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ARTICLES

Currency Substitution: Evidence from Nigeria

[1]**Sani I. Doguwa**

This paper examines the existence, causes and effects of currency substitution in Nigeria by estimating conventional money demand equations based on a partial adjustment and an autoregressive distributed lag models using three definitions of monetary aggregates. The behavior of the foreign currency/Naira deposit ratios have been influenced by devaluation expectations, exchange rate risks and political uncertainties during the Yar'adua-Jonathan presidency. Also, the money demand estimations reveal that short-term foreign interest rates significantly affect the demand for the Naira, suggesting strong evidence of currency substitution and the possibility of importing considerable instability in the economy.

Keywords: Currency Substitution, Demand for Money Function; Autoregressive Distributed Lag Approach; Monetary Policy

JEL Classification: E51, E41, C22

1.0 Introduction

The idea of currency substitution dates back to the post World War I era when Europe experienced severe hyperinflations, when there was lack of stable domestic means of payment. Consequently, the use of foreign currencies was desired not only as a store of value, but as a means of payment as well, (Gomis-Porqueras *et al.* 2000). The increasing use of foreign currency appears to mirror the attempts of economic agents to hedge against inflation and/or exchange rate depreciation during periods of large macroeconomic imbalances. In this context, permitting foreign currency deposits may have also served as a vehicle to foster financial intermediation and financial deepening at a time when banking systems were considered fragile, thereby laying the foundation for the expansion of deposit money banks' operations.

The definition of currency substitution in the literature has subsequently been linked to the holding of foreign currency by domestic residents, in relation to

[1] The author is a staff of the Statistics Department, Central Bank of Nigeria, Abuja – Nigeria. The views expressed in the paper are those of the author and do not necessarily represent the views of the Central Bank of Nigeria. The author acknowledges the rich comments of the referees which led to some improvements in the paper.

varying exigencies that derive from the traditional roles that money plays in the economy. At one extreme, Calvo and Vegh (1992) limit the concept to the use of foreign currency by domestic residents as a medium of exchange. On the other hand, others such as Clements and Schwartz (1992) and Agenor and Khan (1992) adopt a more general stance; they define currency substitution as a process whereby foreign currency substitutes for domestic money as a unit of account, medium of exchange and as a store of value.

Boamah, *et al.* (2012) noted that increased currency substitution may have several negative spill-off effects such as weakening the autonomy of monetary policy; increasing vulnerability to economic shocks; the potential for significant deterioration of the balance of payments account and/or exchange rate volatility. Furthermore, currency substitution has the potential to negatively impact overall economic growth, especially for small open economies.

Currency substitution explains the conditions under which foreign money balances will be held and adapted to expected changes in relative risks and returns among the various currencies. The general idea of several representative papers [see Miles (1978) and Girton and Roper (1981)] is that monetary policy will be ineffective in a country where foreign currencies are regarded as good substitutes for domestic currency. An implication of this hypothesis is that the elasticity of substitution between domestic and foreign currencies is likely to increase in periods when the exchange rate is floating. Hence, if the issue of currency substitution is empirically relevant, one of the stronger arguments for floating exchange rates, which is greater national monetary independence, is seriously weakened.

The relevance of the currency substitution problem for Nigeria is not so much related to the choice of fixed versus floating exchange rates, but to the potential problems of short-run monetary instability that currency substitution can create. If the demand for domestic currency is strongly influenced by foreign variables, a substantial degree of instability may be imported from abroad, even if the monetary authorities follow consistent monetary and exchange rate policies. It is therefore important that policy makers in Nigeria have a realistic notion about the extent of currency substitution in the country and its potential impact on policy decision and the wider economy as a whole.

The objective of this paper is to examine the presence and extent of currency substitution in Nigeria and explores discussion on policy implications. For ease of exposition, the paper is structured into six sections, with Section one as the introduction. Section two reviews the literature, while a historical perspective of the trend of currency substitution in Nigeria is provided in Section three. While the theoretical framework is presented in Section four, an attempt is made to explain and quantify the main forces determining the behavior of the foreign currency/Naira deposit ratio and the effects of currency substitution in Section five. Section six concludes the paper.

2.0 Literature Review

Although there are varying approaches to modeling currency substitution, most studies have utilized M2 in a simple money demand function, as M2 is deemed to be more relevant for monetary policy formulation. As Bahmani-Oskooee and Tanku (2006) noted, Mundell was the first to argue that the demand for money could depend on the exchange rate in addition to income and interest rates, but since this was only a conjecture and not supported by any empirical analysis, not much attention was paid to Mundell's idea.

In estimating the demand for money in Nigeria, Doguwa *et. al.* (2014) noted that the demand for money had often ignored the influence of foreign money developments. The authors estimated the demand for real cash balances as a function of real income, real monetary policy rate, exchange rate spread and movements in exchange rate. The results verified the hypothesis that foreign financial aid and monetary influences on the demand for real cash balances are transmitted by changes in exchange rate expectations and concluded that ignoring the effects of exchange rate expectations may lead to misspecification of the demand for money.

A majority of the studies in the literature have utilized the model or variant of Arango and Nadiri (1981) as the basis for estimating currency substitution. In particular, Bordo and Choudhiri (1982) posited that if currency substitution is important, the expected devaluation in the exchange rate should be a significant determinant of the demand for foreign currency. The efficient market hypothesis suggests that the forward rate is a good measure of the expected exchange rate. To account for departure from the simple efficiency hypothesis they used the proportional spread between 90 – day forward and spot exchange rates to measure the expected rate of exchange rate appreciation. They estimated demand for money functions using both M_1 and

M_2 in Canada, but found the influence of the expected return on foreign money on the demand for domestic money to be negligible.

Bahmani-Oskooee and Techaratanachai (2001) found that currency depreciation in Thailand has indeed resulted in currency substitution away from the Thailand Baht. Following Arango and Nadiri (1981), the authors estimated a money demand function with M_2 (real money stocks) as a function of real income, the interest rate on alternative assets and the nominal effective exchange rate. Using the Johansen and Juselius co-integration technique, the results indicated that the nominal exchange rate was positive, indicating that, as the Thai baht depreciates, public holding of M2 declines.

Kaplan *et al.* (2008) investigated whether currency depreciation in Turkey has resulted in currency substitution away from the Turkish dollar. The study estimated a money demand function (real money stocks) as a function of real income, nominal domestic interest rate and the nominal effective exchange rate. Since all of the variables appeared to be integrated of order one, using the Johansen and Juselius co-integration method they found one co-integrating relationship, and estimated the long-run model. All variables were found to be significant and the positive sign on the nominal exchange rate variable implied the existence of currency substitution.

Instead of utilizing the money demand function, some studies have defined a currency substitution variable, for instance, El-khafif (2002). Currency substitution was defined as the share of nominal foreign currency in money supply and was modeled as a function of the nominal exchange rate, and the interest rate differential between the interest rate on local currency and that on the dollar. The author used an error-correction model to examine the dynamic of the currency substitution phenomenon in two of Africa’s emerging economies: Egypt and South Africa. The results indicated that currency substitution does exist, but its elasticity with respect to the exchange rate variable is larger in South Africa than in Egypt.

The economic impact of currency substitution on the financial and economic development of a country is generally well documented in the literature. Many studies have alluded to the potential effects on the effectiveness of macroeconomic policy and the ability to formulate and conduct monetary policy. For instance, Cuddington (1983) made reference to Miles (1978) argument that even though some degree of monetary independence is attained with a flexible exchange rate regime as opposed to a fixed exchange rate system, this independence may vanish in the presence of currency substitution.

Ortiz (1983) also agreed that the argument for floating exchange rates, that is, autonomy of monetary policy, is severely weakened in the presence of currency substitution. He noted that a considerable amount of instability may be imported from foreign territories as the demand for domestic currency is significantly influenced by foreign factors. Similarly, Ho (2003) noted that given a fixed amount of money supply, as domestic currency is substituted for foreign currency, the domestic economy becomes susceptible to monetary shocks both at home and abroad, and hinders any attempts of the monetary authorities to pursue policies independent of foreign influences.

Ramirez-Rojas (1985) noted that currency substitution may redirect the effects of macroeconomic policy, as heavy substitution could lead to deficits in the balance of payments accounts and/or exchange rate depreciation. He argued that either way deficit financing through money creation will fall, as well as the inflation tax base. Also, in analyzing the Asian economic crisis, Bahmani-Oskooee and Techaratanachai (2001) suggested that implications of currency substitution for domestic money holdings could impact on economic growth. They argued that depreciation of the domestic currency raises the domestic currency value of foreign assets. Therefore, those expecting further depreciation, substitute more foreign currency for domestic currency, thereby reducing their domestic money holdings. If these effects are strong, the decline in domestic currency holdings could cause economic slowdown and further aggravate economic crisis.

