a variable in the work of Dollar and Kraay (2002) and Anyanwa and Erhijakpor (2010). Data on capital stock is the capital stock at constant 2011 national prices (in million 2011 US$). The data cover the period 1981-2014 when data on all the variables of concern are available for the selected countries. The period is considerably long enough for energy consumption to have the required impact on poverty in the chosen countries.

However, the choice of the countries selected from each region was based on the availability of the data required for this study. Consequently, only South Africa was selected from the Southern region while Cameroon and Angola were selected from the central region. Three countries were selected each from the other three regions.

The study assesses the impact of energy consumption, capital stock, GDP and political stability on poverty level through the multivariate panel model specified

as follows:

$$LNPOV_{i,t} = \delta_i + \gamma_t + \alpha_1 LNENC_{i,t} + \alpha_2 LNGDP_{i,t} + \alpha_3 LNKSTK_{i,t}$$
$$+\alpha_4 POL_{i,t} + \varepsilon_{i,t} \quad (1)$$

where δ_i and γ_t are the country-specific fixed effects and deterministic trends respectively; LNGDP = log of GDP per capita; LNENC = log of per capita energy consumption; LNPOV = log of poverty level; LNKSTK = log of capital stock and POL = political stability. Panel data analysis of this nature provides more information and gives a high degree of freedom than cross-sectional data or times series data. Apart from POL that contains negative values, all the other variables were transformed to harmonize the units of measurement of the variables using the natural logarithm.

Recent developments in panel data analysis encouraged preliminary test for cross section dependence and slope homogeneity of variables (Baltagi & Pesaran, 2007). This is necessary because turbulence in one country can easily be transmitted to other countries either through international trade or regional integration (Nazlioglu, Lebe & Kayhan, 2011; Pesaran, 2006).

Thus, Breusch and Pagan (1980) and Pesaran (2004) test the possibility of cross sectional correlation through ε_{i_t} in equation 1. The null hypothesis assumed ε_{i_t} to be cross sectional independent while the alternative hypothesis assumes ε_{i_t} to be correlated across sections. Breusch and Pagan (1980) therefore proposed the following Lagrange Multiplier statistics:

$$LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{i,j}^2 \quad (2)$$

where $\hat{\rho}_{i,j}$ is the sample estimate of the pair wise correlation of the residuals expressed as:

$$\hat{\rho}_{i,j} = \hat{\rho}_{j,i} = \frac{\sum_{t=1}^{T} \hat{\varepsilon}_{i,t} \hat{\varepsilon}_{j,t}}{\left(\sum_{t=1}^{T} \hat{\varepsilon}_{i,t}^2\right)^{1/2} \left(\sum_{t=1}^{T} \hat{\varepsilon}_{j,t}^2\right)^{1/2}} \quad (3)$$

The Lagrange Multiplier (LM) is an asymptotical distribution chi-square with $N(N-1)/2$ degree of freedom. The Breusch and Pagan (1980) cross sectional dependence test is suitable for panel analysis with small N and large T. For analysis with large N and T, Pesaran (2004) proposed cross sectional dependence (CD) test that is based on the pair-wise correlation coefficients expressed thus:

$$CD = \sqrt{\frac{2T}{N(N-1)}}(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{i,j}) \tag{4}$$

Baltagi, Feng and Kao (2012) [BFK henceforth] also proposed a scaled LM test statistics that is suitable for both small and large N and T. BFK cross sectional dependence test is specified thus:

$$LM = \sqrt{\frac{1}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(T_{i,j}\hat{\rho}_{i,j}^{2}-1) - \frac{N}{2(T-1)} \tag{5}$$

Both the BFK and Pesaran (2004) statistics are chi-square with asymptotic normal distribution. The Breusch and Pagan (1980), Pesaran (2004) and the Baltagi, Feng and Kao (2012) tests are used to test the cross section dependence of each of the variables. The test for cross section dependence is important because its presence distort the usual panel unit root test and helps to determine the appropriate panel unit root that addresses the problem. We conduct the cross section dependence tests and found that cross sectional dependence exist in all the variables. The presence of cross sectional dependence in the variables invalidates the first generation panel unit root tests that assume cross sectional independence. The study therefore adopts the panel unit root test as proposed by Choi (2002) and Pesaran (2007) which take into account cross sectional dependence by assuming that one or more common unobserved factors are present in the variables. A common factor can be represented in a variable as:

$$y_{it} = \rho_i\theta_t + \varepsilon_{it} \tag{6}$$

here $i = 1, 2, 3, \ldots, N$ is the country index;$t = 1, 2, 3, \ldots, T$ is the time index; y is the specific variables of concern (in this case GDP, energy consumption, poverty rate, capital stock and political stability); θ_t captures the unobserved factors.ε_{it} is

the error term.

Just like the panel unit root test, not all panel cointegration tests are suitable to test for the existence of cointegration when the series exhibit cross sectional dependence. In this study, we use the Westerlund (2007) cointegration test because it is robust against heterogeneity and cross sectional dependence in panel. The aim of the co-integration test is to determine whether there exists a long-run relationship among the variables used in this study. The Westerlund (2007) cointegration test checks for the existence of error correction for series that are I(1) in the individual group and for panel by using four cointegration test statistics: the group-mean tests and the panel tests. The two group-mean test statistics (Gt and Ga) test the alternative hypothesis that at least one element in the panel is cointegrated while the panel test statistics (Pt and Pa) test the alternative hypothesis that the panel is cointegrated as a whole. In addition, the bootstrap test can be applied to the Westerlund (2007) cointegration test so as to reduce the distortions that may arise from the asymptotic test. The Westerlund's cointegration test is performed as follows:

$$\Delta POV_{it} = \alpha_{1i} + \sum_{i=1}^{q} \beta_i \Delta POV_{i,t-i} + \sum_{i=1}^{q} \varphi_i \Delta X_{i,t-i} + \gamma_i ECM_{i,t-i} + \varepsilon_{it} \qquad (7)$$

where X = the vector of independent variables which include GDP, ENC, KSTK and POL; γ_i is the value of the speed of adjustment of the error term. If $\gamma_i = 0$ then there is no error correction and the variables are not cointegrated; if $\gamma_i < 0$ it means that there is error correction and the variables are cointegrated.

Once the cointegration relationship is established, the long-run parameters is then estimated using the panel fully modified ordinary least squares (FMOLS) as developed by Phillips and Hansen (1990) and (Saikkonen, 1991 and Stock and Watson, 1993) respectively. The panel FMOLS as modified by Pedroni (2000) is not only essential in estimating cointegrating regression but also useful in addressing the problem of cross section dependence and heterogeneity. The long-run relationship for each of the country is estimated as specified in equation (1).

Once it is determined that the variables are cointegrated, a panel-base vector

error correction is used to examine the short-run and long-run causality. The VECM captures both the long-run and short-run relationship among variables. The VECM can identify the sources of causation and also distinguish between the long-run and short-run among the series (Oh & Lee, 2004). The study employed the two-step Granger causality test proposed by Engle and Granger (1987). To do this, first, the long-run model is estimated so as to obtain the estimated residuals ε_{it} (from which error correction term is derived). The residuals tell us the extent to which the observed values deviate from the long-run equilibrium in the short-run. The second step is to estimate the Granger causality model with a vector error correction model. It is expected that since the variables are cointegrated all deviation in a particular period should be forced back to the long-run equilibrium through the error correction mechanism. The following vector error correction model is stated for this analysis:

$$\Delta LNGDP_{it} = \alpha_{1i} + \sum_{i=1}^{q} \beta_{11}\Delta LNGDP_{i,t-i} + \sum_{i=1}^{q} \beta_{12}\Delta LNENC_{i,t-i} + \sum_{i=1}^{q} \beta_{13}\Delta LNPOV_{i,t-i} + \sum_{i=1}^{q} \beta_{14}\Delta POL_{i,t-i} + \sum_{i=1}^{q} \beta_{15}\Delta LNKSTK_{i,t-i} + \gamma_{1i}ECM_{i,t-i} + \varepsilon_{i,t}^{GDP} \quad (8)$$

$$\Delta LNENC_{it} = \alpha_{2i} + \sum_{i=1}^{q} \beta_{21}\Delta LNGDP_{i,t-i} + \sum_{i=1}^{q} \beta_{22}\Delta LNENC_{i,t-i} + \sum_{i=1}^{q} \beta_{23}\Delta LNPOV_{i,t-i} + \sum_{i=1}^{q} \beta_{24}\Delta POL_{i,t-i} + \sum_{i=1}^{q} \beta_{25}\Delta LNKSTK_{i,t-i} + \gamma_{2i}ECM_{i,t-i} + \varepsilon_{i,t}^{ENC} \quad (9)$$

$$\Delta LNPOV_{it} = \alpha_{3i} + \sum_{i=1}^{q} \beta_{31}\Delta LNGDP_{i,t-i} + \sum_{i=1}^{q} \beta_{32}\Delta LNENC_{i,t-i} + \sum_{i=1}^{q} \beta_{33}\Delta LNPOV_{i,t-i} + \sum_{i=1}^{q} \beta_{34}\Delta POL_{i,t-i} + \sum_{i=1}^{q} \beta_{35}\Delta LNKSTK_{i,t-i} + \gamma_{3i}ECM_{i,t-i} + \varepsilon_{i,t}^{POV} \quad (10)$$

$$\Delta POL_{it} = \alpha_{4i} + \sum_{i=1}^{q} \beta_{41} \Delta LNGDP_{i,t-i} + \sum_{i=1}^{q} \beta_{42} \Delta LNENC_{i,t-i}$$

$$+ \sum_{i=1}^{q} \beta_{43} \Delta LNPOV_{i,t-i} + \sum_{i=1}^{q} \beta_{44} \Delta POL_{i,t-i} + \sum_{i=1}^{q} \beta_{45} \Delta LNKSTK_{i,t-i}$$

$$+ \gamma_{4i} ECM_{i,t-i} + \varepsilon_{i,t}^{POL} \tag{11}$$

$$\Delta LNKSTK_{it} = \alpha_{5i} + \sum_{i=1}^{q} \beta_{51} \Delta LNGDP_{i,t-i} + \sum_{i=1}^{q} \beta_{52} \Delta LNENC_{i,t-i}$$

$$+ \sum_{i=1}^{q} \beta_{53} \Delta LNPOV_{i,t-i} + \sum_{i=1}^{q} \beta_{54} \Delta POL_{i,t-i} + \sum_{i=1}^{q} \beta_{55} \Delta LNKSTK_{i,t-i}$$

$$+ \gamma_{5i} ECM_{i,t-i} + \varepsilon_{i,t}^{KSTK} \tag{12}$$

where Δ is the first difference operator; $\alpha_{1i}, \ldots, \alpha_{1i}$ are the cross-sectional mean value of each fixed effect model, β parameters shows the short-run, q is the optimal lag length, γ_i is the parameter that tells the speed of adjustment to equilibrium after a shock. According to Granger (1969), there is Granger-causality from x to y if including the past values of x improves the prediction of the current value of y. x does not predict y if including the past values of x does not improve the prediction of the current value of y. Equations 8 to 12 enables us to determine the short and long-run causality between the variables.

To identify the source of causality, we test the significance of all coefficients in each of the equation. For the short-run causality, we test the short-run causality from energy consumption, poverty level, political stability and capital stock to GDP based on $H_0 : \theta_{12ik} = 0$ for every ik, $H_0 : \theta_{13ik} = 0$, for every ik, $H_0 : \theta_{14ik} = 0$ for every ik, $H_0 : \theta_{15ik} = 0$ for every ik in equation 8. The significance of any of coefficient means there is short-run causality from that variable to GDP. In equation 9, the short-run causality from GDP, poverty level, political stability and capital stock to energy consumption are tested respectively based on $H_0 : \theta_{21ik} = 0$ for every ik, $H_0 : \theta_{23ik} = 0$, for every ik, $H_0 : \theta_{24ik} = 0$ for every ik, $H_0 : \theta_{25ik} = 0$

for every ik in equation 8. Equation 10 is the short-run causality from GDP, energy consumption, political stability and capital stock to poverty rate are tested respectively based on $H_0 : \theta_{31ik} = 0$ for every ik, $H_0 : \theta_{32ik} = 0$, for every ik, $H_0 : \theta_{34ik} = 0$ for every ik, $H_0 : \theta_{35ik} = 0$ for every ik in equation 8. In equation 11, the short-run causality from GDP, energy consumption, poverty rate and capital stock to political stability are tested respectively based on $H_0 : \theta_{41ik} = 0$ for every ik, $H_0 : \theta_{42ik} = 0$, for every ik, $H_0 : \theta_{43ik} = 0$ for every ik, $H_0 : \theta_{45ik} = 0$ for every ik in equation 8. Lastly, in equation 12, the short-run causality from GDP, energy consumption, poverty rate and political stability to capital stock are tested respectively based on $H_0 : \theta_{51ik} = 0$ for every ik, $H_0 : \theta_{52ik} = 0$, for every ik, $H_0 : \theta_{53ik} = 0$ for every ik, $H_0 : \theta_{54ik} = 0$ for every ik in equation 8. The long-run causality is then tested by looking at the significance of the coefficients of the error correction term λ in equation 8 to 12. The null hypothesis $H_0 : \lambda_{1i} = 0$ for every i is tested against the alternative hypothesis $H_1 : \lambda_{1i} \neq 0$ for every i. The significance of λ determines whether the movement along the long-run equilibrium is permanent and deviation in such a case is temporal. The magnitude of λ determines the speed of adjustment after such deviation.

5.0 Discussion of Empirical Results

We checked for the cross section dependence among the variables as well as the residual of the fixed effects regression using the Breusch-Pagan LM, Pesaran (2004) and the Baltagi, Feng and Kao (2012) [BFK hence forth] cross section dependence test.

Table 2: Cross Section Dependence Test

Variable	Breusch-Pagan LM	BFK	Pesaran CD	Decision
POV	507.32***	37.18***	5.07***	Cross section dependent
GDP	1983.96***	165.71***	44.46***	Cross section dependent
ENC	969.14***	77.38***	12.64***	Cross section dependent
KSTK	1759.66***	146.18***	41.7***	Cross section dependent
POL	808.51***	63.40***	0.39	Cross section dependent
Resid $_{\text{Fixed Effect}}$	488.96***	35.58***	9.52***	Cross section dependent

Note: Null hypothesis states that there is no cross section dependence or correlation. *** indicates rejection of the null hypothesis at 1 percent level of significance. The Breusch-Pagan LM, follows a chi-square distribution, BFK and Pesaran CD follow standard normal distribution.

Table 2 shows the results of the Breusch-Pagan LM, BFK and Pesaran (2004) cross section dependence test. The test indicated that there is cross section dependence in all the variables among the countries. This implies that a shock in one of the selected country tends to be transmitted to other countries. The summary of the panel unit root test for the variables used is presented in Table 3.

Table 3: Panel Unit Root Test Results

Variables ➔	**GDP**	**ENC**	**POV**	**POL**	**KSTK**
Level					
Pesaran	4.16	2.18	0.21	0.18	5.46
Choi	8.35	0.55	-1.23	-0.002	5.42
First Difference					
Pesaran	-6.63***	-9.24***	-8.73***	-7.81***	-5.03***
Choi	-2.84***	-7.34***	-7.67***	-9.19***	-4.75***

Notes: *** the null hypothesis of a unit root is rejected at 1% significant level. H_0: individual unit root process.