Akinlo (2003) investigated whether the depreciation of the Naira has a significant effect on currency substitution in Nigeria. He found that Naira depreciation in the study period spanning 1980 to 2000 did not cause currency substitution. Rather as Naira depreciates, those holding foreign currencies see it as an increase in wealth. Yinusa and Akinlo (2008) indicated the presence of currency substitution in the domestic banking system in Nigeria during 1986 to 2005, with the parallel market exchange rate volatility being the major driver. The authors indicated that currency substitution was low during the period and classified Nigeria as a moderately dollarized economy.

3.0 Trend of Currency Substitution in Nigeria

This paper uses two definitions to measure the degree of currency substitution in the Nigerian economy. The first measure (CS_1), which is widely used in the empirical currency substitution literature, is based on demand deposits only defined as the ratio of foreign currency deposits (FCD) to Naira demand deposits (DD) in the Nigerian banking system. That is:

$$CS_1 = \frac{FCD}{DD} \quad (1)$$

The second measure (CS_2) incorporates all deposits and is defined as the ratio of FCD to Naira demand deposit, as well as time and savings deposits (TSD) in the banking system. Thus, the CS_2 is expressed as:

$$CS_2 = \frac{FCD}{DD + TSD} \quad (2)$$

These ratios are derived from the monetary survey of the Central Bank of Nigeria (CBN). Note that foreign currency denominated bills and coins circulating within the economy are generally omitted in the CS ratios of most studies ostensibly because the stock of foreign cash in circulation within a particular country is difficult to measure and can only be approximated roughly, based on generally very restrictive assumptions. Figure 1 shows the monthly ratios of foreign to domestic currency demand and total deposits held in Nigeria's banking system from December 1994 to June 2014.

During the last two military administrations (December 1994 to May 1999), the CS_1 ratio fell from a peak of 9.43 per cent in June 1996 to a low of 2.04 per cent in July 1997. Similar trend was exhibited by the CS_2 ratio. In 1994 fixed exchange rate regime was introduced to regulate the economy. However, in 1995, the government operated a dual exchange rate system – the fixed and the autonomous foreign exchange market as a guided deregulation. This policy of guided deregulation and dual exchange rate continued with a merger achieved in January 1999.

Following the transition to civilian democracy in May 1999, the CS_1 ratio averaged 14.2 per cent, with a minimum of 5.9 per cent recorded in Jan 2000 and a maximum of 19.95 per cent achieved in January 2004. The increase in CS_1 ratio from an average of 2.05 per cent during the period Dec 1994 to May

1999 to 14.2 per cent during the period June 1999 to May 2003 was largely explained by the pursuance of the financial sector liberalization policy and the introduction of the inter-bank foreign exchange market (IFEM) in October 1999 to replace the autonomous foreign exchange market. Similar trend was also observed with the CS_2 ratio.

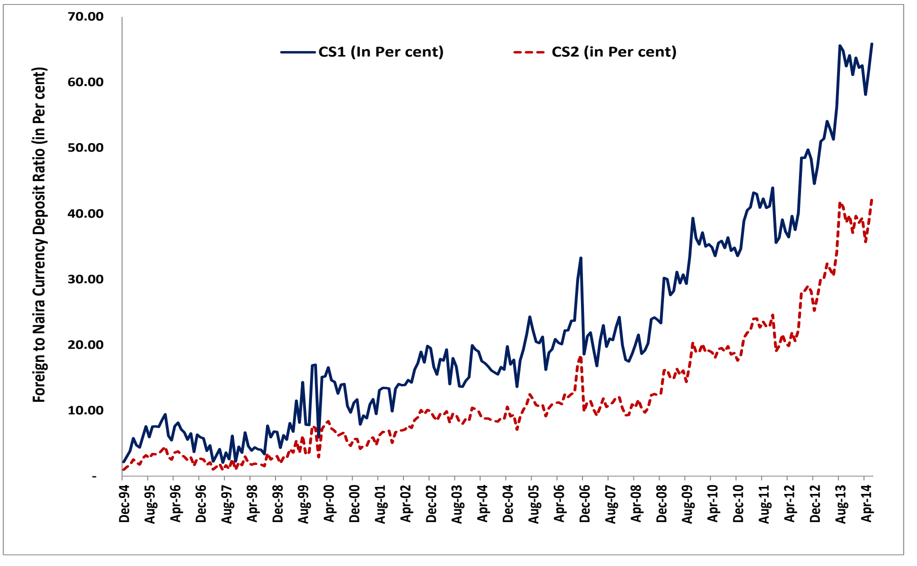

Fig. 1: Currency Substitution Ratio in the Nigerian Banking System

The period June 2003 to June 2009 witnessed further increases in the CS_1 and CS_2 ratios. These two ratios averaged 21.1 per cent and 11.3 per cent in the period up from 14.2 per cent and 7.2 per cent attained during the first term of President Obasanjo, respectively. The CS_1 and CS_2 ratios peaked at 33.3 per cent and 18.5 per cent in November 2006, respectively. This coincided with the period of further liberalization of the Foreign exchange market and unification of the exchange rate between official and inter-bank. Before 2006, the CBN maintained a narrow band policy of +\- 3 per cent of the moving central rate intended to anchor expectations.

The first term of President Yar'adua-Jonathan administration witnessed substantial increases in both CS_1 and CS_2 ratios. The CS_1 ratio rose from 29.3 per cent in August 2009 to a peak of 65.6 per cent in August 2013. Similar trend is observed for the CS_2 ratio. In 2009 the CBN decided to return to a regime of fully liberalized foreign exchange market over a three months period and reverted to the wholesale Dutch auction system.

The period February 2014 to June 2014 indicated an uptrend in the CS_1 and CS_2 ratios. These two ratios averaged 62.1 per cent and 38.9 per cent in the period, up from 42.7 per cent and 24.2 per cent attained during the preceding period, respectively. The CS_1 and CS_2 ratios peaked at 65.9 per cent and 49.4 per cent in June 2014, respectively. This reflected the uncertainties associated with the macroeconomic policy direction of the CBN in the months leading to June 2014 when Governor Emefiele assumed office.

4.0 Theoretical Framework

Following Ortiz (1983), we consider these two simple money demand functions:

$$\left(\frac{DD}{P}\right)_t^* = f\left(r_t^d, r_t^f, r_t, \theta_t, \gamma_t, \omega_t\right) \quad (3)$$

and

$$\left(\frac{FCD}{P}\right)_t^* = h\left(r_t^d, r_t^f, r_t, \theta_t, \gamma_t, \omega_t\right) \quad (4)$$

where the left hand sides of equations (3) and (4) are the real domestic and foreign desired demand money balances in period t, P is the price index, r_t^d, r_t^f and $r_t$are the real returns on domestic currency, foreign currency and an alternative asset; $\theta_t$is a measure of foreign exchange risk, $\gamma_t$is a proxy for political risk factors, and $\omega_t$is the real wealth. Assuming that $f(.)$ and $h(.)$ are exponential functions, the desired money demand functions can be written as:

$$\left(\frac{DD}{P}\right)_t^* = \alpha_0\omega_t exp\{\alpha_1\left(r_t^d - r_t^f\right) + \alpha_2\left(r_t^d - r_t\right) - \alpha_3\theta_t - \alpha_4\gamma_t\} \quad (5)$$

and

$$\left(\frac{FCD}{P}\right)_t^* = \beta_0\omega_t exp\{\beta_1\left(r_t^f - r_t^d\right) + \beta_2\left(r_t^f - r_t\right) + \beta_3\theta_t + \beta_4\gamma_t\} \quad (6)$$

Taking the natural logarithm of equations (5) and (6) and subtracting the natural log of (5) from (6) gives:

$$ln\left(\frac{FCD}{DD}\right)_t^* = ln\left(\frac{\beta_0\omega_t}{\alpha_0\omega_t}\right) + \{\beta_1(r_t^f - r_t^d) + \beta_2(r_t^f - r_t) + \beta_3\theta_t + \beta_4\gamma_t\} - \{\alpha_1(r_t^d - r_t^f) + \alpha_2(r_t^d - r_t) - \alpha_3\theta_t - \alpha_4\gamma_t\} \quad (7)$$

Imposing the following symmetry conditions $\alpha_i = \beta_i$ for i=1, 2,...4 in equation (7) and adding the stochastic term μ_t gives equation (8):

$$ln\left(\frac{FCD}{DD}\right)_t^* = \rho_1(r_t^f - r_t^d) + \rho_2\theta_t + \rho_3\gamma_t + \mu_t \quad (8)$$

where $\rho_1 = 2\alpha_1 + \alpha_2$, $\rho_2 = 2\alpha_3$ and $\rho_3 = 2\alpha_4$. The desired level of the left hand side of equation (8), that is, the natural log of currency substitution is not directly observable. We then use the partial adjustment hypothesis of Nerlove (1958) expressed as:

$$ln\left(\frac{FCD}{DD}\right)_t - ln\left(\frac{FCD}{DD}\right)_{t-1} = \lambda\left\{ln\left(\frac{FCD}{DD}\right)_t^* - ln\left(\frac{FCD}{DD}\right)_{t-1}\right\} \quad (9)$$

where λ is the coefficient of adjustment and is expected to fall in the interval (0,1], and the left hand side and the right hand side of equation (9) are the actual change and desired change, respectively. The equation postulates that actual change in currency substitution in any given time period, is a function λ of the desired change for the period. Now substituting (8) in (9) yields the partial adjustment model:

$$ln\left(\frac{FCD}{DD}\right)_t = \lambda\{\rho_1(r_t^f - r_t^d) + \rho_2\theta_t + \rho_3\gamma_t\} + (1 - \lambda)ln\left(\frac{FCD}{DD}\right)_{t-1} + \epsilon_t \quad (10)$$

where $\epsilon_t = \lambda\mu_t$. Equation (8) represents the long-run, or equilibrium demand for currency substitution, while equation (10) is the short-run demand function for currency substitution. Once the short-run function is estimated to obtain the estimate of the adjustment coefficient λ, we can then derive the long-run function by dividing the parameter estimates in equation (10) by the adjustment coefficient and ignore the lag term to get equation (8).