Table 3 depicts the panel unit roots test of the five variables in level and first difference for individual effect and trend. The table shows that the variables are not stationary at level. However, after taking the first difference, the series became stationary as the null of a unit root process is strongly rejected at 1 percent significance level. The result implies that all the variables are non-stationary and are integrated of order one. To account for the cross section dependence, we apply the Westerlund (2007) error correction based panel cointegration tests with boot-

strapped P-values. The result of the cointegration test is shown in Table 4.

Table 4: Westerlund Panel Cointegration test Results

Statistics	Value	Z-value	P-value	Robust P-value
Gt	-2.687	-2.385	0.009	0.000
Ga	-6.322	1.732	0.958	0.630
Pt	-38.542	-26.002	0.000	0.000
Pa	-25.578	-9.222	0.000	0.007

Note: The P-values are for test that follows the normal distribution while the robust P-values are for test that follows the bootstrapped distribution.

Table 4 shows the Westerlund (2007) cointegration test result. Considering the outcome of the p-value and the robust p-value, all the statistics apart from Ga strongly reject the null hypothesis of no cointegration at 1 percent level of significance. The none rejection of the null hypothesis of the Ga statistics is not surprising because according to Westerlund (2007), the Ga works better in cases of small samples of less than 10 countries. The overall result implies that we can conclude that there exists a long run relationship among the variables.

The study used the fully modified OLS (FMOLS) techniques for heterogeneous cointegrated panel as proposed by Pedroni (2000) to estimate the long run impact of energy consumption, real GDP, capital stock and political instability as shown in Table 5. The coefficients of LENC, GDP and POL are negative and statistically significant at 1 percent level of significant respectively, while the coefficient of LKSTK is positive and significant at 1 percent. Poverty level (LPOV), GDP (LGDP), capital stock (LKSTK) and energy consumption (LENC) are expressed in natural logarithms. The result of the FMOLS suggests that an increase in energy consumption and GDP by one percent causes poverty level to decrease by 1.42 and 0.17 percent respectively. Also, an increase in capital stock by one percent increases poverty level by 0.26 percent. Increasing the political stability index by unit is shown to decrease poverty level of the selected African countries by 0.1 percent.

Table 5: Fully Modified Ordinary Least Square (FMOLS) estimates

Dependent variable: LNPOV	FMOLS	$FGLS_{SUR}$
LNENC	-1.42***	-1.31***
	(-99.47)	(-25.62)
LNGDP	-0.17***	-0.16***
	(-22.27)	(-7.03)
LNKSTK	0.26***	0.24***
	(25.73)	(10.23)
POL	-0.10***	-0.049***
	(-5.28)	(-3.95)
C	-	22.85***
		(62.64)
R^2	0.74	0.75
Observations	408	408
Wald test X_4^2	17041.71***	1440.81***

Notes: t-values in parenthesis. *** Significant at 1% respectively.

The FMOLS outputs in Table 5 provide an interesting result; first, the result of the long-run impact of energy consumption on poverty is quite similar to the findings in earlier studies such as Karezi et al. (2001) and Foster and Tre (2014) who in their various country specific study observed that improved energy consumption reduces poverty in Guatemala and Kenya respectively. According to Foster and Tre (2014) in the study of energy –poverty relationship, it is important to look at the entire portfolio of energy sources rather than just the energy source from electricity: thus, improving the energy source tends to improve the entire welfare of the society. The result of the GDP and political stability are also significant in reducing poverty among the countries. The result of the capital stock does not meet our a priori expectation, its significance connotes that capital stock of the selected countries is not tailored towards poverty reduction. To ensure the robustness of the estimates, the Wald test statistics shows that the model is significant. Furthermore, the Panel Feasible General least Square (FGLS) SUR that also addresses the problem of cross section dependence yielded almost similar result.

Owing to the differences and coupled with the fact that the selected countries cut across different region in Africa, we examine FMOLS result for the individual countries so as to examine the effect of energy consumption on poverty level in the respective countries. The estimates of the effects of energy consumption, political

stability, capital stock and GDP on poverty in individual countries are depicted in Table 6.

Table 6: FMOLS Result for 12 Selected African Countries: Poverty as Dependent Variable

Countries/ Variables	Ghana (1)	Nigeria (2)	Tanzania (3)	Egypt (4)	Morocco (5)	Togo (6)	Tunisia (7)	South Africa (8)	Kenya (9)	Cameroon (10)	Angola (11)	Algeria (12)
LNENC	-0.39	2.01	0.63	2.83	1.38	1.03	-3.91**	-0.94	-4.52***	-3.05**	-0.15	-5.04***
	(-0.90)	(0.49)	(0.11)	(1.23)	(0.56)	(1.10)	(2.46)	(-0.89)	(-7.89)	(-2.63)	(-0.06)	(-3.31)
POL	-0.342	-0.78*	-1.16	0.084	0.92	0.22	2.72***	-1.34**	-1.36***	-0.45**	-0.52	2.14***
	(-1.11)	(-2.03)	(-0.53)	(0.13)	(0.50)	(0.29)	(3.49)	(-2.49)	(-21.48)	(2.71)	(-0.58)	(5.53)
LNKSTK	-1.11***	0.93***	2.372***	-2.44	-4.51*	0.83	-2.85	2.40***	1.41***	-2.57***	-0.49	-4.23***
	(-7.51)	(3.00)	(3.05)	(-1.17)	(-1.78)	(0.71)	(-0.67)	(3.20)	(3.87)	(-10.35)	(-0.39)	(-5.64)
LNGDP	0.79***	-	-2.66	0.87	0.974	0.057	1.81	-0.92**	-0.72***	1.64***	0.91	3.08***
	(3.31)	1.36*** (-3.39)	(-1.43)	(0.47)	(0.66)	(0.07)	(0.92)	(-2.22)	(-3.23)	(10.15)	(1.30)	(5.32)
C	22.29***	8.64	13.19	16.7	47.02**	0.86	48.47***	4.71	34.74***	41.84***	9.66	62.22***
	(13.09)	(.324)	(0.69)	(1.05)	(2.61)	(0.15)	(3.16)	(0.38)	(14.23)	(4.84)	(0.49)	(9.94)
Adj R^2	0.94	0.69	0.93	0.30	0.39	0.80	0.95	0.87	0.98	96	0.65	0.95

Notes: t-values in parenthesis. *, ** and *** Significant at 10%, 5% and 1% respectively.

The Table 6 shows that energy consumption is significant in reducing poverty in four of the countries. Political stability affects poverty in six of the countries. Capital stock significantly affects poverty in nine of the selected countries, while GDP affect five of the countries. Contrary to the general FMOLS results, the results in Table 6 show that capital stock and political stability are important in reducing the level of poverty in at least nine and six of the selected countries respectively. This implies that capital stock and political stability are important variables in the reducing poverty in the selected countries.

The long run causality test is determined based on the statistical significance of the respective error term in the each of the equation while the short run Granger causality test is conducted by testing the significance of the lagged values of the first difference of the respective variables. The source of causation is identified if coefficients of a lag variable in an equation are significant.

Table 7 shows the results of the short-run and long-run causality among the variables. The values of short run causality are result of the chi-square test and the associated probability values using the Wald test. This is done by testing the significance of the coefficient of first difference of lagged variables in the respective equation (that is equation 8 to 12). Equation 8 indicates that poverty level has

a significant impact on GDP in the short-run while energy consumption, political stability and capital stock are insignificant. In equation 9, all the variables are insignificant in the short-run. Equation 10 shows that real GDP, energy consumption and capital stock are significant while political stability is not. The results of equation 8 and 10 show that there is a short-run bidirectional causality between real GDP and poverty level. Equation 11 indicates that none of the variables are significant, thus there is no short run or long-run causal effect. Lastly, in equation 12, real GDP and political stability have a significant impact on capital stock in the short-run. Equation 10 and 12 also shows evidence of unidirectional short-run Granger causality between poverty level and capital stock.

The significance of ECM in equation 12 implies that there is unidirectional causality that flows from political stability and real GDP to capital stock. The relationship between political stability and capital stock suggests that reducing the risk of internal unrest could improve capital accumulation both in the long-run and short-run. The ECM in the equation 10 is also significant and shows a unidirectional causality that flows from energy consumption, real GDP and capital stock to poverty. The result implies that energy is important in reducing poverty in the region as it has been buttressed in others studies (Bazellian and Yumkella, 2015; Eggoh, Bangake and Rault, 2011). This means energy is important in the short-run among these countries as the error correction term suggests that poverty level responds to the deviations from the long-run equilibrium.

Table 7: Results of Panel Causality Test

Dependent Variable	Sources of Causation (Independent Variables)						
		Short-run					Long-run
	Equation	$\Delta LNGDP$	$\Delta LNENC$	$\Delta LNPOV$	ΔPOL	$\Delta LNKSTK$	ECM
$\Delta LNGDP$	(8)	-	1.748	22.072***	3.843	2.11	-0.0006
			(0.417)	(0.000)	(0.146)	(0.348)	(0.864)
$\Delta LNENC$	(9)	0.733	-	0.41	3.73	0.25	0.000*
		(0.693)		(0.81)	(0.15)	(0.88)	(0.084)
$\Delta LNPOV$	(10)	12.00***	5.79*	-	3.97	57.3***	-0.114***
		(0.002)	(0.055)		(0.131)	(0.00)	(0.002)
ΔPOL	(11)	3.76	0.63	1.26	-	0.69	0.0004
		(0.15)	(0.72)	(0.53)		(0.71)	(0.667)
$\Delta LNKSTK$	(12)	20.52***	0.85	3.80	12.05***	-	-0.067*
		(0.00)	(0.65)	(0.15)	(0.00)		(0.09)

Notes: Probability values in parenthesis. * and *** means the coefficient is significant at 10% and 1%.

Table 8: Variance Decomposition of Variables

Panel B:		Variance Decomposition of LPOV:				
Period	S.E.	LENC	LPOV	LKSTK	LGDP	POL__STAB
1	0.808440	0.028950	99.97105	0.000000	0.000000	0.000000
2	0.903323	0.746835	86.45814	10.33455	2.193727	0.266752
3	0.962701	1.336219	84.98587	11.22965	2.136304	0.311950
4	1.054986	1.296203	84.15762	12.22930	2.055251	0.261628
7	1.221775	1.524849	79.65161	16.42402	2.124075	0.275444
8	1.267282	1.552430	78.60348	17.43677	2.126822	0.280494
9	1.308716	1.569449	77.78139	18.24478	2.120476	0.283907
10	1.347363	1.576882	77.05650	18.95819	2.121176	0.287257

In addition to the Granger causality test, we examine the response of poverty to GDP, energy consumption, capital stock and political stability using the variance decomposition analysis. The results of the variance decomposition are depicted in Table 8. The study is particularly interested on the response of poverty level to all the variables of concern. Panel B shows that the response of the poverty level is more to capital stock, than to real GDP and very little to energy consumption and political instability. The result suggests that although there is unidirectional causality that flows from energy consumption to poverty; poverty tends to respond quickly to capital stock across the selected countries. Thus, despite the importance of energy to national development policies to increase energy supply will yield little

impact in the reduction of poverty in the long-run if the necessary infrastructures are not in place. This implies that energy supply without creating the necessary environment could lead to energy waste and loss in the selected African countries.

6.0 Conclusion and Policy Implications

The attention of most policy makers among Africa countries is on increasing energy supply with the hope of meeting the energy needs and ensuring sustainable development. Although this is a veritable way in reducing poverty, however, most African countries are faced with problems such as poor infrastructural facilities, political instability, income inequality and other macroeconomic instabilities that tend to inhibit the efficacy of energy-GDP relationship on poverty level. This study contributes to existing literature by examining the nexus between energy consumption, real GDP, poverty level, political stability and capital stock across 12 African countries. The results of the long-run relationship reveal that energy consumption, and real GDP have a negative and significant impact on poverty in the selected African countries. However, long run impact for the individual shows that capital stock and political stability have significant impact in most of the countries. The implication is that capital stock and political stability have significant impact on poverty reduction across these countries. As such policies geared at poverty reduction and increased energy supply should include increasing capital stock as well as providing a stable environment.

The study also found a unidirectional causality that runs from energy consumption, real GDP and capital stock to poverty level in the selected African countries. The poverty level across the countries is also found to respond to the long run equilibrium after a shock. The variance decomposition shows that poverty responds more to capital and GDP than to energy consumption whenever there is a change in any of the variables. This implies that there is no strong link between poverty and energy consumption both in the short-run and long-run across these countries. Thus, increasing energy consumption may have no impact on poverty reduction except there is deliberate effort in building strong institutions that will encourage the distribution and use of energy.

On the basis of the short-run and long-run relationship between energy consumption, poverty level and real GDP, this paper pointed out that although energy plays an important role on economic growth, its role in reducing poverty rate is secondary, thus, the hypothesis of increasing energy supply so as to reduce poverty should be treated with caution in the selected countries. This is particularly important because for GDP-energy relationship to be sustainable, policy makers must ensure that the problems of poor infrastructure and violence in these countries must be addressed. Thus, the study suggests that effort should be made in ensuring a stable political climate as this will create and enhance efficient energy consumption. Furthermore, in addition to providing stable and efficient energy, the government in the selected African countries can reduce poverty rate by embarking on policies geared toward providing basic infrastructure, increasing income equality and ensuring increased access to modern energy at a subsidized rate.

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Modelling Volatility Persistence and Asymmetry of Naira-Dollar Exchange Rate

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This paper modelled the volatility persistence and asymmetry of naira-dollar exchange rate in interbank and Bureau de Change (BDC) using monthly data between January 2004 and November 2017. The study employed Generalized Autoregressive Conditional Heteroscedasticity [GARCH (1,1)], Threshold GARCH [TGARCH (1,1)] and Exponential GARCH [EGARCH (1,1)]. The results of Bai-Perron (2003) structural break identified two significant breaks in each market. Interestingly, the breaks, particularly for the interbank exchange rate(December, 2014 and January, 2015), seem to have coincided with the period of depreciation in the country's exchange rate which could be linked to the precipitous movement in the international crude oil prices. The findings showed that persistence is generally explosive in the BDC market as compared to interbank market where the persistence was high but not explosive especially under asymmetric models. Based on our model selection criteria, the symmetric GARCH model, appears to be better than the asymmetric ones in dealing with exchange rate volatility in the interbank market while asymmetric GARCH, especially TGARCH, seems to be better in the case of BDC market. By implication, it is important that the monetary authority considers the developments and reactions of the markets to news most especially the BDC, when designing appropriate exchange rate policies for the country.

Keywords: Bureau De Change (BDC); Exchange rate; Interbank Market; Volatility modelling.
JEL Classification: F0; F310; G150; G190.