One method of estimating the potential monetary instability problems of currency substitution is to examine the properties of alternative definitions of monetary aggregates. If foreign currency deposits are effectively regarded by the public as money, they should be included as part of the money stock for policy making purposes. In fact the FCD are included as part of quasi money in Nigeria. Alternatively, if the currency substitution problem is important, domestic money demand estimations that fail to account for the foreign currency component should be unstable. To explore the relevance of this question for the case of Nigeria, a conventional money demand equation will be estimated based on the three definitions of the monetary aggregates:

$$M^j = COB + DD \quad (11)$$

$$M^k = M^j + FCD \quad (12)$$

$$M^h = M^k + TSD \quad (13)$$

The money demand equations are given in equation (14) as:

$$ln\left(\frac{M^{j,k,h}}{P}\right)_t = \alpha_0 + \alpha_1 ln\, Y_t + \alpha_2 RD_t + \alpha_3 FR_t + \alpha_4 IR_t + \alpha_5 SP_t + \alpha_6 ln\left(\frac{M^{j,k,h}}{P}\right)_{t-1} + \in_t \quad (14)$$

where $(M^{j,k,h}/P)$ is the real monetary aggregates with $(M^j$ and $(M^h$ representing the Nigeria's narrow and broad money supply, respectively; Y_t is current real income; RD_t is the period average interest rate payable on 3 months Nigerian naira deposits; FR_t is the short-term US money market rate; the weighted average inflation rates of the past three periods is taken as proxy for expected inflation, IR_t and $\in_t$, is a random error term; SP_t is the spread between the official and parallel market exchange rate. COB is domestic currency outside banks; TSD, DD, FCD are as defined in equations (1) to (2).

5.0 Causes and Effects of Currency Substitution

5.1 Causes of Currency Substitution

For a local resident, the real return of the holdings of desired domestic currency r^d, can be approximated by the rate of inflation. The real return on desired foreign money is simply r^f which is equal to r^d plus the expected percentage rise in the domestic currency price for foreign currency. Thus, the differential $(r^f - r^d)$ is just the expected depreciation (ED) of the exchange rate. However, foreign exchange futures market for most developing countries' currencies did not exist and exchange rate forwards started most recently in Nigeria.

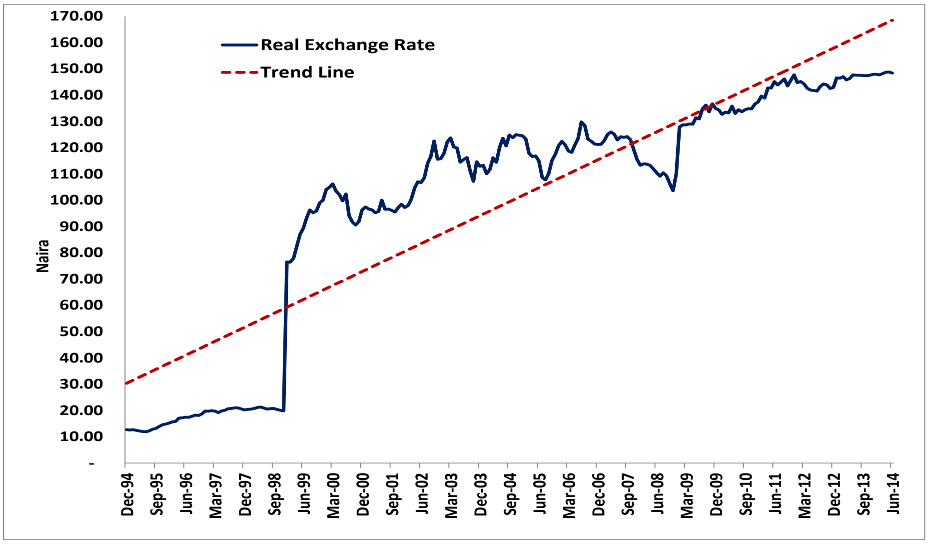

Fig. 2: Real Naira/Dollar Exchange Rate and its Long-run Trend

Therefore, to account for the departure from the simple efficiency hypothesis, an obvious proxy for the expected rate of depreciation of the exchange rate is the spread (SP) between the official and parallel market exchange rate. Given the length of the period in which the exchange rate was fixed, the deviations of the real exchange rate from trend were used as a proxy measure of foreign exchange risks (ER) (see Fig. 2). Finally, dummy variables $(PR^k, k = 1\ 2, 3)$ were included to reflect the various tenures of the three heads of Government to take account of the political risk factors in the study period.

Equation (8) and (10) can be expressed as

$$\ln(CS)_t = \rho_1 SP_t + \rho_2 ER_t + \sum_{k=1}^{3} \rho_{k+2} PR_t^k + \mu_t \tag{15}$$

$$\ln(CS)_t = \lambda\rho_1 SP_t + \lambda\rho_2 ER_t + \sum_{k=1}^{3} \lambda\rho_{k+2} PR_t^k + (1-\lambda)\ln(CS)_{t-1} + \epsilon_t \tag{16}$$

where the adjustment coefficient λ and ρ_1, ρ_2 , ρ_3 , ρ_4 , and ρ_5 are parameter values to be determined. The variables CS, SP, ER are as earlier defined. The political risk variable PR_t^k is defined as:

$$PR_t^k == \begin{cases} 1, & t \in President\ \ k\ tenor \\ 0, & Otherwise \end{cases}$$

Thus, PR_t^1, PR_t^2 and PR_t^3 represent the "political risks" associated with the regime of the three heads of Government covered in the study period - starting with General Abacha-Abdulsalam (up to May, 1999), President Obasanjo (June, 1999 to May 2007) and Presidents Yar'adua-Jonathan (June 2007 to date), respectively. The error term $\epsilon_t = \lambda\mu_t$ and μ_t is normally distributed with a constant mean and variance.

Empirical results from the Augmented Dickey Fuller (ADF) test showed that the null hypothesis of a unit root test cannot be rejected at the 10 per cent level for all the variables used in this paper, except for three month average deposit rate (RD) and expected inflation (IR) that are level stationary, I(0). All the other variables in Table 1 are I(1), which suggest short run disequilibrium. Thus, estimates of equations (15) and (16) would only be valid if all the variables are level stationary. Therefore, there is need to correct for the short-run disequilibrium.

Table 1: Testing The Null Hypothesis of a Unit Root using ADF Test

Variable	ADF	Prob	Difference	ADF	Prob
SP	-1.8889	0.3372	d(SP)	-15.0891	0.0000
ER	-1.6403	0.4604	d(ER)	-14.7147	0.0000
CS_1	0.9959	0.9965	$d(CS_1)$	-15.4192	0.0000
CS_2	1.6329	0.9996	$d(CS_2)$	-14.6609	0.0000
Y	4.4861	1.0000	d(Y)	-2.5935	0.0990
RD	-2.9352	0.0460	d(RD)	-5.6422	0.0000
IR	-9.0659	0.0000			
FR	-2.0074	0.2832	d(FR)	-4.0999	0.0017
M^i/P	-0.8445	0.8004	$d(M^i/P)$	-10.9117	0.0001
M^j/P	0.0031	0.9555	$d(M^j/P)$	-11.0077	0.0001
M^k/P	-0.2094	0.9319	$d(M^k/P)$	-9.8522	0.0000

ADF meand Augmented Dickey Fuller

Pesaran *et al*. (2001) proposed a new approach to testing for the existence of a relationship between variables in levels which is applicable irrespective of whether the underlying variables are either I(0), purely I(1) or mutually cointegrated. The statistic underlying the new approach is the familiar F Wald test in a generalized Dickey-Fuller type regression used to test the significance of lagged levels of the variables under consideration in a conditional unrestricted equilibrium correction model. The ARDL (p, q, r) bound test representation of equation (15) is specified as:

$$\Delta\ln(\mathrm{CS}_t) = c + \rho_1 \ln(CS_{t-1}) + \rho_2 SP_{t-1} + \rho_3 ER_{t-1} + \sum_{i=1}^{p} \beta_{1i} \Delta\ln(CS_{t-i}) + \sum_{j=1}^{q} \beta_{2j} \Delta SP_{t-j} + \sum_{k=1}^{r} \beta_{3k} \Delta ER_{t-k} + \epsilon_t \qquad (17)$$

where

$$c = \sum_{h=1}^{3} \partial_h PR_t^h$$

With PR^h_t defined earlier. The β parameters are the short-run coefficients and the ρ parameters represent the long-run coefficients of the model. Δ represents a first difference operator and p, q, r are the optimal lag lengths selected for the right hand variables. This bound testing approach for testing the null hypothesis of no co-integration amongst the variables against the presence of co-integration involves testing for the joint significance of the coefficients of the lagged level variables in equation (17) using the F Wald test as follows:

$$H_o\colon \rho_1 = \rho_2 = \rho_3 = 0 \;\; Vs \;\; H_1\colon \rho_1 \neq \rho_2 \neq \rho_3 \neq 0$$