1.0 Introduction

A key issue that has attracted considerable attention in international economics is modelling the dynamics of exchange rate in an economy. Inspite of the elaborate and detailed literature on volatility of financial series, divergent views still exist on the major causes of economic fluctuations in developing countries. Some studies in the literature have explained these fluctuations through the perspective of inflation and oil price volatility (See Fasanya and Adekoya 2017; Salisu and Fasanya, 2013); others have considered exchange

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volatility as the major cause of economic instability (See Bala and Asemota, 2013; Adeoye and Atanda, 2012). There are still some outstanding issues requiring further investigation. For instance, there is no consensus on the appropriate measure of exchange rate volatility in an economy. This lack of consensus is attributable to a number of factors. While theory provides some direction as to fundamental factors, the choice of measures of such factors are within the purview of the empiricists. In addition, the choice of measures is influenced to some extent by the constraint imposed by the scope of analysis. In other words, considerable attention should be paid to the period in which the variability will be captured; if the volatility is conditional, and the level of correlation between unexpected movement in the exchange rate and its predicted value.

The degree of exchange rate volatility in emerging markets such as Nigeria is largely driven by the United State dollar, a major trading currency. In the last two decades, the vacillations have been considerable and often unrelated to economic fundamentals. This prompted monetary authorities in most developing countries to intervene in the markets regularly with the objective of stabilizing the exchange rate. However, such interventions are often done without any clear sense of a sustainable equilibrium. In addition, the interventions operate with lags and sometimes too late to forestall severe exchange rate misalignment and volatility. The natural reactions to these imbalances include economic fluctuations, protectionist trade pressures, and inevitably sharp exchange rate policy reversals. Indeed, the exchange rate instability experienced in Nigeria especially between 2015 and 2017 exposed all these foregoing challenges.

It is incontrovertible that economic activities in Nigeria rely mostly on imported inputs. Coupled with this, the average consumer has excessive preference for foreign goods due to product quality disparity. On the exports side, Nigeria's main export commodity is oil that is subject to vagaries of international market challenges and quota allocations. This has had a moderating impact on the flows of foreign exchange and thus led to high exchange

rate volatility over the years. In other words, exchange rate volatility in an import dependent economy may lead to huge losses or gains to government and domestic investors that engage frequently in foreign trade and hence are confronted with greater risk of uncertainty about the exchange rate. Thus, the extent of exchange rate volatility is of great importance to both the policy makers and investors.

A plethora of studies have extensively explored exchange rate volatility in Nigeria. Some of these studies including Olowe (2009), Clement and Samuel (2011), Adeoye and Atanda (2013), Bala and Asemota (2013), Emenike and Peter (2016), Ajao and Igbekoyi (2013), Clement and Samuel (2011), Musa and Abubakar (2014) and Isenah and Olubusoye (2016) focus more on the official exchange rate markets. A more recent study by Atoi and Nkwede (2017) accounted for asymmetry in exchange rate volatility for both official and unofficial markets. However, many areas still require significant attention which this study seeks to explore. Specifically, this paper contributes to the literature on exchange rate in Nigeria in two main ways.

First, the volatility persistence of exchange rate is critical to the understanding of exchange rate behaviour in Nigeria. A critical look at foreign exchange rate episodes in Nigeria from 2010 to late 2014 indicates that both official and unofficial markets experienced significant shocks in terms of excessive demand pressure and speculative aggression from foreign exchange market participants which promote volatility in these markets. Recently, the persistent exchange rate instability witnessed in Nigeria after the significant drop in oil price revealed the extent to which unofficial market is important to the economy. The huge activities in the foreign exchange markets which official market failed to handle prompted the booming of unofficial foreign exchange market. Accounting for these two markets in the study for better understanding of exchange rate volatility is necessary for efficient and effective policy formulation. In addition, the demand pressure was heightened in 2015 before the introduction of more liberalized new exchange rate regime. Thus, understanding and comparing the level of volatility persistence in these

markets may shed more light on the challenges facing the foreign exchange markets as well as guide the investors in decision making especially in their portfolio diversification.

Second, the issue of asymmetry calls for concern in these two markets. The upward and downward movements of domestic currency against foreign currency (i.e. Naira/Dollar) in the foreign exchange markets over the years create more uncertainty for the players in the markets. More so, the policy of the Central Bank to rely heavily on external reserves contributed to the issue of asymmetry in the markets. Thus, we explore asymmetric conditional volatility model to sufficiently estimate the variations in exchange rate in these markets and compare the extent of the asymmetry. In addition, the study gives detailed information in both markets from persistence and asymmetric perspective for better understanding of the issues surrounding exchange rate and policy formulation. Therefore, this study is motivated to model and compare the extent of persistence and asymmetry for both markets.

The rest of this paper is organized as follows. Section two presents the stylized facts on development in the foreign exchange market, while section three presents the literature review. Section four provides the data and preliminary analysis while section five presents the empirical results as well as ensuing discussion. Section six concludes the study.

1.1 Developments in the Foreign Exchange Market and Exchange Rate Movements in Nigeria

The management of the foreign exchange (forex) rate market in Nigeria has witnessed series of reforms which first led to a shift from a controlled exchange rate to the Second-tier Exchange Market introduced in September 1986. As part of the reform, the Bureau de Change Foreign Exchange Market was introduced in 1989 purposely to deal with privately sourced foreign exchange. The introduction of this segment of the exchange rate market led to large volatility in the rates, thus prompting further reforms ranging from

the formal pegging of the naira exchange rate to reaffirmation of the illegality of the parallel exchange rate market. By 1995, the Central Bank of Nigeria enhanced the sale of foreign exchange to end-users through the Autonomous Foreign Exchange Market. Central to the reforms is the handling of the Bureau de Change Market as authorized dealers. To further enhance accessibility of forex market, the interbank foreign exchange market was introduced in 1999. In 2002 and 2013 the exchange rate policy was managed between a Retail Dutch Auction System and Wholesale Dutch Auction System. Subsequently, the interbank foreign exchange market (with CBN interventions) operated from November 2013 till June 2016 when it was further enhanced to improve the exchange rate flexibility. Nonetheless, the Central Bank of Nigeria continued to intervene in the market to stabilize the exchange rate.

There was relative stability in the exchange rate market, as expected, under the control regime, with the official exchange rate at an average of N1.75 per US dollar (USD). The movement of the foreign exchange experienced mostly depreciation since the liberalization of the 1986 until 1993 when it was again, fixed at N22/USD. This fixed exchange rate could not be supported again leading to further depreciation to N92/USD by 1999. Meanwhile, at this same time, the AFEM intervention rate depreciated continuously from N81.98 in 1997 to N91.83 in 1999. Subsequent reforms led to unceasing depreciation between 1999 and 2004, when it reached N132/USD. A slight respite for the economy was achieved between 2004 and 2008 when it appreciated for the first time. The rate however, has been heading north since then, reaching N192/USD in 2015 and N253/USD on the average in 2016. It should be noted that the rate depreciated between June and September 2016, when it was officially maintained at N305/USD till date (July, 2018).

The movement in the bureau de change rate followed similar trend, but more volatile as expected. As at 1995, the rate was N83.69/USD and depreciated to N99.26/USD in 1999. The rate increased to N140/USD in 2004 and appreciated continuously till it reached N120/USD in 2008. By 2009, at the period of the fallout of the global financial crisis, it depreciated to average of

N161/USD, a rate that was maintained until 2014 and 2015, when it depreciated again to N171/USD and N222/USD, respectively. The period marked the new era of continuous and unwavering depreciation in the market due to the inability of the Central Bank of Nigeria to fully support the forex as a result of the dwindling fortune of the country which suffered immensely from the global oil price crash. The management of exchange rate was hampered by speculative activities at this period. The exchange rate reached the peak of N493.29/USD by January 2017, until it stabilized to about N360/USD by end of 2017 and till mid of 2018.

2.0 Literature Review

2.1 Theoretical Framework

This sub-section presents the Purchasing Power Parity (PPP) as the underlying theoretical framework for this study. Following the introduction of the concept by Cassel (1918), it has been explored by many studies, including Officer (1976) and Rogoff (1996). Empirical validation of the theory has been carried out by several studies such as Sollis (2005) and Oyinlola et al. (2011). The purchasing-power-parity (PPP) theory involves the ratio of two countries' price levels (absolute PPP) or price indices times a base period exchange rate (relative PPP) as the most important variable determining the exchange rate, but it allows both for other explanatory variables and for random influences. The basic rationale for PPP theory is that the value of a currency is determined fundamentally by the amount of goods and services that a unit of the currency can buy in the country of issue. To this end, PPP is regarded as one of the most important theories in explaining the behaviour of exchange rate. As documented in Atoi and Nkwede (2017), the theory explains that exchange rate between two currencies will adjust to reflect price level changes between two countries. More specifically, the theory proposes that the same goods (in terms of basket) should have the same costs in each country given that allowance between different currencies is taken into consideration. This theory relies on "law of one price" which argues that identical goods should sell at the same price irrespective of the

country. Thus, the understanding of exchange rate behaviour is well captured through "real exchange rate". The real exchange rate is driven by some key factors that are subjected to volatility which in turn causes volatility in the real exchange rate and this leads to nominal exchange rate volatility.

However, the theory failed to explain this behaviour because of its assumption of identical goods in any two countries and there is little or no transport costs and trade barrier. In reality, this assumptions cannot hold due to differences in the quality of commodities produced in the two countries. In addition, PPP theory does not account for good and services whose prices are excluded in country's measure of price level and non-tradable goods across borders, this leads to evolution of interest rate parity condition (IRP). The interest rate parity theory explains the relationship among domestic interest rates, the interest parity and expected appreciation of the domestic currency. It also stipulates that domestic interest rate should equal the foreign interest rate less the expected appreciation of the domestic currency. The algebraic form of domestic interest in the IRP theory is presented below:

$$i^d = i^f - \frac{\varepsilon^e_{t+1} - \varepsilon_t}{\varepsilon_t} \tag{1}$$

where i^d represents domestic interest rate,i^d is the foreign interest rate, ε^e_{t+1} is the expected domestic currency at time and ε_t is the actual domestic currency at time t. on the other hand, IRP is presented as:

$$\varepsilon_t = \frac{\varepsilon^e_{t+1}}{i^f - i^d + 1} \tag{2}$$

2.2 Empirical Literature

The modelling of exchange rate volatility has increasingly gained prominence in the international economics literature in recent years. A number of factors have been attributed to this development. First is the availability of high frequency exchange rate series which provides robust evidence for the presence of statistically weighty correlations between series. Second, high frequency data on exchange rate creates the possibility of time varying volatility which is popularly known as conditional heteroscedasticity (see Harris and Sollis, 2004). Specifically, exchange rate fluctuations signify huge gains or losses arising from exchange rate misalignment in countries operating a mono-product economy and thereby leading to economic instability. Also, exchange rate volatility exposes investors to greater danger of uncertainty with either making huge losses or gains from their investment. Therefore, both the policy makers and investors are interested in the extent of exchange rate volatility to make informed decisions (Salisu and Fasanya, 2012).

Surveying economic literature revealed that modelling exchange rate volatility has followed different dimensions over the years (See Diebold and Nerlove, 1989; Sengupta and Sfeir, 1996; Usman and Adejare, 2010; Ojebiyi and Wilson, 2011; Adeoye and Atanda, 2012; Ajao and Igbekoyi, 2013; Bala and Asemota, 2013 among others). The Diebold and Nerlove (1989) appears to be the first study to model the exchange rate volatility using the Auto Regressive Conditional Hereteroskedasticity (ARCH) framework. The ARCH model only account for symmetric impacts in a shock. However, economic agents do not respond the same way to both positive and negative shocks. Thus, the study did not account for asymmetric shocks in the model. Estimating the likely presence of asymmetric shocks in exchange rate is of immense importance to individuals, firms and government who are concerned on managing the associated risk and uncertainties of the foreign exchange market.

Also, Sengupta and Sfeir (1996) attempted the modelling of exchange rate volatility in five countries (Japan, France, United Kingdom and West Ger-

many) using the Autoregressive Conditional Hereteroskedasticity (ARCH) and Generalized Autoregressive Conditional Hereteroskedasticity (GARCH). The study revealed that exchange rate follows a random walk while the volatility follows a persistent nonlinear behaviour. Again, the study failed to capture for asymmetric impact that is often common with volatile series.

Examining Ghana Cedi-United States Dollar exchange rate volatility, Luguterah et al. (2015) applied monthly exchange rate returns between January 1990 and November 2013 on symmetric and asymmetric GARCH models. Their results show the volatility persistence and absence of leverage effects from the asymmetric models. Consequently, the results suggest that the investors who hedged against future exchange rate risk do not rely on information about asymmetry in the Ghana foreign exchange market. Similarly, Rofael and Hosni (2015) employed daily data between January 2003 and June 2013 in modelling exchange rate volatility in Egypt using ARCH type and the State Space models. Their results revealed that exchange rate returns display volatility clustering and there is existence of time-varying variance in the exchange rate which has to be considered when modelling nominal exchange rates. This further shows that financial returns series exhibit sustained period of relative calmness and high volatility in the Egyptian exchange rate market.

In Nigeria, a number of studies have attempted to model exchange rate volatility. A notable work in this regard is Adeoye and Atanda (2012). The study revealed the presence of overshooting volatility shocks. However, the study did not account for asymmetric impacts in the model. This is because the ARCH and GARCH framework only account for symmetric impacts and shocks in a model. Further, Bala and Asemota in their 2013 paper on modelling exchange rate volatility in Nigeria, argued that asymmetric impacts and shocks are important when dealing with high frequency data. Therefore, evaluating the presence of asymmetric shocks on exchange rate is very pertinent to investors and policy makers. In their paper, Atoi and Nkwede (2017)examined asymmetric analysis of exchange rates volatility in Nigeria using three segments of the Nigerian foreign exchange market, namely; (Inter-

bank Foreign Exchange Market (IFEM), Bureau de Change and Wholesale Dutch Auction System (WDAS). The authors employed Asymmetric Threshold Generalized Autoregressive Conditional Heteroscedasticity (TGARCH) and their results showed that there was persistence of exchange rate volatility in all markets. They found that interbank exchange rate volatility was persistent and explosive compared to the other two markets. Similarly, Yakubu and Abubakar (2014) employed different approaches such as GARCH, GJR-GARCH, TGARCH and TS-GARCH and found the persistence of exchange rate volatility and non-existence of leverage effect.

The study by Olowe (2009) investigated the volatility of Naira/Dollar exchange rates using first order symmetric and asymmetric models on monthly data from January 1970 to December 2007. The study addressed the volatility issue through the separation of volatility during fixed exchange regime from managed float regime and the findings indicate that volatility was persistent and there was presence of leverage effect for the two regimes. In addition, the examination of the consistency, persistency, and severity of volatility in exchange rates of Naira/Dollar by Adeoye and Atanda (2013) revealed that the nominal and real exchange rates of Naira/US Dollar is not consistent with the traditional long-run PPP model. They concluded that symmetric GARCH model does not fully account for the stylized facts in terms of leverage effect inherent in financial time series. Clement and Samuel (2011) employed symmetric GARCH model to study volatility of Naira/US Dollar and Naira/UK Pound Sterling exchange rates in Nigeria and their results showed that volatility on the returns was persistent. In addition, Olusola and Opeyemi (2013) examined exchange rate volatility in Nigeria using Parametric Measure. They found that exchange rate volatility represents uncertainty and risk, which impose costs on risk averse economic agents. The results from their Exponential Generalised Autoregressive Conditional Heteroscedasticity (E-GARCH) model indicated that exchange rate was volatile in Nigeria as a result of unusually high and low deviations.

This present study recognises that some studies have captured both the sym-

metric and asymmetric effects on exchange rate in Nigeria; these studies, however, did not consider a comparison of the levels of volatility persistence and asymmetry in the interbank and Bureau de Change exchange markets in Nigeria. Thus, to complement results from the previous studies, we examine this comparison to provide better insight to investors and policy makers since they also engage in buying and selling of currencies in both markets. In addition, this paper considered the plausible effects of the presence of multiple breaks of the series in the analysis. The study therefore, fills this gap by attempting to model exchange rate volatility persistence and asymmetry in both markets using the ARCH, GARCH, TGARCH and EGARCH frameworks.

3.0 Data and Methodology

3.1 Data sources and Construction

The monthly Naira/USD exchange rates data utilized in this study were collected on interbank market and Bureau de Change. The data which cover the period January 2004 to November 2017 were obtained from Central Bank of Nigeria (CBN) online database. Thus, as a standard precondition in the literature for dealing with volatile financial series, the pre-estimation analysis is done in three stages: the first provides descriptive statistics for the respective exchange rates considered; the second tests for the presence of structural breaks in the series; while the third tests for potential heteroscedasticity feature of the series using ARCH LM test.

A time series exhibiting conditional heteroscedasticity-or autocorrelation- in the squared series is said to have autoregressive conditional heteroscedastic (ARCH) effects. To test the probable existence of ARCH effects in the respective exchange rate series under consideration, we explore the ARCH Lagrangian Multiplier (LM) test procedure developed by Engle (1982) which begins with a univariate model as specified below:

$$r_t = \lambda + \sum_{i}^{k} \delta r_{t-i} + \varepsilon_i; i = 1, ..., k, t = 1, ..., T; \varepsilon_1 \sim iid(0, \sigma^2); \quad |\delta t| < 1 \quad (3)$$

where r_t denote exchange rate returns and is measure in this paper as:

$$R\_BDCEXR_t = 100 \times [\Delta \log(BDCEXR)] \quad (4a)$$

$$R\_IFEXR_t = 100 \times [\Delta \log(IFEXR)] \quad (4b)$$

$$r_t = \lambda + \sum_{i}^{k} \delta r_{t-i} + \varepsilon_i; i = 1, ..., k, t = 1, ..., T; \varepsilon_1 \sim iid(0, \sigma^2); \quad |\delta t| < 1$$

where BDCEXR in equation (4a) denotes Bureau de Change exchange rate, while IFEXR is interbank or official exchange rate and Δ is a first difference operator.

In this section, we consider different plausible symmetric and asymmetric GARCH modeling frameworks to capture volatility and persistence in both the interbank and BDC exchange rate markets. That said, another significant contribution of this paper, as far as modelling of exchange rate volatility is concerned, is the inclusion of two break dates as earlier established by the outcomes of the Bai-Perron (2003) structural break test. Starting with the symmetric GARCH model, our mean equation following the standard GARCH (1, 1) procedure is as follow:

$$r_t = \eta + \delta r_{t-1} + \alpha_1 D_{1,t} + \alpha_2 D_{2,t} + \varepsilon_t \quad (5)$$

where r_t represents the returns on Bureau de Change and interbank exchange rates, $D_{i,t} = 1\text{if} \geq BD_i \text{and} \text{zero} \text{otherwise}; BD_i (i = 1, 2)$ denote the selected break dates. Given that $\varepsilon_t = \sigma_t e_t$ and $e_t \sim (0, 1)$ However, while the mean equation (5) is applicable to all the models used in this paper, the variance for the GARCH(1,1) model can be expressed as below:

$$\sigma_t^2 = \alpha + \beta \varepsilon_{t-1}^2 + \gamma \sigma_{t-1}^2; \quad \alpha > 0, \quad \beta \geq 0, \quad \gamma \geq 0 \quad (6)$$

Equation (6) typically expresses the conditional variance dependent on information about volatility observed in the previous period (the ARCH term,ε_{t-1}^2) and forecasted variance from last period (the GARCH term,σ_{t-1}^2). The persistence of σ_{t^2} is captured by $\beta + \gamma$ and covariance stationarity requires that$\beta + \gamma < 1$.The model is consistent with volatility clustering where large changes in returns are likely to be followed by further large changes and small values of variance from last period will be followed by small values of conditional variance in current period (Mandelbrot, 1963). The pattern of the volatility clustering may vary if bad and good news are received. Zivot (2008) argued that the signs of the residuals or shocks have no effect on conditional volatility in the basic GARCH model because the observed volatility in the previous period enters in squared value. The study also noted the fact that bad news (negative shocks) tends to have a larger impact on volatility than good news (positive shocks) of the same magnitude. In other words, volatility tends to be higher with negative shocks than with positive shocks. Black (1976) inferred that this effect increases the leverage effect and causes more volatility. Based on this conjecture, the asymmetric news impact on volatility is commonly referred to as the leverage effect. This asymmetric effects is demonstrated in this study with the use of EGARCH(1,1) and TGARCH(1,1) in equations 8 and 9, respectively. The EGARCH model was developed by Nelson (1991) to specifically capture asymmetries in the volatility. It is typically represented as follows:

$$\ln(\sigma_t^2) = \phi + \psi \left| \sqrt{\varepsilon_{t-1}^2/\sigma_{t-1}^2} \right| + \tau \sqrt{\varepsilon_{t-1}^2/\sigma_{t-1}^2} + \gamma \ln(\sigma_{t-1}^2) \qquad (7)$$

For the asymmetric effect to hold, then,$\tau < 0$ implying that negative shocks increases volatility more than positive shocks of the same magnitude. If the sign is positive and statistically significant, that suggests positive shocks lead to higher volatility than negative shocks of the same magnitude. However, if the parameter is not statistically significant then the model is symmetric. The TGARCH model is a modification of equation (6) by the inclusion of the dummy variable I_{t-1}.

$$\sigma_t^2 = \alpha + \beta\varepsilon_{t-1}^2 + \gamma\sigma_{t-1}^2 + \ \vartheta\varepsilon_{t-1}^2 I_{t-1} \tag{8}$$

where $I_{t-1} = 1$ if $\gamma_{t-1} > 0$ and 0 otherwise. Hence, there is evidence of asymmetric effect if $\vartheta < (>)0$ which implies that positive (negative) shocks reduce the volatility of r_t by more than negative (positive) shocks of the same magnitude.

4.0 Analysis and Discussion of Results

4.1 Descriptive statistics

Table 1 below presents the descriptive statistics for exchange rate returns in both markets covering the entire period under investigation. There appears to be an evidence of significant variations in exchange rate as shown by the large difference between the minimum and maximum values for both markets. On the statistical distribution of exchange rate, both official and BDC rates show evidence of positive skewness for all the sample period, suggesting that the right tail was predominant. In relation to kurtosis, the BDC exchange rate is leptokurtic while the official exchange rate is platykurtic. Lastly, the study discovered that exchange rate is not normally distributed in both markets judging by the Jarque Bera (JB) statistic.

Table 1: Descriptive Statistics of BDC and Interbank Market Exchange Rate Returns

	R_BDCEXR	R_IFEXR
Mean	0.0053	0.0048
Median	0.0000	0.0000
Maximum	0.1448	0.2398
Minimum	-0.1748	-0.0340
Std. Dev.	0.0374	0.0278
Skewness	0.2471	5.7986
Kurtosis	8.3545	41.6440
Jarque-Bera (prob.)	201.1984 (0.0000)	11327.1600 (0.0000)
Observations	166	166

Source: Author's computation

An analysis of the trend of the exchange rate in the BDC and interbank markets in Nigeria is presented in Figures 1 and 2. Figure 1 depicts the trends of returns in the Bureau de Change (BDC) market and the underlying data. The trajectory of Figure 1 presents an apt picture of instability of exchange rate. The Figure portends traits of volatility clustering; these are periods of high volatility shadowed by that of relatively low volatility. This reflection supports the evidence in Table 1 thus demonstrating that volatility is highest in 2008 and around 2016 which coincided with the global financial crises and the fall in global oil price that affected the Nigerian economy. Indeed, as a consequence of the structure of the economy that depends mainly on crude oil for foreign exchange, the economy fell into recession by second quarter of 2016.

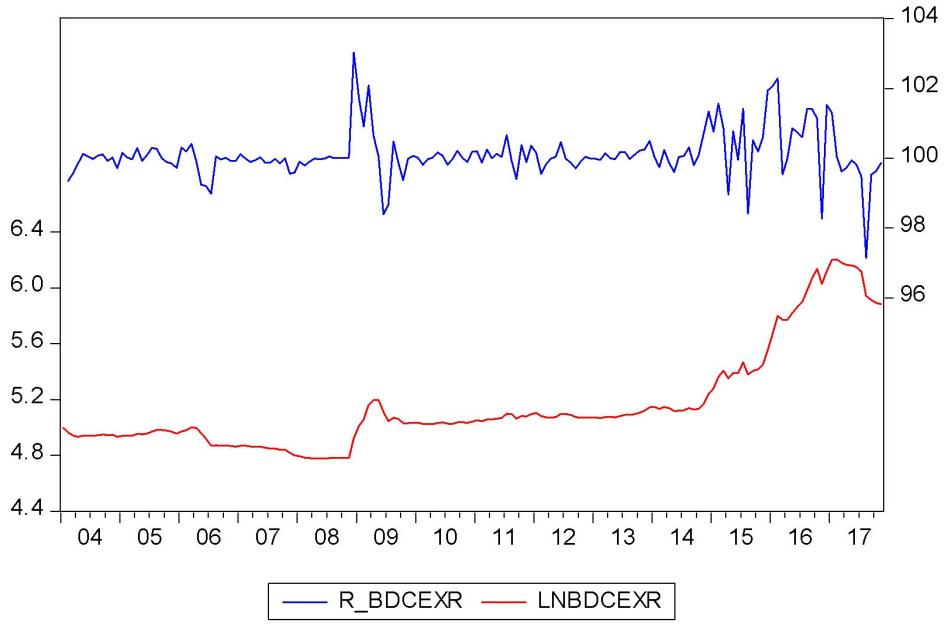

Figure 1: Graph of BDC Exchange Rate Returns

Figure 2 shows the dynamics of the returns in the interbank foreign exchange market and its underlying data. The behaviour of the interbank market exchange rate is also unsteady similar to the observed trend in Figure 1. As seen in the figure below, the volatility is highest in 2016.

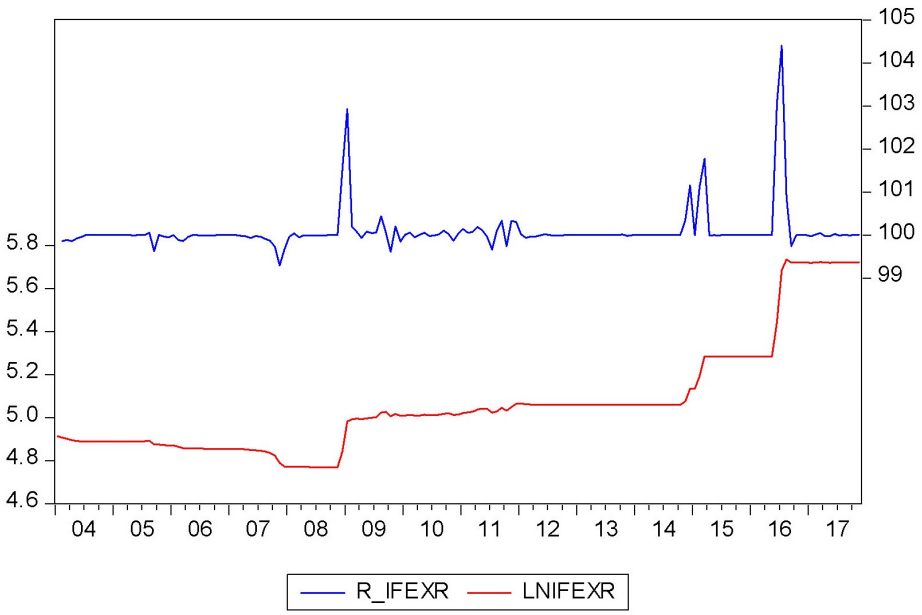

Figure 2: Graph of Interbank Exchange Rate Returns

4.2 Structural Break Test

Table 2: Bai-Perron Multiple Structural Breaks Test Results

Variable	T_1		T_2		**NSB**
	$\sup F_T(\ell+1\|\ell)$	**Break Date(BD_1)**	$\sup F_T(\ell+1\|\ell)$	**Break Date(BD_2)**	
R_BDCEXR	10.37	09/2016	14.07	11/2016	2
R_IFEXR	59.53	12/2014	93.60	01/2015	2

Note: NSB denotes number of significant structural breaks. The $\sup F_T(\ell+1|\ell)$ test statistic for the breaks are reported in Table 2 above. The critical values for $\sup F_T(\ell+1|\ell)$ at 10% level of significance as obtained from the Bai and Perron (2003) paper are 7.04 and 8.51 respectively for $\ell = 1, 2$.

Presented in Table 2 above are the results of the structural break test prompted by the notable indication of shifts in the historical movements of exchange rates in both the BDC and interbank exchange rate markets (see Figures 1 and 2). In essence, we follow the Bai and Perron multiple structural breaks test to determine significant structural shifts in the movement of the series. Our choice of Bia-Perron (2003) in determining the breaks is hinged on the

fact that it allows for a maximum of five structural breaks in time series (see Narayan and Liu, 2015). The test also involves a sequential application of $\sup F_T(\ell+1|\,\ell)$test which is assumed to work best in selecting the number of breaks. The results of the structural break using Bai-Perron (2003) shows that the exchange rates (nonetheless the market under consideration) exhibit at least two significant structural breaks. Interestingly, the breaks particularly for the interbank exchange rate seem to have coincided with the period of depreciation in the country's exchange rate which may be linked to the recent precipitous movement in the international crude oil prices. Consequently, the identified break dates in the case of the BDC exchange rate may be traceable to the period of significant response of the market to shocks due to monetary policy intervention to mitigate the depreciation of the exchange rate which was due to fall in crude oil prices.

4.3 ARCH LM test

Essentially, Engle (1982) proposes three steps for the implementation of ARCH test: the first step is to estimate equation (3) by OLS and obtain the fitted residuals; the second step is to regress the square of the fitted residuals on constant and lags of the squared residuals, i.e., estimate equation (9) below:

$$\hat{\varepsilon}_t^2 = \rho_0 + \rho_1\hat{\varepsilon}_{t-1}^2 + \rho_2\hat{\varepsilon}_{t-2}^2 + \cdots + \rho_p\hat{\varepsilon}_{t-p}^2 + \mu_t; \tag{9}$$

and the third and final step is to use the LM test option to evaluate the validity or otherwise of the null hypothesis of no ARCH effects, $H_0 : \rho_1 = \rho_2 = \cdots = \rho_p = 0$

Table 3: ARCH LM test results

BDC Exchange Rate			
F-statistic	13.318	Prob. F(1,163)	0.000
Obs*R-squared	12.468	Prob. Chi-Square(1)	0.000
Interbank Exchange Rate			
F-statistic	26.288	Prob. F(1,163)	0.000
Obs*R-squared	22.933	Prob. Chi-Square(1)	0.000

Table 3 presents results of the ARCH effects for the BDC and interbank exchange rate. In the case of BDC exchange rate, the Obs*R-squared statistic which is Engle's LM test statistic shows a value of 12.468 and has a probability limit of 0.000. Similarly, obs*R-squared for interbank exchange rate is 22.933 and has a probability limit of 0.000. This clearly suggests that we reject the null hypothesis of homoscedasticity and confirm the presence of ARCH effects in the BDC exchange rate and the interbank market exchange rate series. We can conclude that exchange rates in both interbank and BDC exchange markets exhibit ARCH effects. Thus, this necessitates the modelling of exchange rate volatilities under symmetric and asymmetric scenarios in both markets for better understanding of exchange rate dynamics for meaningful policy formulation and investment decisions.