The ARDL bound test is based on F Wald statistic and the asymptotic distribution of the statistic is non-standard under the null hypothesis of no co-integration. If the computed F Wald statistic lies above the upper bound critical value (or P-value of less than 10 per cent) the null hypothesis is rejected, implying the existence of co-integration amongst the variables in the model. Once the presence of co-integration is established, an appropriate distributed lag error correction model of equation (15) is specified as follows:

$$\Delta\ln(CS)_t = \sum_{h=1}^{3} \partial_h PR_t^h + \sum_{i=1}^{p} \lambda_{1i} \Delta\ln(CS_{t-i}) + \sum_{j=0}^{q} \lambda_{2j} \Delta SP_{t-j} + \sum_{k=0}^{r} \lambda_{3k} \Delta ER_{t-k} + \gamma\mu_{t-1} + \varepsilon_t \qquad (18)$$

Using monthly data from December 1994 to June 2014, the (estimated) orders of an ARDL(p, q, r) model in the three variables $ln(CS)_t$, SP_t and ER_t in equation (17) were selected by searching across the 6^3 =216 ARDL models, spanned by p = 1, 2, ….., 6, q = 1, 2,….,6 and r = 1, 2, ….,6, using the AIC criterion. This resulted in the choice of ARDL (3,1,3) specification for $ln(CS_1)$ and $ln(CS_2)$ with estimates of the levels relationships given by

$$\ln(CS_1)_t = 2.107\, PR_t^1 + 3.070\, PR_t^2 + 3.467\, PR_t^3 - 0.305\, SP_t - 0.014\, ER_t + \hat{\pi}_t \quad (19)$$

and

$$\ln(CS_2)_t = 1.457\, PR_t^1 + 2.485\, PR_t^2 + 2.850\, PR_t^3 - 0.389\, SP_t - 0.017\, ER_t + \hat{\mu} \quad (20)$$

where $\hat{\pi}_t$ and $\hat{\mu}_t$ are the equilibrium correction terms. All the levels estimates are highly significant.

In order to investigate if there is a long run relationship amongst the regressors in the $ln(CS_1)$ and $ln(CS_2)$ models, we conducted the ARDL bounds test of Pesaran *et al*. (2001). We estimated an ARDL(3,1,3) model of equation (17) and conducted the Wald F test for the joint significance of the coefficients of the lagged levels of the included variables H_o. If the coefficients of the lagged levels are jointly zero, we conclude that the variables are not co-integrated. The ARDL (3,1,3) bound test regressions are presented in Table 2, with the associated F Wald statistic and its P-value. The computed F Wald statistic P-value for both models is less than 10 per cent suggesting that the null hypothesis of no co-integration should be rejected, implying the existence of co-integration amongst the variables in the two models.

The associated ECM regression associated with the level relationships in equation (19) and (20) are given in Table 3. The conditional ECM regression also passes the test against residual serial correlation as the hypothesis of no serial correlation in the residuals is accepted in both models. The regression results are satisfactory in spite of the crude measures of expected depreciation or devaluation of the official exchange rate and the foreign exchange risks. All the regressors have the correct sign. The coefficient of the monthly change in

Table 2: Regression Results of ARDL(3,1,3) Bound Testing Approach

Dependent Variable:	$\Delta ln(CS_1)_t$		
Variable	Coefficient	Std Error	P-Value
C	0.3931	0.1351	0.0040
$ln(CS_1)_{t-1}$	-0.1087	0.0404	0.0077
SP_{t-1}	-0.0951	0.0361	0.0089
ER_{t-1}	-0.0028	0.0013	0.0308
$\Delta ln(CS_1)_{t-1}$	-0.6085	0.0690	0.0000
ΔSP_{t-1}	0.1679	0.1141	0.1425
ΔER_{t-1}	0.0080	0.0051	0.1179
$\Delta ln(CS_1)_{t-2}$	-0.3063	0.0743	0.0001
ΔER_{t-2}	-0.0005	0.0029	0.8651
$\Delta ln(CS_1)_{t-3}$	-0.1884	0.0626	0.0029
ΔER_{t-3}	0.0052	0.0029	0.0783
Adjusted R^2		0.3581	
AIC		-0.3854	
F Wald Test		**2.4869**	**0.0614**

Dependent Variable:	$\Delta ln(CS_2)_t$		
Variable	Coefficient	Std Error	P-Value
C	0.2892	0.1012	0.0047
$ln(CS_2)_{t-1}$	-0.0932	0.0368	0.0121
SP_{t-1}	-0.0933	0.0364	0.0112
ER_{t-1}	-0.0028	0.0013	0.0337
$\Delta ln(CS_2)_{t-1}$	-0.6041	0.0681	0.0000
ΔSP_{t-1}	0.1441	0.1139	0.2071
ΔER_{t-1}	0.0076	0.0051	0.1364
$\Delta ln(CS_2)_{t-2}$	-0.3028	0.0738	0.0001
ΔER_{t-2}	0.0001	0.0029	0.9809
$\Delta ln(CS_2)_{t-3}$	-0.1933	0.0625	0.0022
ΔER_{t-3}	0.0061	0.0029	0.0367
Adjusted R^2		0.3487	
AIC		-0.392	
F Wald Test		**2.2604**	**0.0823**

Table 3: Equilibrium Correction Form of the ARDL(3,1,3) Currency Substitution Equation

Dependent Variable:	$\Delta ln(CS_1)_t$		
Regressor	Coefficient	Std Error	P-Value
PR^1_t	0.0273	0.0281	0.3331
PR^2_t	0.0252	0.0199	0.2061
PR^3_t	0.0336	0.0213	0.1155
ΔSP_t	0.1906	0.1125	0.0917
ΔER_t	0.0021	0.0051	0.6805
$\Delta ln(CS_1)_{t-1}$	-0.6053	0.0690	0.0000
ΔSP_{t-1}	0.1106	0.1130	0.3291
ΔER_{t-1}	0.0080	0.0051	0.1652
$\Delta ln(CS_1)_{t-2}$	-0.3061	0.0742	0.0001
ΔER_{t-2}	0.0005	0.0029	0.8556
$\Delta ln(CS_1)_{t-3}$	-0.2016	0.0624	0.0014
ΔER_{t-3}	0.0061	0.0029	0.0369
$\hat{\mu}_{t-1}$	-0.1039	0.0446	0.0208
Adjusted R^2		0.3665	
AIC		-0.3905	
BG-SC Test	**0.0685**		**0.9338**

Dependent Variable:	$\Delta ln(CS_2)_t$		
Regressor	Coefficient	Std Error	P-Value
PR^1_t	0.0307	0.0281	0.2751
PR^2_t	0.0264	0.0199	0.1854
PR^3_t	0.0390	0.0212	0.0674
ΔSP_t	0.2273	0.1122	0.0440
ΔER_t	0.0043	0.0051	0.4000
$\Delta ln(CS_2)_{t-1}$	-0.3032	0.0739	0.0001
ΔSP_{t-1}	0.0816	0.1129	0.4704
ΔER_{t-1}	0.0063	0.0051	0.2157
$\Delta ln(CS_2)_{t-2}$	-0.3032	0.0739	0.0001
ΔER_{t-2}	0.0010	0.0029	0.7382
$\Delta ln(CS_2)_{t-3}$	-0.2104	0.0625	0.0009
ΔER_{t-3}	0.0068	0.0029	0.0184
$\hat{\mu}_{t-1}$	-0.0804	0.0403	0.0470
Adjusted R^2		0.3563	
AIC		-0.3956	
BG-SC Test	**0.0760**		**0.9268**

expected depreciation/devaluation estimated for the short-run equation of the $ln(CS_1)$ and $ln(CS_2)$ variables are significantly different from zero at the 10 and 5 per cent levels, respectively. Thus, any expectation of devaluation/depreciation would have immediate impact on the degree of currency substitution. The third period lag of the changes in exchange rate risk variable for the two models are also statistically significant. While all the dummy variables are not significant in terms of $ln(CS_1)$, the dummy variable representing Yar'adua-Jonathan presisency was statistically significant in explaining $ln(CS_2)$. We can, therefore, infer that the policies implemented since the beginning of the Yar'adua-Jonathan presidency have led to increased currency substitution.

It is revealing to note that persistent rise in exchange rate spread would raise economic agents' suspicion for possible devaluation of the local currency and therefore, may increase his desire for currency substitution. The implication of this is that the monetary authority should ensure that the spread between the official exchange rate and the parallel market rate is contained at any point in time. In addition elevation of the foreign exchange risks resulting from exogenous shocks may facilitate currency substitution. Based on the two definitions of the degree of currency substitution, the empirical results in this paper suggest that exchange rate risks and expected depreciation/devaluation of the exchange rate as well as some of the political uncertainties during the Yar'adua-Jonathan presidency were the main causal factors of currency substitution in Nigeria.

5.2 Effects of Currency Substitution

The monetary and real effects of currency substitution on economic activity will depend on the degree to which domestic currency is being displaced by foreign currency. Ortiz (1983) observes that "*If the substitution process goes to the extreme of eliminating or substantially reducing the circulation of domestic coin and currency, the monetary habitat of the country will be changed*". This implies giving up to the country issuing the substitute currency the seniorage of money creation and eroding the base of the inflation tax. Even in less drastic situations, it has been pointed out in the currency substitution literature that substantial monetary instability might arise as a result of diversified currency holdings by domestic residents. The relevance of this substitution problem for monetary policy can only be evaluated empirically.

To explore the relevance of this question for the case of Nigeria, a conventional money demand equation was estimated using quarterly data from Q4 1994 to Q2 2014., based on the three definitions of the monetary aggregates and the money demand function defined in equations (11) to (14), respectively. Fig 3 presents the plot of the three definitions of real money balances $RM_1 = M^j/P$, $RM_{21} = M^k/P$, and $RM_2 = M^h/P$, with P being the price level over the study period.

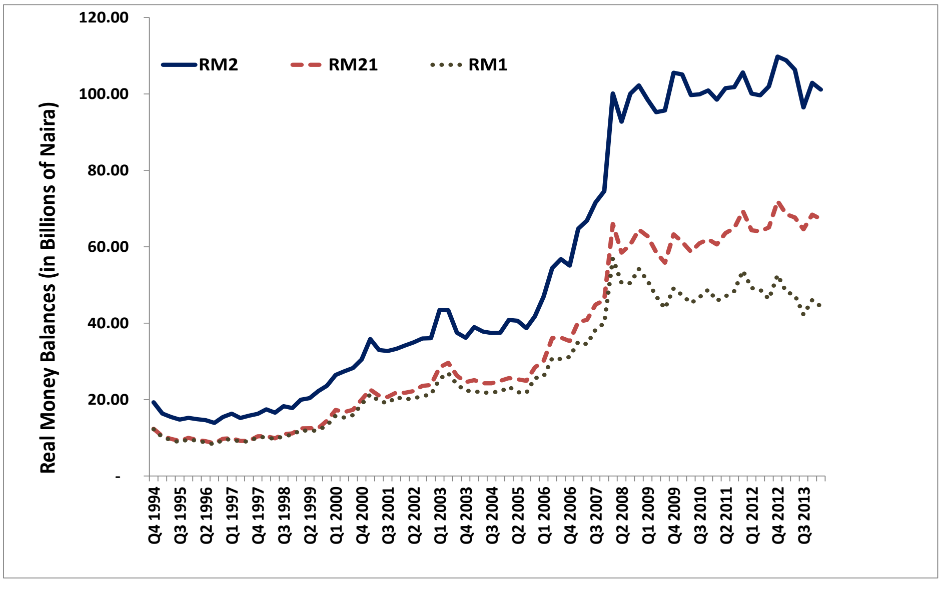

Fig 3: Real Money Balances

The unit root test conducted on the variables in equation (14) suggests the use of the ARDL approach to estimate the parameters of the model. Using quarterly data covering the period Q4 1994 to Q1 2014, the (estimated) orders of an ARDL(p, q, r, s, v, w) model in the six variables $ln(M^{j,k,h}/P)_t$, $ln(Y_t)$, RD_t, FR_t, IR_t and SP_t in equation (14) were selected by searching across the 4^6 =4096 ARDL models, spanned by $p = 1,2,\ldots,4$, $q = 1,2,\ldots,4$, $r = 1,2,\ldots,4$, $s = 1,2,\ldots,4$, $v = 1,2,\ldots,4$ and $w = 1,2,\ldots,4$, using the AIC criterion. This resulted in the choice of ARDL (4,1,1,2,1,1) specification for the models with estimates of the levels relationships given by

$$\ln(RM_1)_t = -12.879 + 1.432\ln(Y_t) + 0.007\,RD_t + 0.001\,IR_t - 0.019\ FR_t - 0.148\,SP_t \quad + \hat{\pi}_t \qquad (21)$$

$$\ln(RM_{21})_t = -16.628 + 1.678\ln(Y_t) + 0.003\,RD_t + 0.002\,IR_t - 0.028\ FR_t - 0.149\,SP_t \quad + \hat{\tau}_t \qquad (22)$$

and

$$\ln(RM_2)_t = -16.351 + 1.689 \ln(Y_t) + 0.002\, RD_t + 0.001\, IR_t - 0.025\; FR_t - 0.138\, SP_t \quad + \hat{\mu}_t \qquad (23)$$

where $\hat{\pi}_t$, $\hat{\tau}_t$ and $\hat{\mu}_t$ are the equilibrium correction terms. The levels estimates for $ln(Y_t)$, SP_t and the constant are significant for all the three equations. The foreign interest rate coefficient (FR_t)is significant for the RM_{21} equation only, while all the other variables coefficients are not statistically significant. The ARDL (4,1,1,2,1,1) bound test regressions results using Eviews software are presented in Table 4, with the associated *F* Wald statistics and their P-values. The P values for the computed *F* Wald statistic of the three models are less than 10 per cent implying that the null hypothesis of no co-integration should be rejected. This suggests the existence of co-integration amongst the variables.

Table 4: Regression Results of ARDL(4,1,1,2,1,1) Bound Testing Approach

Dependent Variable:	$\Delta\ln(M^j/P)_t$		$\Delta\ln(M^k/P)_t$		$\Delta\ln(M^h/P)_t$	
Variable	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
C	2.6112	0.1540	2.1418	0.2602	1.5235	0.3312
$\ln(M^{j,k,h}/P)_{t-1}$	0.0872	0.2471	0.0808	0.2605	0.1154	0.0608
$\ln(Y)_{t-1}$	-0.2102	0.1536	-0.1785	0.2442	-0.1707	0.1821
RD_{t-1}	-0.0076	0.1296	-0.0047	0.3129	0.0008	0.8411
IR_{t-1}	-0.0033	0.0233	-0.0041	0.0049	-0.0036	0.0084
FR_{t-1}	0.0294	0.0016	0.0280	0.0018	0.0334	0.0002
SP_{t-1}	-0.0386	0.0396	-0.0340	0.0607	-0.0184	0.2228
$\Delta\ln(M^{j,k,h}/P)_{t-1}$	-0.5521	0.0009	-0.5508	0.0007	-0.6019	0.0004
$\Delta\ln(Y)_{t-1}$	0.0663	0.5768	0.0366	0.7562	0.0374	0.7182
ΔRD_{t-1}	-0.0043	0.5633	-0.0049	0.4819	-0.0021	0.7457
ΔIR_{t-1}	0.0025	0.2804	0.0018	0.4133	-0.0001	0.9598
ΔFR_{t-1}	-0.0165	0.5924	-0.0187	0.5265	0.0060	0.8250
ΔSP_{t-1}	0.0072	0.7874	-0.0073	0.7759	-0.0175	0.4389
$\Delta\ln(M^{j,k,h}/P)_{t-2}$	-0.5081	0.0013	-0.5220	0.0010	-0.4578	0.0048
ΔIR_{t-2}	-0.0041	0.0711	-0.0042	0.0497	-0.0014	0.4330
$\Delta\ln(M^{j,k,h}/P)_{t-3}$	-0.3340	0.0200	-0.2897	0.0400	-0.4375	0.0036
$\Delta\ln(M^{j,k,h}/P)_{t-4}$	0.0487	0.7269	0.0328	0.8110	0.0371	0.8003
Adjusted R^2	0.2857		0.2711		0.2817	
AIC	-2.1977		-2.3019		-2.5738	
F Wald Test	**3.6745**	**0.0038**	**3.6918**	**0.0037**	**3.6661**	**0.0039**

The associated ECM regression associated with the level relationships in equations (21) to (23) are given in Table 5. The conditional ECM regression also passes the test against residual serial correlation as the hypothesis of no serial correlation in the residuals is accepted in the three models. The regression results are also satisfactory. The results for the two definitions of money RM_1 and RM_{21} are very similar. However, the results for the RM_2 model appear to conform to the priori expectations. All the ECM terms have the correct signs, but not statistically significant.