4.4 Discussion of Results

The discussion here focuses on the GARCH models. Given the evidence of ARCH effects in the series, the estimation proceeds with the implementation of the symmetric GARCH(1,1) model in equation (7) and subsequently considers the variants of asymmetric models specified in equations (8) and (9), respectively in each market. The subsequent discussion is twofold. First, the models with a better fit is determined. Model selection criteria such as the Schwartz Information Criterion (SIC), Akaike Information Criterion (AIC) and Hannan-Quinn Information Criterion (HQC) were used to decide the model with the best fit. Fitness of models is typically determined using the Rsquared and adjusted Rsquared but these are flawed with over-fitting and loss of degrees of freedom. Thus, in this study, we chose the SIC in the two markets for ease of interpretation. Within each market also, the extent of volatility persistence and asymmetry were also discussed.

4.4.1 Volatility persistence and asymmetry of BDC exchange rate

The discussion here focuses on results of different volatility models with structural breaks presented in Table 4 below. Volatility persistence measures the period of time required for volatility in the market to dissipate or decay and it is computed by the sum of the coefficients of ARCH and GARCH effects.

In the BDC exchange rate market, the sum of the coefficients in the GARCH and TGARCH models is greater than one (1.77, 1.20, respectively) while persistence in the EGARCH (1, 1) model (0.91) is also close to one. The results indicate that EGARCH model has high persistence while GARCH and TGARCH are both highly explosive. However, there is an indication of greater explosive level of persistence under GARCH model with structural breaks compared to the TGARCH model.

Following standard inferences from the literature, it suggests that there is greater indication of explosive level of persistence in the BDC market. This clearly lends support for the generalization of persistence by other studies such Bala and Asemota (2013), Emenike and Peter (2016) Clement and Samuel (2011), in the exchange rate market. In comparing the performance of the volatility models in the BDC market, the TGARCH(1,1) model appears to provide a better fit over the GARCH(1,1) and EGARCH (1,1) models as judged by the SIC value.

The answer to the question as to whether BDC exchange is more volatile after bad or good news (negative or positive shocks) is provided by the sign and significance of the coefficients of asymmetry in the TGARCH model. The coefficient of asymmetry for TGARCH (1,1) in Table 4 is negative and statistically significant, but only at the 10 percent level. This suggests that in the BDC market, negative shocks have the penchant of reducing volatility more than positive shocks of the same magnitude. In other words, bad news in the exchange rate markets has more propensity of increasing exchange rate volatility in the BDC market than good news.

Table 4: Estimation results of Volatility Models with two structural breaks for BDC

Variable	GARCH (1,1)	TGARCH (1,1)	EGARCH (1,1)
Mean equation			
	-0.00048*	-0.00049	$3.68x10^{-6}$
η	(0.00012)	(0.00034)	(0.00023)
δ	0.02629*	0.08856**	0.2709*
	(0.00864)	(0.03560)	(0.0368)
α_1	0.08283	0.0777*	0.0620
	(1.35268)	(0.00483)	(0.1538)
α_2	-0.01064**	-0.01199*	-0.0102*
	(0.00457)	(0.00221)	(0.0018)
Variance equation			
α	0.000109**	$5x10^{-5*}$	-0.7648**
	$(4.64x10^{-5})$	$(1.41x10^{-5})$	(0.306)
β	1.46796	0.5657	-
	(0.91603)	(0.351)	
γ	0.31086***	0.6412*	0.9094*
	(0.17631)	(0.039)	(0.035)
ϑ	-	-0.5894***	-
		(0.3481)	
ψ	-	-	0.1055
	-		(0.1345)
τ	-	-	0.3422**
			(0.1373)
Persistence	1.779	1.207	1.015
Observations	167	167	167
AIC	-4.965	-5.063	-4.906
SIC	-4.814	-4.894	-4.737
HQC	-4.904	-4.995	-4.837
ARCH LM			
F Stat.(prob.)	0.968	0.968	0.970

Note: *, **, *** indicate 1%, 5% and 10% levels of significance, respectively. Standard errors are reported in the parenthesis

4.4.2 Volatility persistence and asymmetry of interbank exchange rate

Persistence in the interbank exchange rate market as shown in Table 5 indicates moderate to high persistence especially in the TGARCH (0.74) and EGARCH (0.72) models. The GARCH model has a persistence of 1.49, which suggests an explosive persistence. However, on the whole, the results suggest that the BDC exchange rate market is more persistent than the interbank exchange rate market. In terms of the performance of the volatility models, the symmetric model, GARCH(1,1), proved to have a better fit based on the SIC value. This indicates that participants in the interbank foreign exchange market do not respond to news differently.

In summary, the TGARCH provides better insight into the impact of news on the exchange rate returns volatility in the BDC market while the interbank seems to be unresponsive (or less responsive) to news. The results may

not be unsurprising based on the structure of these markets. These results further confirm the responses of the markets to news and indeed, to market forces as determined by the participants. The BDC market is adjudged to be more market driven, hence its ostensible asymmetric reaction to news.

As a follow up to the pre-estimation test that confirms the presence of ARCH effects in the foreign exchange markets, the study also provides post-estimation diagnostic test using the F-test. Adjudging by the probability values of the models in the two markets we could not reject the null hypothesis of no ARCH effects in the BDC and the interbank markets (with and without structural breaks). All the values were statistically insignificant at 5% and 1% levels of significance.

Table 5: Estimation results of Volatility Models with two structural Breaks for interbank

Variable	GARCH (1,1)	TGARCH (1,1)	EGARCH (1,1)
Mean equation			
η	$2.17\text{x}10^{-8}$ $(2.88\text{x}10^{-8})$	-0.00014^{*} $(5.13\text{x}10^{-6})$	$3.41\text{x}10^{-5*}$ $(4.83\text{x}10^{-7})$
δ	0.000287 (0.0004)	0.479^{*} (0.0067)	0.3847^{*} (0.0167)
α_1	0.0588 (283.477)	0.0508 (0.0034)	0.0522^{*} (0.008)
α_2	$-7.16\text{x}10^{-9*}$ $(1.53\text{x}10^{-9})$	0.00014^{*} $(1.83\text{x}10^{-5})$	$-5.36\text{x}10^{-5*}$ $(1.6\text{x}10^{-5})$
Variance equation			
α	$3.82\text{x}10^{-5}$ $(3.09\text{x}10^{-5})$	0.0003 (0.0005)	-2.9848^{*} (1.0008)
β	0.8750 (0.830)	0.2571 (0.3049)	-
γ	0.6130 (0.1500)	0.4864 (0.6115)	0.7261^{*} (0.097)
ϑ	-	-0.4852 (0.8312)	-
ψ	- -	-	1.7858^{*} (0.5862)
τ	-	-	-1.3495^{**} (0.5277)
Persistence	1.488	0.743	0.726
Observations	167	167	167
AIC	-9.405	-8.5149	-9.003
SIC	-9.255	-8.3455	-8.834
HQC	-9.344	-8.4461	-8.934
ARCH LM test(2)			
F-test(Prob)	0.997	0.5782	0.988

Note: *, ** indicate 1% and 5% levels of significance, respectively. Standard errors are reported in the parenthesis

5.0 Conclusion and Policy Implications

The specific objective of this study was to model volatility persistence and asymmetry of Naira-Dollar exchange rates in both BDC and Interbank markets using monthly data between January 2004 and November 2017. The essence of volatility in exchange rate is to provide useful information to participants in the market with respect to uncertainty or risk in the market. The investors are more interested in the stability of exchange rate before investing in the host country. The implication of fluctuation in the exchange rate suggests huge losses (gains) to the investors and thus, low return on investment may be detrimental to both investors and economy as a whole. For the profit maximizing and risk averse agents/investors, the occurrence of high volatility persistence may shape the investment decision in the area of portfolio diversification to less risky assets. Therefore, modelling volatility persistence and asymmetry is critical to policymakers and thus motivating the study. The contribution of this paper is twofold. First, we employed Bai-Perron Multiple Structural Breaks Test which gives opportunity for determining more than one structural break from BDC and Interbank markets. Second, we augmented for the latter in both symmetric and asymmetric models.

Based on our model selection criteria, the symmetric GARCH model, appeared to be better than the asymmetric ones in dealing with exchange rate volatility in interbank markets while asymmetric GARCH, especially TGARCH, appeared to be better in the case of BDC market whether structural breaks are accommodated in the models or not. These findings revealed evidence of asymmetric effects in both markets. In addition, the persistence in the BDC market was largely moderated after the shocks (i.e. structural breaks) compared to interbank market where the persistence was not explosive especially under asymmetric models. These results tend to suggest the need to account for market differences when designing appropriate exchange rate policies for the country as the market participants respond differently to developments in the markets. This will go a long way in aligning the exchange rate in the two markets for proper investment decision making and policy formulation. Finally, shocks to exchange rate need to be subdued

through sufficient reserves accumulation to absorb any unforeseen shocks to the exchange rate structure.

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Modeling Volatility Persistence and Asymmetry with Exogenous Breaks in the Nigerian Stock Returns

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This study examines the volatility persistence and asymmetry with exogenous breaks in Nigerian stock market. The study utilizes daily closing quotations of stock prices from the Nigerian stock exchange for the period 3rd July, 1999 to 12th June, 2017. Standard symmetric GARCH (1,1), asymmetric EGARCH (1,1) and GJR-GARCH (1,1) models with and without structural breaks were employed to measure shocks persistence and leverage effects in the presence of varying distributional assumptions. The empirical findings showed high persistence of shocks in the return series for the estimated models. However, the study found significant reduction in shocks persistence when structural breaks were incorporated in the estimated models. Empirical evidence for the existence of asymmetry without leverage effect was found in Nigerian stock market. The EGARCH (1,1) model with student-t innovation density was found to fit the data better than other competing models. The study recommends the incorporation of structural breaks while estimating volatility in the Nigerian stock market. This will help to avoid over-estimation of volatility shocks and restore investor's confidence in the stock market.

Keywords: Asymmetry; GARCH Family Models; Leverage Effect; Nigeria; Shock Persistence; Volatility.
JEL Classification: C22, C32, C52.

1.0 Introduction

Volatility modeling of stock market returns has been gaining great interest by financial markets participants, academia, financial analysts and the general public. Volatility measures the uncertainty and risk which play significant role in modern financial analysis. Measuring and predicting volatility is crucial for financial decision making and has significant applications in areas such as portfolio selection, option pricing, risk management, hedging and strategic pair-trading as well as Value-at-Risk (VaR) estimation.

Providing accurate volatility estimates in Nigeria market avails regulators,

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government, traders and investors the opportunity to formulate better policies and make appropriate financial investment decisions. However, the accuracy of volatility estimates and the precision of interval forecast is compromised if structural breaks are ignored (Orabi and Alqurran, 2015; Adewale et al., 2016; Kuhe and Chiawa, 2017). Studies conducted by Perron (1989, 1990)); Diebold and Inoue (2001); Yaya, Gil-Alana and Shittu (2005), among others, revealed that when stationary processes are contaminated with structural breaks, the sum of Autoregressive Conditional Heteroscedasticity (ARCH) and Generalized ARCH (GARCH) terms are always biased to unity. It is therefore, reasonable to incorporate these sudden shifts in variance when modeling and estimating parameters of volatility models. In our opinion, if the causes of shocks in stock prices are identified and accounted for, it will yield more reliable and accurate volatility estimates, this could also help in making good financial reforms that may have positive impacts and direct bearing on financial institutions and the economy.

This paper discusses some of the modern methods of modeling and estimating volatility of stock returns with application on daily financial time series from the Nigerian stock market. One of the important aspects that must be put into consideration while modeling volatility of financial time series data such as stock returns is that such series exhibits some regular patterns called statistical regularities or stylized facts which are well recognized and documented in the literature and which are crucial for correct model specification and parameter estimation. The objectives of this study are therefore in twofolds: (i) to examine the persistence of shocks and asymmetric response in the Nigerian stock market; (ii) to investigate the impact of exogenous breaks on the conditional variance in Nigerian stock returns. This study shall employ Bai and Perron multiple structural breakpoints testing procedure that detects breakpoints in the entire data set of the Nigerian stock returns. Once the breakpoints are detected, they can be accounted for by creating an indicator variable which takes the value zero for stable and one for unstable regimes. These breakpoints will be incorporated in the variance equation of all symmetric and asymmetric GARCH models to avoid over persistence of

volatility shocks in the conditional variance.

The rest of the paper is organized as follows: Section 2 reviews relevant literature on the subject matter, Section 3 presents data and methodology; Section 4 discusses results of empirical findings while Section 5 hinges on conclusion and policy implications.

2.0 Literature Review

Modeling volatility of stock market return series using time varying GARCH models proposed by Engle (1982), Bollerslev (1986) and extended by Nelson (1991), Glosten et al. (1993), Ding et al. (1993), Zakoian (1994), etc. has been gaining attention in recent times by policy makers, academics, financial analysts and researchers among others. This is partly as a result of the fact that GARCH family models have been more successful in capturing stylized facts (statistical regularities) of financial time series such as volatility clustering, volatility shock persistence, volatility mean reversion, leverage effect and risk premium among others; and partly because volatility is an important concept for many economic and financial applications such as risk management, option trading, portfolio optimization and asset pricing. The prices of stocks and other assets depend on the expected volatility of returns. As part of monitoring risk exposure, banks and other financial institutions make use of volatility assessments (Engle and Patton, 2001).

Recent studies have shown that estimates of stock returns volatility are considerably affected by sudden structural breakpoints or sudden regime shifts which occur as a result of domestic and external shocks(Kumar and Maheswaran, 2012).

Many scholars have documented evidence relating to volatility models in the presence of structural breaks across developed and emerging economies. Lamoureux and Lastrapes (1990) found out that not incorporating structural breakpoints in the conditional variance while modelling volatility increases persistence of volatility shocks whereas incorporating the sudden shifts in

conditional variance reduces the persistence of shocks in volatility models. In a similar vein, Malik et al. (2005) investigated the persistence of volatility shocks on the Canadian stock data using heteroskedastic models. Results showed reduction in shocks persistence in volatility when structural break points were incorporated in the conditional variance while estimating volatility. Hammoudeh and Li (2008) also found significant decrease in volatility shock persistence when valid sudden shifts in variance were incorporated while predicting volatility in Gulf Arab countries stock markets. Muhammad and Shuguang (2015) investigated the impact of random level shifts in conditional volatility and variance persistence of GARCH family models while employing Bai and Perron multiple breakpoints test procedure to detect structural breakpoints in conditional variance of daily stock returns of 7 emerging markets from 1977 to 2014. They estimated asymmetric EGARCH (1,1) and TGARCH (1,1) with and without breaks and found that persistency in the conditional variance significantly reduced when level shifts were considered in the conditional volatility of these models. The half-lives to shocks were also found to decline significantly in the presence of these sudden break points.