Table 5: Equilibrium Correction Form of the ARDL(4,1,1,2,1,1) - Effects of Currency Substitution in Real Money Balances

Dependent Variable:	$\Delta\ln(M^j/P)_t$		$\Delta\ln(M^k/P)_t$		$\Delta\ln(M^h/P)_t$	
Variable	Coefficient	P-Value	Coefficient	P-Value	Coefficient	P-Value
C	0.0017	0.8931	0.0020	0.8851	0.0052	0.6587
$\Delta\ln(Y)_t$	0.2324	0.0414	0.2709	0.0243	0.2074	0.0403
ΔRD_t	-0.0003	0.9739	-0.0016	0.8327	0.0012	0.8601
ΔIR_t	-0.0032	0.2315	-0.0025	0.3200	-0.0042	0.0600
ΔFR_t	-0.0933	0.0073	-0.0766	0.0292	-0.0424	0.1831
ΔSP_t	-0.0503	0.0571	-0.0455	0.0749	-0.0312	0.1564
$\Delta\ln(M^{j,k,h}/P)_{t-1}$	0.0034	0.9781	-0.0116	0.9308	0.0010	0.9944
$\Delta\ln(Y)_{t-1}$	-0.0695	0.5309	-0.1018	0.3767	-0.0511	0.6139
ΔRD_{t-1}	-0.0068	0.3748	-0.0042	0.5695	0.0024	0.7221
ΔIR_{t-1}	0.0013	0.5664	0.0007	0.7729	-0.0009	0.6694
ΔFR_{t-1}	0.0926	0.0068	0.0728	0.0287	0.0740	0.0196
ΔSP_{t-1}	0.0151	0.5868	0.0059	0.8310	-0.0064	0.7895
$\Delta\ln(M^{j,k,h}/P)_{t-2}$	0.1275	0.2969	0.1053	0.4089	0.1488	0.2248
ΔIR_{t-2}	-0.0020	0.3510	-0.0019	0.3637	0.0001	0.9520
$\Delta\ln(M^{j,k,h}/P)_{t-3}$	0.0566	0.6676	0.1375	0.3156	0.0527	0.7032
$\Delta\ln(M^{j,k,h}/P)_{t-4}$	0.4515	0.0006	0.4493	0.0008	0.4917	0.0002
$\hat{\pi}_{t-1}$	-0.1479	0.1027				
$\hat{\tau}_{t-1}$			-0.1601	0.1013		
$\hat{\mu}_{t-1}$					-0.0593	0.4537
Adjusted R^2	0.2346		0.1886		0.2023	
AIC	-2.1285		-2.1945		-2.4689	
BG-SC Test	**0.4930**	**0.6135**	**0.2452**	**0.7834**	**1.6678**	**0.1982**

Perhaps the most striking difference is the change in real income elasticity term, which turns out to be positive and significant on the real demand for money functions. The coefficient of the change in the domestic short-term (3 months) deposit rate current and lag one quarter has the expected sign though not significant. The change in short-term foreign deposit interest rate lag one quarter is positive and significantly different from zero for all the short-run equations.

The coefficient of the foreign interest rate variable on the aggregate is positive and significant for the broad definition of money (RM_2), indicating strong empirical evidence of currency substitution in Nigeria. Thus, on the short-run an increase in the short-term money markets foreign interest rate in the current quarter will put an upward pressure on the demand for money in Nigeria in the next quarter. This will imply that a considerable amount of instability may be imported from foreign territories as the demand for domestic currency is significantly influenced by foreign factors.

Also, high inflation expectation is expected to erode the current value of the domestic currency and would tend to increase currency substitution as the inflation expectation coefficients in the current period for all the short-run equations were negative and significant for real broad money balances. While there may be a ratchet effect in the currency allocation of deposits, such an effect can be detected for the deposit – only CS ratio (CS_1 or CS_2). The presence of the ratchet effect, which captures the extent of persistence in currency substitution, if confirmed, will suggests that the Nigerian economy has reached a degree of currency substitution that would make the process asymmetric and difficult to reverse, implying that monetary policy may not have an impact on the portfolio decisions of the private sector.

6.0 Conclusion

The econometric results indicate that the behavior of the foreign currency/naira demand deposit ratio in Nigeria has been influenced by devaluation expectations and exchange rate risk as well as some of the policies being pursued since the advent of the democratic governance.

The money demand estimations show that short-term foreign money market interest rates do significantly affect the demand for Naira, so there is strong evidence of currency substitution. Moreover, while there may be a ratchet effect in the currency allocation of deposits, such an effect can be detected for the deposit – only CS ratio (CS_1 or CS_2).

The presence of the ratchet effect, if established, may suggest that the Nigerian economy has reached a degree of currency substitution that would make the process asymmetric and difficult to reverse. This may imply that monetary policy may not have the expected impact on the portfolio decisions of the private sector.

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Forecasting Nigerian Stock Market Returns using ARIMA and Artificial Neural Network Models

[1]Godknows M. Isenah and Olusanya E. Olubusoye

The study reports empirical evidence that artificial neural network based models are applicable to forecasting of stock market returns. The Nigerian stock market logarithmic returns time series was tested for the presence of memory using the Hurst coefficient before the models were trained. The test showed that the logarithmic returns process is not a random walk and that the Nigerian stock market is not efficient. Two artificial neural network based models were developed in the study. These networks are $TECH\ (4-3-1)$ *and* $TECH\ (3-3-1)$ *whose out-of-sample forecast performance was compared with a baseline* $ARIMA\ (3,0,1)$ *model. The results obtained in the study showed that artificial neural network based models are capable of mimicking closely the log-returns as compared to the* $ARIMA$ *based model. The out-of-sample evaluations of the trained models were based on the* $RMSE$, MAE, $NMSE$ *and the directional change metric* D_{stat} *respectively. Based on these metrics, it was found that the artificial neural network based models outperformed the* $ARIMA$ *based model in forecasting future developments of the returns process. Another result of the study shows that instead of using extensive market data, simple technical indicators can be used as predictors for forecasting future values of the stock market returns given that the returns has memory of its past.*

Keywords: Artificial neural networks, Long memory, Random walk, Forecasting, Training, Stock Market Returns, Technical analysis indicator, ARIMA.

JEL Classification: E44, G17

1.0 Introduction

Artificial neural networks are one of the most popular tools for forecasting financial and economic time series. They are universal and highly flexible function approximators for pattern recognition and classification, [Beresteanu (2003); Chan *et al.* (2009)]. An artificial neural network based model requires

[1] Department of Statistics, University of Ibadan, Nigeria *E-mail*: isenahgodknows@yahoo.com,oe.olubusoye@mail.ui.edu.ng

no prior assumptions on the behaviour and functional form of the related variables, but can still capture the underlying dynamics and nonlinear relationships that exist amongst the variables. This paper proposes artificial neural network based models for forecasting the *Nigerian Stock Exchange All-Share-Index* logarithmic returns, and comparing the out-of-sample forecast performance of the networks with a baseline $ARIMA\ (p, d, q)$ model.

In stock market predictions, many methods for technical analysis and forecasting have been developed and are being used, [see Pring (1985)]. In technical forecasting, technical indices (*in the form of rolling means, rolling standard deviations/or variances, lagged values etc.*) are usually computed from a time series and are used to forecast future changes in the levels of the series. Several artificial neural network based models have been developed for stock market forecasting. Some of these models are applied to forecasting the future rates of changes of stock prices, [see Kimoto *et al* (1990)], and some are applied to recognizing certain patterns in stock prices that are characteristics of the future price changes, [Kamojo and Tanigawa (1990)]. The performance of artificial neural networks has been extensively compared to that of various parametric statistical methods within the areas of prediction and classification [Ripley (1996)]. In particular, some literature on time series forecasting using artificial neural networks has been generated, though, with mixed results. Some of the articles reviewed on the performance of artificial neural networks at the time of this study are Lepedes and Farber (1987), Tang *et al*. (1991), Shada(1994) and Stern (1996). These articles show that neural network models outperform conventional parametric models especially for time series with little or no stochastic component. An interesting result by Tang *et al*. (1991) is that the relative performance of an artificial neural network model is influenced by the memory of the time series when compared with the Box-Jenkins ARIMA models.

In Nigeria, Akinwale *et al.* (2009) used regression neural network with back-propagation algorithm to analyze and predict *translated* and *un-translated* Nigerian stock market prices (NSMP). Their study compared forecast performance of the neural networks with translated and un-translated NSMP as inputs, and this revealed that the network with translated NMSP inputs outperformed the network with un-translated NSMP inputs. In terms of prediction accuracy measures, the translated NSMP network predicted accurately 11.3% of the stock prices as compared to 2.7% prediction accuracy of the un-translated NSMP network model.

Similarly, from the ARIMA scheme's perspective of forecasting the Nigerian stock market returns, Ojo and Olatayo (2009) studied the estimation and performance of subset autoregressive integrated moving average (ARIMA) models. They estimated parameters for ARIMA and *subset* ARIMA processes using numerical iterative schemes of Newton-Raphson and the Marquardt-Levenberg algorithms. The performance of the models and their residual variance were examined using AIC and BIC. The result of their study showed that the SARIMA model outperformed the ARIMA model with smaller residual variance. On the other hand, Emenike (2010) studied the NSE market returns series using monthly data of the All-Share-Index for the period January 1985 through December 2008. In his study, an ARIMA (1,1,1) model was selected as a tentative model for predicting index points and growth rates. The results revealed that the global meltdown destroyed the correlation structure existing between the NSE All-Share-Index and its past values. Agwuegbo *et al.* (2010) also studied the daily returns process of the Nigerian Stock Market using *Discrete Time Markov Chains*$(DTMC)$, and *martingales*. Their study provided evidence that the daily stock returns process follows a random walk, but that the stock market itself is not efficient even in weak form.

Several other studies that have used ARIMA schemes for analysis and forecasting of stock market prices/or returns in Africa include Simons and Laryea (2004), Rahman and Hossain (2006), and Al-Shiab (2006) among others. These studies did not test whether or not the stock price/or returns processes are fractal in nature. This we intend to determine for the Nigerian stock market before we proceed with further analysis.

For our study, we will apply the *Feed-forward multilayer perceptron (MLP) neural network models* with a single hidden layer. The architecture of the log-returns prediction system for the Nigerian stock market consists of a pre-processing unit, a MLP neural network and a post-processing unit. The pre-processing unit scales each of the inputs (*the predictors*) to have zero mean and standard deviation of 1, before they are passed into the network for processing. In a similar fashion, the response variable (*log-return*) is scaled to fall within the interval of the activation functions of the neural network. The output/or signal produced by the neural network is then passed to the post-processing unit which converts the networks output/or signal to the predicted stock market returns.

The Box and Jenkins (1976) ARIMA method of forecasting is different from most optimization based methods. This technique does not assume any particular pattern in the historical data of the time series to be forecasted. It uses iterative procedures to identify a tentative model from a general class of models. The chosen model is then checked for adequacy and if found to be inadequate, the modeling process is repeated all over again until a satisfactory model is found.

The rest of the study is as follows: Section 2 discusses the Methodology, Random Walk and Efficient Market Hypothesis, Tools for detection of memory in time series, Statistical concepts and Training of artificial neural networks. Section 3 discusses the proposed models and data analysis. Section 4 gives results and discussions, while Section 5 ends with summary and conclusion.

2.0 Methodology

2.1 The random walk and efficient market hypotheses

A school of thought in the theory of financial econometrics that is widely accepted by financial economists is the *Efficient Market Hypothesis*(EMH). They believe generally that financial markets are very efficient in reflecting information about individual securities traded in the markets and about the market as a whole. The EMH states, according to Ongorn (2009) that prices of securities traded, for example: stocks, bonds, or properties reflects all known information and therefore are unbiased in the sense that they reflect the collective beliefs of all investors about the future prospects. Under the EMH, information is quickly and efficiently incorporated into asset prices at any point in time, so that the price history cannot be used to predict future price movements of the assets. In general, under theEMH, an asset price, say stocks, denoted by S_t already incorporates all relevant information, and the only reason for the prices to change between time t and time $t+1$ will be due to shocks. The EMH therefore postulates that the assets price process follow a *random walk*. The random walk model without drift parameter is expressed as:

$$S_t = S_{t-1} + \varepsilon_t, \qquad t = 1, 2, \dots, n \qquad (1)$$

where $\varepsilon_t \sim iid(0, \sigma_\varepsilon^2)$ is a white noise process. When ε_t is not a white noise process, the price series is said to have memory which violates the EMH, [Shiriaev, (1999)]. According to Fama (1965; 1995), a stock market where successive price changes in individual securities are independent, is by definition a random walk. Stock prices following a random walk imply that the price changes are independent of one another as the gains and losses [Kendal, (1953)]. The independence of the random walk or the EMH is valid as long as the time series of the price changes of the securities does not have memory. In this study, our objective is to forecast the monthly logarithmic returns of the NSE using artificial neural network based models with technical analysis indicators of the returns as inputs. This objective can only be achieved if the log-returns process has memory. And to test for the presence of memory in the returns series, we employed the fractional difference parameter (d) of a fractal time series; the Hurst (1951) coefficient (H); and the sample autocorrelation and partial autocorrelation functions (ACF) and $(PACF)$ respectively.

2.2 Tools for detection of memory in stock market returns time series

The Hurst coefficient(H), is a measure of the bias in fractionally integrated time series. This coefficient could be used to test financial time series for the presence of memory. The presence of memory in a time series indicates the possibility of predicting the future values using its history. The rescaled range, (R/S) analysis which was proposed by Hurst (1951), and later refined by Mandelbrot and Ness (1968) and Mandelbrot (1975; 1982), is able to distinguish a random series from a fractionally integrated series, irrespective of the distribution of the underlying process. The R/S statistic is the range of partial sums of deviations of a time series from its mean, rescaled by its standard deviation. Specifically, let X_t denote a stationary time series, then the R/S statistic is defined as:

$$R/S = \frac{1}{S_N}\left[\max_{1\le k\le N}\sum_{t=1}^{K}(X_t - \bar{X}) - \min_{1\le k\le N}\sum_{t=1}^{K}(X_t - \bar{X})\right] \qquad (2)$$

where $\bar{X} = \frac{1}{N}\sum_{t=1}^{N} X_t$ is the sample mean and $S_N = \left[\frac{\sum_{t=1}^{N}(X_t - \bar{X})^2}{N}\right]^{1/2}$ is the sample standard deviation. When there is absence of long memory in a stationary time series, the R/S statistic converges to a random variable $N^{-1/2}$, where N denotes the length of the time series. However, when the stationary time series X_t has long memory, Mandelbrot (1975) showed that the R/S statistic converges to a random variable at N^H, where H is the Hurst coefficient, [see also Zivot and Wang (2003) for more details].

The Hurst coefficient is computed using the expression:

$$H = \frac{\log(R/S)}{\log(N)} \tag{3}$$

It describes three distinct categories of time series. These categories are:(i) $H = 1/2$describe uncorrelated noise processes, whether they are Gaussian or not; (ii) $0 \leq H < 1/2$describe ergodic processes with frequent reversals and high volatility, and(iii) $1/2 \leq H < 1$describe reinforcing processes that are characterized by long memory.The Hurst coefficient H is related to the *fractional differencing* parameter d, of a fractionally integrated time series. The relationship is given by:

$$d = H - \frac{1}{2} \tag{4}$$

According to Hosking (1981; 1996) and Mills (2007), for values of $d \in (0, \frac{1}{2})$, the series is stationary and has long memory. For values of $d \in (-\frac{1}{2}, 0)$, the time series is anti-persistent, while for values of $d \in (-\frac{1}{2}, \frac{1}{2})$, the series is stationary and ergodic. Therefore, the Hurst coefficient and the fractional difference parameter, d can be used interchangeably for testing for the presence of long memory in a stationary time series.

The monthly NSE All-Share-Index logarithmic returns are defined as:

$$r_t = ln\left[\frac{NSE\ INDEX_t}{NSE\ INDEX_{t-1}}\right] = \Delta ln[NSE\ INDEX_t] \tag{5}$$

The application of the memory tests just discussed on the log-returns series give the results reported in Table 1. From these results, we conclude that the monthly log-returns do not follow a random walk and neither is the Nigerian Stock market efficient; this confirming one of the results provided by

Agwuegbo *et al* (2010). Figures 1 through 3 (see Appendix) show the time plots of the monthly NSE All-Share-Index and the monthly logarithmic returns; sample ACF and $PACF$; the histogram and quantile-quantile plot of the log-returns. The graphs show that the returns process is stationary, but its distribution is leptokurtic and skewed to the left with long tails. While the plots of sample ACF and $PACF$ further confirm the results of the memory test above by showing small but significant spikes in the correlograms.

Table 1: Sample descriptive statistics of NSE log returns and memory test results

Series length (N)	Mean of log returns $(\bar{r})$	Variance of log returns $(S_{r_t}^2)$	Standard deviation of log returns (S_{r_t})	Rescaled range statistic (R/S)	Hurst coefficient (H)	Fractional difference parameter (d)
311	0.01738	0.00383	0.0686	2.05104	0.609996	0.109996

2.3 Statistical concepts

The MultiLayer Perceptron (MLP) neural networks describe mapping of input variables $\boldsymbol{X} \in \mathbb{R}^p$ onto the output variable $\boldsymbol{y} \in \mathbb{R}^q$. For the feed-forward multilayer perceptron neural network with a single hidden layer and one output variable, $(q = 1)$, $\boldsymbol{y} \in \mathbb{R}$ is a function of the vector of input variables $\boldsymbol{X}$. This relationship can be expressed using an MLP neural network model of the form:

$$y_{nn} = \gamma_0 + \sum_{h=1}^{H} \gamma_h \psi\left(\omega_{0,h} + \sum_{j=1}^{p} \omega_{j,h} x_j\right) = g_h(\boldsymbol{\gamma}_h^T \boldsymbol{N}) \qquad (6i)$$

where we define

$$N_h = \psi\left(\omega_{0,h} + \sum_{j=1}^{p} \omega_{j,h} x_j\right) = \psi(\boldsymbol{\omega}_{0,h} + \boldsymbol{\omega}_h^T \boldsymbol{X}) \qquad (6ii)$$

$\boldsymbol{N} = (N_1, N_2, \dots, N_H)$ is the vector of hidden layer nodes of the network; $g_h(.)$ is a function of the hidden layer nodes; H denotes the number of nodes in the hidden layer; $\psi(.)$ is an activation function, and T denotes the transpose of a matrix. The parameter vector:

$\boldsymbol{\Omega} = (\boldsymbol{\omega}, \boldsymbol{\gamma}) = (\omega_{0,1}, \cdots, \omega_{p,1}, \omega_{0,2}, \cdots, \omega_{p,h};\ \gamma_0, \cdots, \gamma_H)^T \in \mathbb{R}^{H(p+1)+H+1}$ contains all the weights of the neural network.