In emerging economies like Nigeria, empirical evidence relating to volatility modeling with structural breaks are also documented in the literature. For example, Dikko et al. (2015) modeled abrupt shift in time series using dummy variable by employing both symmetric and asymmetric GARCH models with and without sudden shifts in variance. They used daily quotations of 10 insurance stocks of the Nigerian stock exchange from 02/01/2006 to 26/05/2014. They found significant reduction in shock persistence in volatility of most insurance stock returns when the regime shifts were incorporated into the models. Bala and Asemota (2013) employed GARCH models with and without breaks to examine the volatility of exchange rate of naira against US Dollar, British Pounds and European Euro using monthly exchange rate data. There was high persistence of shocks in all the models, although the introduction of structural breakpoints improved the volatility estimates by reducing shock persistence in most of the estimated models.

Asymmetric property was not evidenced in most estimated models. Salisu and Fasanya (2012) examined the relative performance of symmetric and asymmetric GARCH models for West Texas Intermediate (WTI) daily closing oil prices by considering the pre-crises, during crises and the post global financial crisis periods. The WTI oil stock price was found to be most volatile during the financial crises period than other sub-periods. Asymmetric models found empirical evidence for the existence of leverage effects and were found superior over the symmetric GARCH model. The study concluded that ignoring these effects in modeling oil price volatility will lead to misleading results and serious biases.

Adewale et al. (2016) investigated shock persistence and asymmetry in Nigerian stock market by incorporating structural breaks using monthly stock returns for the period from January 1985 to December 2014. They segmented the study period into pre-structural break period and after break period having identified breakpoints in the series. Result from the basic GARCH model showed higher shock persistence during pre-break sub-period than the post-break sub-period. No evidence of asymmetry or leverage effect was found in the asymmetric GARCH model with or without incorporating the breakpoints in Nigerian stock market. Recently, Fasanya and Adekoya (2017) investigated the performances of different GARCH models while estimating the volatility of headline and core CPI inflation in Nigeria for the period 1995M01 to 2016M10 using ADF breakpoint testing procedure. They applied both symmetric and asymmetric GARCH variants and observed empirical evidence of shock persistence in both CPI stock returns with the presence of leverages only in the headline CPI return series. The authors concluded that ignoring the role of structural breaks in estimating the volatility of inflation rate in Nigeria will amount to misleading policy prescriptions.

Gil-Alana et al. (2015) employed fractional integration and structural break procedures in studying the daily share prices of the Nigerian banking sector between 2001 and 2012. The results obtained through parametric and semi-parametric methods indicated little evidence of mean reversion in the return

series. There was evidence of long memory in the absolute and squared return series. The presence of structural breaks was also evident with the number of breaks depending on the bank examined. The breaks which were more noticed in the month of December 2008 relating to the global financial crisis also affected the Nigerian banking sector. Kuhe and Chiawa (2017) examined the impact of structural breaks on the conditional variance of daily stock returns of 8 commercial banks in Nigerian stock market for the period 17th February, 2003 to 31st September, 2016. They employed symmetric GARCH, asymmetric EGARCH and TGARCH models with and without dummy variables to evaluate variance persistence, mean reversion, asymmetry and leverage effects. Results showed high persistence in conditional volatility for the banking stocks when the shift dummies were ignored, but when the random level shifts were incorporated into the models, there was reduction in the conditional volatility of these models. The half-lives of volatility shocks also reduced in the presence of regime shifts.

From the reviewed literature, it is glaring that authors who examined shock persistence in conditional variance in Nigerian stock market in the presence of exogenous breaks using either daily or monthly all share index (ASI) from Nigerian stock exchange segmented the data into sub-periods either as pre-crises period (pre-breaks), during crises period (break period) and post crises period (post breaks period). However, it is not only the well-known banking reform of 2004 in Nigeria and the global financial crises which started from 2007 to 2009 that can affect the Nigerian stock market. Other internal factors can also affect the stock market (Muhammad and Shuguang, 2015). This study therefore, extends the existing literature by investigating the symmetric and asymmetric responses in shocks persistence on the conditional variance of daily stock return of Nigerian stock market using both symmetric and asymmetric GARCH type models with and without structural breakpoints with more current data. This study uses methodology slightly different from the ones mentioned in the literature as it employs Bai and Perron multiple breaks testing procedure that detects breakpoints in the entire data set of the Nigerian stock returns. Once the breakpoints are detected, they are ac-

counted for by creating an indicator (dummy) variable which takes the value zero for stable and one for unstable economy which is incorporated in the variance equation of all GARCH models to avoid over persistence of shock in the conditional variance.

3.0 Data and Methodology

3.1 Data

The data used in this research work are the daily closing all share index (ASI) of the Nigerian Stock Exchange (NSE) obtained from www.nse.ng.org for the period 03/07/1999 to 12/06/2017 making a total of 4726 observations. The daily returns r_t are calculated as:

$$r_t = 100. \ln \Delta p_t \tag{1}$$

where r_t denotes the stock return series, Δ is the first difference operator and P_t denotes the closing market index at the current day (t).

3.2 Ng and Perron (NP) modified unit root test

To check the stationarity properties of the daily stock prices and returns, Ng and Perron modified unit root test is employed because of its good power property. Ng and Perron (2001) constructed four test statistics which are based on the Generalized Least Squares detrended series $Y_t{}^d$.The four test statistics are the modified forms of Phillips and Perron Z_α and Z_t statistics, the Bhargava (1986) R_1 statistic, and the Elliot, Rothenberg and Stock Point Optimal statistic (Elliot et al., 1996). First, define the term:

$$k = \sum_{t=2}^{T} \frac{(Y_{t-1}^d)^2}{T^2} \tag{2}$$

The four modified statistics are then written as,

$$MZ_\alpha^d = (T^{-1}(Y_T^d)^2 - f_0)/(2K)$$

$$MZ_t^d = MZ_\alpha \times MSB$$

$$MSB^d = (k/f_0)^{0.5}$$

$$MP_T^d = \left\{ \begin{array}{ll} \left(-7^2k + 7T^{-1}\left(Y_T^d\right)^2\right)/f_0 & \text{if } x_t = \{1\} \\ \left(-13.5^2k + (1+13.5)\,T^{-1}\left(Y_T^d\right)^2\right)/f_0 & \text{if } x_t = \{1,t\} \end{array} \right\} \quad (3)$$

where $MZ_\alpha{}^d$ is the modified detrended Z_α transformation of the standardized estimator given by:

$$T(\hat{\alpha}-1) = \{T^{-1}\sum_{t=1}^{T}(y_t - y_{t-1})\}/\{T^{-1}\sum_{t=1}^{T}y_t^2 - 1\} \quad (4)$$

MZ_t^d is the modified detrended Z_t transformation of the conventional regression t statistic defined by:

$$t_\alpha = (\sum_{t=1}^{T} y_{t-1}^2)^{\frac{1}{2}}(\hat{\alpha}-1)/s \quad (5)$$

where

$$s^2 = T^{-1}\sum_{t=1}^{T}(y_t - \hat{\alpha}y_{t-1})^2 \quad (6)$$

MSB is the modified Bhargava R_1 statistic (Stock, 1990). The R_1 statistic is given by:

$$R_1 = \sum_{t=2}^{T}(y_t - y_{t-1})^2 / \sum_{t=1}^{T}(y_t - \bar{y})^2; \bar{y} = \frac{1}{T}\sum_{t=1}^{T} y_i \quad (7)$$

MP_T^d is the ERS modified detrended point optimal statistic (Elliot et al., 1996). The point optimal statistic is given as:

$$P_T = \frac{[S(\hat{\alpha}) - \hat{\alpha}S(1)]}{s^2} \quad (8)$$

Y_T^d is the trended series, x_t is a series of observations at time t, f_0 is the frequency zero spectrum define as:

$$f_0 = \sum_{j=-(T-1)}^{T-1} \hat{\gamma}(j).K(\frac{j}{l}) \quad (9)$$

Where l is a bandwidth parameter, T is the sample size, K is a kernel function and $\hat{\gamma}(j)$ is the $j-th$ sample autocovariance of the residuals $\hat{u}_t$ and is given by:

$$\hat{\gamma}(j) = \sum_{t=j+1}^{T} (\hat{u}_t \hat{u}_{t-j})/T \tag{10}$$

The MZ_α,MZ_t,MSB and MP_T statistices are collectively referred to as M tests and are used in detecting the presence of unit root in a series (Ng and Perron, 2001). In addition to the MZ_α and MZ_t statistics, Ng and Perron also investigated the size and power properties of the MSB statistic. Critical values for the demeaned and detrended case of this statistic were taken from Stock (1990).

3.3 Test for Heteroskedasticity

Test for heteroskedasticity (or ARCH effect) was conducted using the Lagragian Multiplier test proposed by Engle (1982). The test checks the pair of hypotheses $H_0 : \rho_1 =...= \rho_m$ versus $H_1 : \rho_1 \neq 0$ for some $i\varepsilon\{1, \ldots, m\}$. The F-statistic is estimated as:

$$F = \frac{SSR_0 - SSR_1/m}{SSR_1(n-2m-1)} \tag{11}$$

where,

$$SSR_1 = \sum_{t=m+1}^{T} e_t^2, SSR_0 = \sum_{t=m+1}^{T} (a_t^2 - \varpi)^2 and\ \varpi = \frac{1}{n}\sum_{t=1}^{T} a_t^2 \tag{12}$$

$\hat{e}_t$ is the residual obtained from least squares linear regression, ϖ is the sample mean of a_t^2. The ARCH LM test statistic is distributed asymptotically as chi- square distribution with m degrees of freedom under the H_0. The decision is to reject the null hypothesis of no ARCH effect in the residuals if the p-value of F-statistic is less than $\alpha = 0.05$.

3.4 Bai and Perron Multiple Breakpoints Test

Bai and Perron(1998) developed a multiple structural breakpoints testing

procedure which predict persistently several shifts in variance. The power of the test was strengthened by Bai and Perron (2003) which made the test more efficient. The model considered is the multiple linear regression model with m breaks or $m + 1$ regimes.

$$y = x_i^T \beta_i + u_t \tag{13}$$

$$y_i = x_i^T \beta + z_i^T \delta + u_t \tag{14}$$

where $u_i \sim$ iid(0,σ^2),$i = 1, 2, 3, \ldots, n$ and y_i is the response variable at time i and $x_i = [1, x_{i2}, x_{i3}, \ldots, x_{ik}]^T$ is a vector of order $k \times 1$ of independent variables having one as its initial value and β_i is also $k \times 1$ vector of coefficients.

The hypothesis for random level shift is:$H_0 : \beta_i = \beta_0$ for $i = 1, 2, 3, \ldots, n$ (i.e., there is no structural break in the series) versus alternative that with the random level shift in time the vector of coefficients also changes, also assuming that they have no stochastic behaviour as a departure from the null hypothesis. i.e.,

$$\|x_i\| = O(1) \text{ and that } \frac{1}{n}\sum_{i=1}^{n} x_i x_i^T \to Z$$

where Z represents a finite matrix. This expression permits the detection of multiple breakpoints in data and once the breakpoints are recognized, they will be incorporated into each GARCH model in order to avoid spurious results. This same procedure is implemented in this study to detect multiple break points in the given stock return series before moving forwards.

3.5 Model Specification

The following conditional heteroskedasticity models are specified for this study.

3.5.1 The Autoregressive Conditional Heteroskedasticity (ARCH) Model

The ARCH model was first developed by Engle (1982). For the log return

series (r_t), the ARCH (p) model is specified as:

$$r_t = \mu + \varepsilon_t \tag{15}$$

$$\varepsilon_t = \sqrt{h_t u_t}, \quad u_t \sim N(0,1) \tag{16}$$

$$h_t = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 \tag{17}$$

where r_t is the return series, ε_t is the innovation or shock at day t which follows heteroskedastic error process, μ is the conditional mean of (r_t), h_t is the volatility (conditional variance) at day t and ϵ_{t-1}^2 is the square innovation at day $t-i$. For an ARCH (p) process to be stationary, the sum of ARCH terms must be less than one (i.e., $\sum \alpha_i < 1$).

3.5.2 The Generalized Autoregressive Conditional Heteroskedasticity (GARCH) Model

The ARCH model was extended by Bollerslev (1986) called Generalized Autoregressive Conditional Heteroskedasticity (GARCH) Model. Assuming a log return series $r_t = \mu + \varepsilon_t$ where ε_t is the error term at time t.The ε_t follows a GARCH (1,1) model if:

$$h_t = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} \tag{18}$$

with constraints $\omega > 0$,$\alpha_1 \geq 0$ and $\beta_1 \geq 0, j = 1$;$\alpha_1 + \beta_1 < 1$ to ensure conditional variance to be positive as well as stationary. The basic GARCH (1,1) model is adequate in capturing all volatility in any financial time series. The GARCH (1,1) model with dummy variable in the conditional variance is specified as:

$$h_t = \omega + \phi_1 D_1 + ... + \phi_n D_n + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} \tag{19}$$

where $D_1,\ldots,D_n$ are dummy variables added to the conditional variance equation which takes value 1 as the sudden break appears in conditional volatility onwards and otherwise it takes value 0.

3.5.3 The Exponential GARCH (EGARCH) Model

The EGARCH model was extended by Nelson (1991) to capture asymmetric effects between positive and negative stock returns. The conditional variance equation for EGARCH (1,1) model specification is given as:

$$\ln(h_t) = \omega + \alpha_1 \mid \frac{\varepsilon_{t-1}}{h_{t-1}} \mid + \gamma[\frac{\varepsilon_{t-1}}{h_{t-1}}] + \beta_1 \ln(h_{t-1}) \tag{20}$$

where γ represents the asymmetric coefficient in the model, β_1 coefficient represents the measure of shock persistence.Asymmetry exists if $\gamma \neq 0$, there is leverage effect if $\gamma < 1$. The EGARCH (1,1) model with dummy variable in the conditional variance is specified as:

$$\ln(h_t) = \omega + \phi_1 D_1 + ... + \phi_n D_n + \alpha_1 \mid \frac{\varepsilon_{t-1}}{h_{t-1}} \mid + \gamma[\frac{\varepsilon_{t-1}}{h_{t-1}}] + \beta_1 \ln(h_{t-1}) \tag{21}$$

where D_1,...,D_n are the dummy variables which take the value 1 for each point of sudden change in variance onwards and 0 otherwise.

3.5.4 Threshold GARCH (GJR-GARCH) Model

The GJR-GARCH model was extended by Glosten, Jaganathan and Runkle, (1993). The generalized specification of GJR-GARCH (1,1)model for the conditional variance is given by:

$$h_t = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} + \gamma \varepsilon_{t-1}^2 I_{t-1}^- \tag{22}$$

where I_{t-1}^- if $\varepsilon_{t-1} < 0$ and 0 otherwise. In GJR-GARCH model, good news is given by $\varepsilon_{t-1} > 0$, and bad news is given by $\varepsilon_{t-1} < 0$. Good news has impact of α_1, while bad news has an impact of $\alpha_1 + \gamma$. If $\gamma > 0$, bad news produces more volatility, an indication of leverage effect. If $\gamma \neq 0$, the impact of news is asymmetric. The GJR-GARCH (1,1) model with dummy variable in the conditional variance is specified as

$$h_t = \omega + \phi_1 D_1 + ... + \phi_n D_n + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 (h_{t-1}) + \gamma \epsilon_{t-1}^2 I_{t-1}^- \tag{23}$$

where $D_1, \ldots, D_n$ are the dummy variables which take the value 1 for each point of sudden change in variance onwards and 0 otherwise. Lastrapes

(1989) and Lamoreux and Lastrapes (1990) argued that when relevant random level shifts in variance are ignored in the standard GARCH variants, they tend to overestimate the persistence in volatility. Thus given the modified GARCH models which take these breakpoints identified by Bai and Perron multiple breakpoint test into consideration, the shock persistence (i.e., $\alpha_1 + \beta_1$) is predicted to be smaller than that found by the conventional GARCH models.

3.5.5 Estimation and Distributional Assumption of GARCH family Models

The estimates of GARCH process are obtained by maximizing the log likelihood function:

$$\ln(L\theta_t) = -\frac{1}{2}\sum_{t-1}^{T}(\ln 2\pi + \ln h_t + \frac{\varepsilon_t^2}{h_t}) \tag{24}$$

The five distributional assumptions employed in the estimation of parameters in this work are given by:

1. Normal (Gaussian) distribution (ND)is given by:

$$f(z) = \frac{1}{\sqrt{2\pi}} e^{\frac{-z^2}{2}}, \quad -\infty < z < \infty \tag{25}$$

and the normal distribution to the log likelihood for observation t is:

$$l_t = \frac{-\frac{1}{2}\log(2\pi) - \frac{1}{2}\log h_t - \frac{1}{2}(y_t - X_t'\theta)^2}{h_t} \tag{26}$$

2. The student- t distribution (STD) is given by

$$f(z) = \frac{\Gamma(\frac{v+1}{2})}{\sqrt{v\pi}\Gamma(\frac{v}{2})}(1 + \frac{z^2}{v})^{\frac{-(v+1)}{2}}; -\infty < z < \infty \tag{27}$$

and the student-t distribution to the log-likelihood contributions is of the form:

$$l_t = \frac{1}{2}\log\{\frac{\pi(v-2)\Gamma(\frac{v}{2})^2}{\Gamma(\frac{v+1}{2})}\} - \frac{1}{2}\log h_t - \frac{(v+1)}{2}\log\{1 + \frac{(y_t - X_t'\theta)^2}{h_t(v-2)}\} \tag{28}$$

where the degree of freedom $v > 2$ controls the tail behaviour. The t-distribution approaches the normal distribution as $v \to \infty$.

3. Skewed Student-t Distribution is given by:

$$f(z;\mu,\sigma,\nu,\lambda)=\begin{cases} bc\left(1+\frac{1}{v-2}\left(\frac{b\left(\frac{z-\mu}{\sigma}\right)+a}{1-\lambda}\right)^2\right)^{-\frac{v+1}{2}}, & \text{if } z<-\frac{a}{b} \\ bc\left(1+\frac{1}{v-2}\left(\frac{b\left(\frac{z-\mu}{\sigma}\right)+a}{1+\lambda}\right)^2\right)^{-\frac{v+1}{2}}, & \text{if } z\geq-\frac{a}{b} \end{cases} \tag{29}$$

where v is the shape parameter with $2<v<\infty$ and λ is the skewness parameter with $-1<\lambda<1$. The constants a,b and c are given as:

$$a=4\lambda c(\frac{v-2}{v-1}),\qquad b=1+3(\lambda)^2-a^2,\qquad c=\frac{\Gamma(\frac{v+1}{2})}{\sqrt{\pi(v-2)\Gamma(\frac{v}{2})}}$$

whereμ and σ^2 are the mean and variance of the skewed student-t distribution respectively.

4. The Generalized Error Distribution (GED) is given as:

$$f(z,\mu,\sigma,\nu)=\frac{\sigma^{-1}v\exp(-\frac{1}{2}\mid\frac{\frac{z-\mu}{\sigma}}{\lambda}\mid^v)}{\lambda 2^{(1+(1/v))}\Gamma(1/v)}\qquad 1<z<\infty \tag{30}$$

$v>0$ is the degrees of freedom or tail -thickness parameter and $\lambda=\sqrt{2^{(-2/v)}\Gamma(1/v)/\Gamma(3/v)}$ and the GED distribution to the log-likelihood contributions is given by:

$$l_t=-\frac{1}{2}\log\{\frac{\Gamma(\frac{1}{v})^3}{\Gamma(\frac{3}{v})(\frac{v}{2})^2}\}-\frac{1}{2}\log h_t-\{\frac{\Gamma(\frac{3}{v}(y_t-X_t'\theta)^2}{h_t\Gamma(\frac{1}{v})}\}^{\frac{v}{2}} \tag{31}$$

The GED is a normal distribution if $v=2$, and fat-tailed if $v<2$.

5. (v) Skewed Generalized Error Distribution (SGED) is given as:

$$f(z;v;\xi)=v(\frac{1}{2\theta\Gamma\frac{1}{v}})exp(\frac{(z-\delta)^2}{1-sign(z-\delta)\xi\}^v\theta^v} \tag{32}$$

where $\theta = \Gamma(\frac{1}{v})^{-0.5} S(\xi) A S(\xi)^{-1}, S(\xi) = \sqrt{1 + 3\xi^2 - 4A^2\xi^2}$,
$A = \Gamma(2/v)\Gamma(1/v)^{-0.5}\Gamma(s/v)^{-0.5}, \quad v > 0$ is the shape parameter controlling the height and heavy-tail of the density function while ξ is a skewness parameter of the density with $-1 < \xi < 1$.

4.0 Results and Discussion

4.1 Preliminary Data Analysis

4.1.1 Descriptive Statistics of Daily Stock Prices and Returns

To further understand the distributional properties of the stock prices and returns, summary statistics for both series are computed and results are presented in Table 1.

Table 1: Descriptive Statistics of Stock Prices and Returns

Statistic	ASI	Returns
Mean	23947.77	0.029172
Maximum	66371.00	11.26503
Minimum	4792.030	-12.54935
Standard Deviation	13316.67	1.004785
Skewness	0.656391	-0.112892
Kurtosis	3.340807	15.11793
Jarque-Bera	362.237	28920.00
P-value	0.0000	0.0000

The summary statistics shown in Table 1 indicates positive means for both daily stock prices and returns which indicate gain in the stock market for the trading period under review. The positive standard deviations for both stock prices and returns show the dispersion from the means and high level of variability of price changes in the stock market during the study period. The summary statistics also show positive asymmetry for daily stock prices (skewness = 0.656391) and negative asymmetry for the daily returns (skewness = -0.112892). The distribution is leptokurtic for both daily stock prices

and daily returns as kurtosis = 3.340807 and 15.11793 respectively indicating the presence of fat-tails in the series. The distribution is non-normal for both series as Jarque-Bera statistic is 362.2371 and 28920 respectively with the marginal p-values of 0.0000 in both series.

4.1.2 Graphical Examination of Daily Stock Prices and Returns

As a first step in time series analysis, the original series (daily stock prices) as well as the transformed series (daily log returns) were plotted against time and the graphical properties of the series were observed. The plots are presented in Figures 1 and 2 respectively.

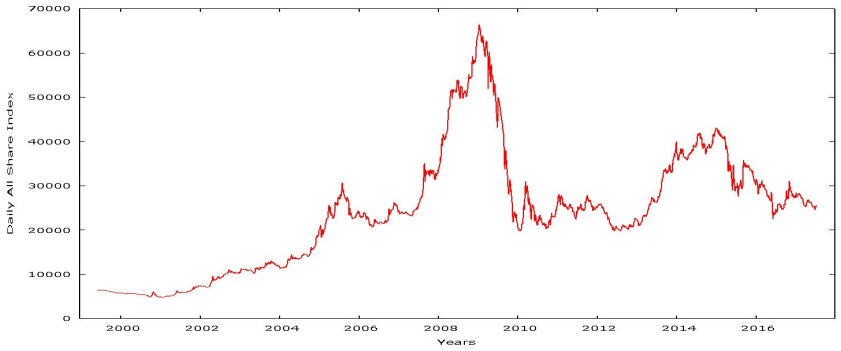

Figure 1: Time Plot of Daily Stock Prices (ASI) from 1999 – 2017.

The daily stock prices presented in Figure 1 suggests that the series has mean and variance that change with time and the presence of a trend indicating that the series is not covariance stationary. The plot of the daily return series presented in Figure 2 suggests that the series has a constant mean and variance with absence of trend indicating that it is generated by a random walk and is thus weakly stationary. The plot in Figure 2 also indicates that some periods are more clustered than others as large changes in stock returns tend to be followed by large changes and small changes are followed by small changes. This phenomenon is described as *volatility clustering*.

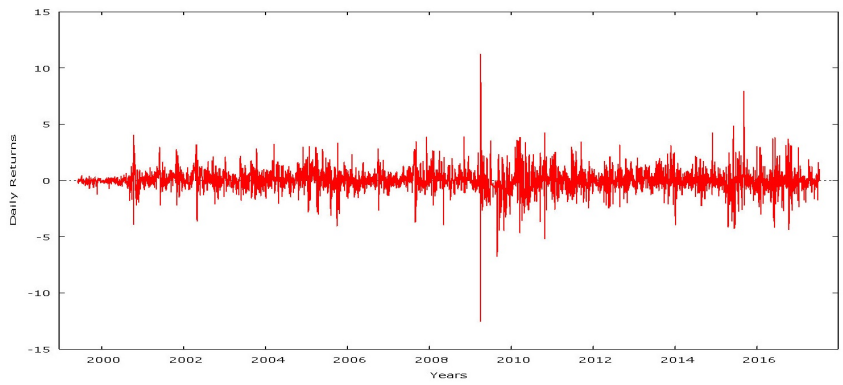

Figure 2: Time Plot of Daily Log Returns in Nigeria

Volatility clustering as one of the characteristic features of financial time series was first noticed in studies conducted independently by Mandelbrot (1963), Fama (1965) as well as Black (1976), when they observed the occurrence of large changes in stock prices being followed by large changes in stock prices of both positive and negative signs and the occurrence of small stock price changes being followed by periods of small changes in prices. Sequel to this result, numerous researchers including Poterba and Summer (1986), Tse (1991), McMillan et al. (2000), Najand (2002), Lee (2009), Emenike (2010), and Ezzat (2012) among others have in recent times documented evidence in literature proving that financial time series normally exhibit volatility clustering and leptokurtosis.

4.1.3 Unit Root and Heteroskedasticity Tests Results

Ng and Perron unit root test is employed in examining stationarity characteristics of both daily stock prices and returns in this work. The results of Ng and Perron unit root test together with heteroskedasticity test for ARCH effects are presented in Table 2.

Table 2: Ng – Perron Unit Root and Heteroskedasticity Tests Results

Variable	Option	Ng-Perron test statistics			
		MZ_α	MZ_t	MSB	MP_T
Y_t	Intercept only	-0.63183	-0.44522	0.70465	26.9371
	Intercept and trend	-3.71650	-1.26353	0.33998	23.1074
r_t	Intercept only	-2102.35*	-32.4217*	0.01542*	0.01169*
	Intercept and trend	-2213.14*	-33.2652*	0.01503*	0.04119*
Asymptotic Critical Values					
1%	Intercept only	-13.8000	-2.58000	0.17400	1.78000
5%		-8.10000	-1.98000	0.23300	3.17000
1%	Intercept and trend	-23.8000	-3.42000	0.14300	4.03000
5%		-17.3000	-2.91000	0.16800	5.48000
Heteroskedasticity Test for ARCH Effect		F-Statistic	1306.912	nR^2	1023.994
		P-value	0.0000	P-value	0.0000

Note: *denotes the significant of Ng-Perron test statistics at 1% and 5% significance levels. MZ_α, MZ_t, MSB and MP_T are the modified transformation of the standardized estimators of Z_α, Z_t, Bhargava R_1 statistic and Elliot *et al.* point optimal statistic respectively (see Phillips, 1987, Phillips and Perron, 1988, Ng and Perron, 2001, Bhargava, 198 and, Elliot *et al.* 1996).

The results of Ng – Perron unit root test reported in Table 2 indicates that the daily market prices are indeed non-stationary. This is shown by the Ng – Perron test statistics being higher than their corresponding asymptotic critical values at 1% and 5% levels. However, the Ng – Perron unit root test result of the daily stock returns show evidence of covariance stationarity as the test statistics are all smaller than their corresponding asymptotic critical values at all the designated test sizes both for constant only and for constant and linear trend. These results confirmed the result observed by visual inspection of time plots reported in Figures 1 and 2.

The lower panel of Table 2 indicates result of the residual test of heteroskedasticity for ARCH effects. The test rejects the null hypothesis of no ARCH effects in the residuals of returns. This means that the errors are time varying and can only be modeled using heteroskedastic ARCH family models.

4.2 Searching for Optimal Symmetric and Asymmetric GARCH Models

To select the best fitting symmetric and asymmetric GARCH models with suitable distributional assumption, information criteria such asAkaike information criterion (AIC) due to Akaike (1978) and Schwarz information criterion (SIC) due to Schwarz (1978)are employed in conjunction with log likelihoods (LogL). The best fitting model is one with largest log likelihood and minimum information criteria. Result is presented in Table 3.

Table 3: Model Order Selection

S/N	Model	Distribution	LogL	AIC	SIC
1	GARCH (1,1)	ND	-5745.7719	11499.5438	11525.3863
2	GARCH (1,1)	STD	-5459.1434	10928.2868	10966.5899
3	GARCH (1,1)	GED	-5462.6070	10935.2144	10967.5175
4	**GARCH (1,1)***	**SSTD**	**-5457.7421**	**10927.4842**	**10960.2479**
5	GARCH (1,1)	SGED	-5462.5949	10937.1898	10975.9535
6	EGARCH (1,1)	ND	-5700.8134	11411.6268	11443.9299
7	**EGARCH (1,1)***	**STD**	**-5432.0372**	**10876.7345**	**10915.4982**
8	EGARCH (1,1)	GED	-5437.2834	10886.5667	10925.3305
9	EGARCH (1,1)	SSTD	-5432.3433	10878.0866	10923.3110
10	EGARCH (1,1)	SGED	-5437.0913	10888.1826	10933.4070
11	GJR-GARCH (1,1)	ND	-5745.6656	11501.3311	11533.6342
12	**GJR-GARCH (1,1)***	**STD**	**-5456.5393**	**10927.0787**	**10965.8424**
13	GJR-GARCH (1,1)	GED	-5461.4886	10934.9771	10973.7409
14	GJR-GARCH (1,1)	SSTD	-5456.7168	10927.4336	10972.6580
15	GJR-GARCH (1,1)	SGED	-5461.4738	10936.9475	10982.1719

Note: * and **bold face** denotes the model selected by the search criteria. ND stands for normal distribution; STD stands for student-t distribution, SSTD stands for skewed STD; GED denotes generalized error distribution while SGED denotes skewed GED.

Table 3 shows results of 15 different symmetric and asymmetric GARCH models estimated with different innovation densities. The information criteria together with the log likelihood optimally selects symmetric GARCH (1,1) with skewed student-t distribution (SSTD), asymmetric EGARCH (1,1) and GJR – GARCH (1,1) both with student-t distribution (STD) as the best

candidates to model the daily stock return volatility in Nigerian stock market.

4.3 Results of Symmetric and Asymmetric GARCH Models

The parameter estimates of the selected GARCH-type models with their respective error distributions are presented in Table 4.

Table 4: Parameter Estimates of Symmetric and Asymmetric GARCH Models

Parameter	Coefficient	Std. Error	z-statistic	P-value
Symmetric GARCH (1,1) Model with Skewed Student-t innovation				
Mean equation				
μ	-0.0004	0.0099	-0.0428	0.0059
Variance equation				
ω	0.0227	0.0058	3.8910	0.0000
α_1	0.3494	0.0331	10.5700	0.0000
β_1	0.7026	0.0248	28.3800	0.0000
v	4.8839	0.3524	13.8600	0.0000
$\alpha_1 + \beta_1$	1.0520			
ARCH LM Test			0.481800	0.4876
Asymmetric EGARCH (1,1) Model with Student-t innovation				
Mean equation				
μ	-0.0105	0.0003	-33.3800	0.0000
Variance equation				
ω	-0.3670	0.0310	-15.2100	0.0000
α_1	0.4683	0.0310	15.0900	0.0000
γ	0.0331	0.0119	2.7690	0.0056
β_1	0.9444	0.0082	115.70	0.0000
v	5.0763	0.3761	13.5000	0.0000
$\alpha_1 + \beta_1$	1.4127			
ARCH LM Test			0.793590	0.3731
Asymmetric GJR-GARCH (1,1) Model with Student-t innovation				
Mean equation				
μ	-0.0074	0.0084	-0.8821	0.3777
Variance equation				
ω	0.0217	0.0057	3.8420	0.0001
α_1	0.2456	0.0332	10.420	0.0000
γ	-0.0401	0.0224	-1.789	0.0436
β_1	0.8064	0.0246	28.710	0.0000
v	4.8654	0.3510	13.860	0.0000
$\alpha_1 + \beta_1 + \gamma/2$	1.0320	ARCH LM Test	0.556927	0.4555

The results of Table 4 shows the parameter estimates of symmetric GARCH (1,1) model with SSTD, asymmetric EGARCH (1,1) and GJR – GARCH (1,1) models both with STD. In the symmetric GARCH (1,1) model, all the parameters of the model are statistically significant. The positive and sig-

nificant coefficients of the ARCH term (α_1) and GARCH term (β_1) clearly shows that stock market news about past volatility have explanatory power on current volatility. The GARCH (1,1) model showed evidence of volatility clustering in Nigerian stock market. However, the sum of ARCH term and GARCH term is greater than unity, i.e., ($\alpha_1 + \beta_1 = 1.0520 > 1$). This shows that the conditional variance is unstable, unpredictable and the entire process is non-stationary. This indicates over persistence of shocks in Nigerian stock market which can eventually explode to infinity. This result corroborates the previous findings of Bala and Asemota (2013), Adewale et al. (2016),Fasanya and Adekoya (2017) among others. Stock markets with explosive shocks are not conducive for long term investment as investors in such markets can loss or gain indefinitely.

From the results of asymmetric EGARCH (1,1) and GJR – GARCH (1,1) models, all the estimated parameters of the models are statistically significant at 5% significance levels, the parameters of the models also show over persistence of shocks as the mean reverting rates are all greater than one in both models. The existence of asymmetric response in the daily stock returns is confirmed given the non-zero asymmetric and leverage effect parameters in both models ($\gamma = 0.0331$) and ($\gamma = -0.0401$) for EGARCH (1,1) and GJR – GARCH (1,1) models, respectively. The positive and significant leverage effect parameter in the EGARCH (1,1) model indicates that positive shocks (good news) increases volatility more than negative shocks (bad news) of the same sign. The negative and significant leverage effect parameter in the GJR – GARCH (1,1) model shows that positive shocks (market advances) leads to increased volatility more than negative shocks (market retreats) of the same magnitude. Thus the study found empirical evidence for asymmetry without leverage effect.

When GARCH models are estimated using student-t and skewed student-t distributions, the t-distribution degree of freedom (shape) parameter,(v) need to be greater than 2 for the distributions to be fat-tailed. From the parameter estimates of GARCH models presented in Table 4, the shape pa-

rameter $v = 4.8839 > 2$ for GARCH model, $v = 5.07632 > 2$ for EGARCH model and $v = 4.8654 > 2$ for GJR-GARCH model indicating that the stock return series under review are fat-tailed (leptokurtic).

The heteroskedasticity (ARCH LM) tests of residuals for ARCH effects of the estimated models shown in Table 3 shows that the conditional variance equations for GARCH (1,1), EGARCH (1,1) and GJR – GARCH (1,1) models were well specified as the models captured all the ARCH effects and none is remaining in the innovations. This is clearly shown by the non-significant p-values of the F-statistics and nR^2 tests associated with the ARCH LM tests.

The estimated GARCH-type models in this work are well specified and captured all the remaining ARCH effects in the residuals, yet the shocks persistence in volatility remained very high giving rise to long memory. This is an indication that the stock return series are contaminated with structural breaks. When stock return series are contaminated with structural breaks, their volatility estimates are biased to unity, see Perron (1989, 1990). Hence there is need to investigate the presence of structural breaks in the series.

4.4 Investigating Exogenous Breaks in the Return Series

To investigate whether the return series were contaminated with structural breaks, Bai and Perron multiple breakpoints testing procedure (Bai and Perron, 1998, 2003) was applied. The structural break points in volatility with time periods were presented in Table 5. A maximum of 3 break points for daily stock returns were detected.

Table 5: Structural Breakpoints in Volatility with Time Periods

Return	Break Points	Time Periods
Daily Returns	3	10th August, 2003 – 15th December, 2004 23rd December, 2008 – 17th March, 2009 19th November, 2015 – 11th April, 2016

One of the reasons for the structural breaks was the economic recession in 2004 and the economic recovery in Nigeria in 2005, the crude oil price fluctuations in the country was another cause, the global financial crises which started in 2007 to 2009 also affected the Nigerian stock market. The terrorist attacks of Niger Delta militants, Boko Haram attacks in 2013 to date were also contributing factors; other reasons were as a result of internal, local, domestic, political or economic crises in the country.

4.5 Symmetric and asymmetric Volatility Estimates with breaks

The detected structural breaks are considered in the volatility models by incorporating indicator (dummy) variable in the conditional variance equations of the symmetric GARCH (1,1), asymmetric EGARCH (1,1) and GJR-GARCH (1,1) models. The result is reported in Table 6.

By incorporating structural break points in the volatility models, it was observed that there were significant decreases in the values of shock persistence parameters (β_1) in all estimated GARCH-type models. There were also significant reductions in the values of mean reversion rates ($\alpha_1 + \beta_1$) in all estimated models of the stock market returns. Also by including the structural breaks in these models, the stationarity and stability conditions of the models are satisfied as the sum of ARCH and GARCH terms were less than one in all the estimated models with breaks. This shows that the conditional variance process was stable and predictable and that the memories of volatility shocks were remembered in Nigerian stock market. Mean reverting and stationary stock returns were good for long term investment. This result agreed with the previous findings of Bala and Asemota (2013), Yaya and Gil-Alana (2014), Dikko *et al.* (2015), Muhammad and Shuguang (2015), Aluko et al. (2016), Adewale et al. (2016) and Kuhe and Chiawa (2017). All the estimated asymmetric models retain the asymmetric response property without the presence of leverage effect. By comparing the performance of the estimated GARCH type models, it was observed that the asymmetric EGARCH (1,1) with student-t innovation density outperformed the symmetric GARCH (1,1) and threshold GJR-GARCH (1,1) models by reducing the

shock persistence in Nigerian stock market more gladly.

Table 6: Parameter Estimates of GARCH models with Structural Breaks

Parameter	Coefficient	Std. Error	z-statistic	P-value
Symmetric GARCH (1,1) Model with Skewed Student-t innovation				
Mean equation				
μ	-0.0103	0.0082	-1.2571	0.2087
Variance equation				
ω	0.0182	0.0030	5.9864	0.0000
ϕ	-0.0005	0.0074	5.5195	0.0000
α_1	0.3348	0.0253	13.2516	0.0000
β_1	0.6505	0.0140	51.3868	0.0000
v	4.8793	0.3134	15.5685	0.0000
$\alpha_1 + \beta_1$	0.9853			
ARCH LM Test			0.136101	0.7122
Asymmetric EGARCH (1,1) Model with Student-t innovation				
Mean equation				
μ	-0.0106	0.0081	-1.3031	0.0025
Variance equation				
ω	-0.3514	0.0175	-20.0806	0.0000
ϕ	--0.0007	0.0034	5.6037	0.0000
α_1	0.2479	0.0243	18.3981	0.0000
γ	0.0329	0.0126	2.6098	0.0091
β_1	0.6481	0.0064	148.245	0.0000
v	5.1639	0.3388	15.2414	0.0000
$\alpha_1 + \beta_1$	0.8960			
ARCH LM Test			0.300670	0.5835
Asymmetric GJR-GARCH (1,1) Model with Student-t innovation				
Mean equation				
μ	-0.0084	0.0083	-1.0061	0.3144
Variance equation				
ω	0.0170	0.0029	5.9175	0.0000
ϕ	-0.0016	0.0174	-18.9024	0.0000
α_1	0.2587	0.0294	11.9758	0.0000
γ	-0.0555	0.0309	-1.79352	0.0029
β_1	0.7388	0.0136	53.6464	0.0000
v	4.9171	0.3152	15.6009	0.0000
$\alpha_1 + \beta_1 + \gamma/2$	0.9698			
ARCH LM Test			0.202133	0.6530

The coefficients of the dummy variable (ϕ) was negative and statistically significant in symmetric GARCH (1,1), asymmetric EGARCH (1,1) and GJR-GARCH (1,1) models suggesting that the global financial crises, the economic recession, the crude oil price fluctuations, the Niger Delta militant and Boko Haram terrorism which impaired the stock return series had negatively affected the Nigerian stock market during the study period.

The stock return series retained the fat-tailed behaviour even after incorporating the sudden shifts in variance as the shape parameter $v = 4.8793 > 2$ for GARCH model,$v = 5.1639 > 2$ for EGARCH model and $v = 4.9171 > 2$ for GJR-GARCH model. This clearly indicated that the Nigerian stock returns were heavy-tailed, one of the stylized facts of financial returns common in developed markets.

The ARCH LM tests of residuals for ARCH effects of the estimated models with breaks shown in Table 6 indicated that the conditional variance equations for the three models have captured all the ARCH effects in the residuals of the stock return series and none was left as the p-values of the F-statistics and nR^2 tests associated with the ARCH LM tests were highly statistically insignificant.

5.0 Conclusion and Policy Implications

5.1 Conclusion

This study examined the symmetric and asymmetric responses of shocks persistence in Nigerian stock market using daily closing all share index (ASI) from Nigerian stock exchange (NSE) from 3rd July 1999 to 12th June 2017. The study modeled heteroskedasticity in Nigerian stock market by employing two different sets of specifications of symmetric GARCH (1,1), asymmetric EGARCH (1,1) and GJR-GARCH (1,1) models with varying innovation densities. The first set of models were estimated without incorporating structural breaks while the second set of estimation incorporated the detected structural breaks in the conditional variance of these models. The results of the GARCH (1,1) with skewed student-t distribution, EGARCH (1,1) and threshold GJR-GARCH (1,1) models all with student-t distributions without structural breaks showed over persistence of shocks giving rise to long memory and non-stationarity of the conditional variance process in Nigerian stock market. The estimated models were unstable with unpredictable property, however, the asymmetric models showed evidence of asymmetry without leverage effect in Nigerian stock market.

After dictating breakpoints in the return series, the second set of model estimation incorporated the structural breaks by including a dummy variable in the conditional variance equations of all the models. By incorporating the structural break points in the volatility models, there was significant decreases in the values of shock persistence parameters (β_1)and in the values of mean reversion rates ($\alpha_1+\beta_1$) in all the estimated GARCH-type models. The stationarity and stability conditions of these models were also satisfied as the sum of ARCH and GARCH terms were less than unity in all the estimated models with breaks. This also reduced the memory in the Nigerian stock market. All the estimated asymmetric models with breaks retain the asymmetric response property without leverage effect. The EGARCH (1,1) with student-t innovation density outperformed the other two competing models by reducing the shock persistence in Nigerian stock market more gladly. The choice of fat-tailed distributions by the competing models in estimating volatility confirms the presence of heavy-tails in Nigerian stock returns. This study recommends the use of asymmetric GARCH models with structural breaks in measuring volatility in Nigerian stock market as this will help to avoid over estimation of shock persistence in the conditional variance and to allow free flow of market information and wide range of aggressive trading of securities so as to increase market depth and make the Nigerian stock market less volatile.

5.2 Policy Implications

The empirical findings of this study suggest that inferences on shock persistence in volatility and long memory are more likely to be episodic and may disguise the short memory property of stock market return series with structural breaks. Consequently, caution should be exercised when inferences on shock persistence in volatility and long memory are being interpreted amid structural breaks. In addition, structural changes caused by economic crises may affect investor's financial decision in the stock market and failure to account for these structural breaks in the stock market may lead to wrong inferences and portfolio decisions by investors. Therefore, policy makers

should consider the regime changes in their financial policy design.

The results of this study also characterized the Nigerian stock market with high degree of risk and uncertainty (see the work of Aluko et al., 2016). The highly explosive nature of the market further suggests that good news or bad news could have permanent effect on future periods' volatility. The higher volatile nature of Nigerian stock market may signal huge threat to both local and foreign investors; hence consistent policy reforms to install investor's confidence in the market should be implemented by government.

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Nnnana, O. J. (2004). Financial Sector Development and Economic Growth in Nigeria: An Empirical Investigation. Central Bank of Nigeria Economic and Financial Review, Vol. 42 No. 3.
Doguwa S. I. and Upton G. J. G. (1989). Edge-corrected Estimators for the Reduced Second Moment Measure of Point Processes. Biom. Journal, 31:563-575.
Tumala, M. M. and Yaya, O. S. (2015). Estimating Bull and Bear Betas for the Nigerian Stock Market Using Logistic Smooth Threshold Model. CBN Journal of Applied Statistics, Vol. 6 No. 1(b) (June, 2015).

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Demirguckunt, A and Detragiache, E. (1998). "Financial Liberalization and Financial Fragility", in proceeding of the Annual Bank Conference in Development Economics, Washington D.C., World Bank.

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