Artificial neural networks are known to possess the properties of *universal approximators,* hence, it is possible to construct nonparametric estimators for regression functions, [see Hornik *et al* (1989), Beresteanu (2003) and Franke *et al.*(2004) for more details]. Given the regression time series model:

$$\boldsymbol{y}_t = f(\boldsymbol{X}_t;\ \boldsymbol{\Omega}) + \boldsymbol{\varepsilon}_t \tag{7}$$

The response function, $f(\boldsymbol{X}_t;\ \boldsymbol{\Omega})$ can be approximated by fitting a neural network model to the predictor variables: $X_{1t}, X_{2t}, \cdots, X_{pt}$ and the response variable y_t. The parameters of the network can be estimated using the nonlinear least squares estimator$\widehat{\Omega}$ obtained by minimizing:

$$Q_n(\Omega) = \sum_{t=1}^{n} \left(y_t - y_{nn,t}\right)^2 = \sum_{t=1}^{n} \sum_{h=1}^{H} \left(y_t - g_h(\widehat{\boldsymbol{\gamma}}_h^T \boldsymbol{N}_t)\right)^2 \tag{8}$$

where $y_{nn,t} = g_h(\widehat{\boldsymbol{\gamma}}_h^T \boldsymbol{N}_t)$ denotes the fitted neural network model.

2.4 Estimation/or training of neural networks

The least squares criterion given by Equation (8) is obviously a nonlinear function of $\boldsymbol{\Omega}$. In this study, the $Quasi - Newton$ iterative scheme will be applied for the minimization of $Q(\boldsymbol{\Omega})$. The iterative scheme is a *local gradient-based search*, in which the first and second order derivatives of $Q(\boldsymbol{\Omega})$ with respect to the weight vector $\boldsymbol{\Omega}$, and continuous updating of the initial conditions of $\boldsymbol{\Omega}$, by the derivatives until some stopping criteria are met. Given the initial weight vector $\boldsymbol{\Omega}_0$, we obtain a second-order Taylor series expansion of $Q(\boldsymbol{\Omega})$, given as:

$$Q(\boldsymbol{\Omega}) \approx Q(\boldsymbol{\Omega}_0) + \boldsymbol{\nabla}'(\boldsymbol{\Omega} - \boldsymbol{\Omega}_0) + \frac{1}{2}(\boldsymbol{\Omega} - \boldsymbol{\Omega}_0)'\boldsymbol{\delta}_0(\boldsymbol{\Omega} - \boldsymbol{\Omega}_0) \tag{9}$$

where $\boldsymbol{\nabla} = \frac{\partial Q}{\partial \boldsymbol{\Omega}}$ is the gradient of $Q(\boldsymbol{\Omega})$ evaluated at $\boldsymbol{\Omega}_0$ and $\boldsymbol{\delta}_0 = \frac{\partial^2 Q}{\partial \boldsymbol{\Omega} \partial \boldsymbol{\Omega}'}$ is the Hessian of $Q(\boldsymbol{\Omega})$ evaluated at $\boldsymbol{\Omega}_0$. The approximating sum of squares function $Q(\boldsymbol{\Omega})$ will have a stationary point when its gradient is zero, that is:

$$\boldsymbol{\nabla} + \boldsymbol{\delta}_0(\boldsymbol{\Omega} - \boldsymbol{\Omega}_0) = \mathbf{0}$$

and this stationary point will be a minimum if $\boldsymbol{\delta}_0$ is positive definite. If $\boldsymbol{\delta}_0$ is positive definite, then the Newton-Raphson step is:

$$\boldsymbol{\Omega} - \boldsymbol{\Omega}_0 = -\boldsymbol{\delta}_0^{-1}\boldsymbol{\nabla} \tag{10}$$

The generic approach to the minimization of $Q(\boldsymbol{\Omega})$ is the*back-propagation*. The back-propagation algorithm is a two-pass filter, [Friedman *et al*. (2008)]. This can be computed by a forward and backward sweep over the network, keeping track of only quantities local to each unit of the network. To create the filter, the partial derivatives of (8) with respect to γ_h and ω_j are calculated, which are respectively given by:

$$\frac{\partial Q(\Omega)}{\partial \gamma_h} = -2[y_t - g_h(\hat{\boldsymbol{\gamma}}_h^T \boldsymbol{N}_t)]g'_h(\hat{\boldsymbol{\gamma}}_h^T \boldsymbol{N}_t)N_{h,t} \tag{11}$$

And

$$\frac{\partial Q(\Omega)}{\partial \omega_j} = -2\sum_{h=1}^{H}[y_t - g_h(\hat{\boldsymbol{\gamma}}_h^T \boldsymbol{N}_t)]\, g'_h(\hat{\boldsymbol{\gamma}}_h^T \boldsymbol{N}_t)\gamma_h \psi'(\boldsymbol{\omega}_h^T \boldsymbol{X}_t)X_{j,t} \tag{12}$$

The gradient descent update at the $(r+1)^{st}$ iteration using these derivatives has the form:

$$\gamma_h^{(r+1)} = \gamma_h^r - \varphi_r \sum_{t=1}^{n} \frac{\partial Q(\Omega)}{\partial \gamma_h^{(r)}}$$

and

$$\omega_j^{(r+1)} = \omega_j^{(r)} - \varphi_r \sum_{t=1}^{n} \frac{\partial Q(\Omega)}{\partial \omega_j^{(r)}}$$

where φ_r is the learning rate. Rewriting (13) and (14) as:

$$\frac{\partial Q(\Omega)}{\partial \gamma_h} = \theta_h N_{h,t}$$

and

$$\frac{\partial Q(\Omega)}{\partial \omega_j} = \emptyset_j X_{j,t}$$

The quantities θ_h and $\emptyset_j$ are errors from the current model at the output and hidden layer units respectively. These errors satisfy $\emptyset_j = N_{h,t} \sum_{h=1}^{H} \gamma_h \theta_h$, which is known as *back-propagation*, [Friedman *et al.*(2008)].

3.0 Proposed artificial neural network based models and data analysis

3.1 The proposed models

The proposed artificial neural network based models to be trained in the study are the multilayer perceptron (MLP) feed-forward neural networks with one hidden and oneoutput layers and without *skip* connections. The neural network's architecture is of the form:

And inputs nodes function:

$$n_{h,j} = \widehat{\omega}_{h,0} + \sum_{j=1}^{p} \widehat{\omega}_{h,j} X_{jt} \qquad (13)$$

Activation or hidden nodes function:

$$N_{h,t} = \psi(n_{h,t}) = \frac{1}{1 + e^{-n_{h,t}}} \qquad (14)$$

Output node function:

$$\hat{r}_{t.scaled} = g(N_{h,t}, \hat{\gamma}) = \hat{\gamma}_0 + \sum_{h=1}^{H} \hat{\gamma}_h N_{h,t} \qquad (15)$$

Following the approach of Yao and Tan (2000) and Erik (2002), the neural network's architecture is denoted as: $I - H - O$, where I denotes the input layer size, H the hidden layer size and O the output layer size respectively.

3.2 Data segmentation, input selection and processing

The log-returns time series is segmented into *training* and *test* data sets respectively. The training data set comprises of data points from January 1985 through December 2009, while the test data set comprises of data points from January, 2010 through December, 2010.

The inputs selected for the networks are technical indices. These indices are:(i) Rolling means denoted as*: One-month* ($ma1$), *three-month* ($ma3$), *six-month* ($ma6$)and *twelve-month* ($ma12$) *moving averages*.(ii) Lagged values of the log-returns denoted as: *one-period* lagged values(r_{t-1}), *two-period* lagged values(r_{t-2})and *three-period* lagged values(r_{t-3}).

Since the activation function chosen (i.e. the *logistic function*) has its output values in the interval [0, 1], the output variable was first scaled to have values in this interval using the transformation:

$$r_{t.scaled} = \frac{r_t - \min(r_t)}{\max(r_t) - \min(r_t)}$$

The de-scaled log-returns fitted by the network are then obtained using the expression:

$$\hat{r}_t = [\max(r_t) - \min(r_t)] * \hat{r}_{t.scaled} + \min(r_t).$$

Similarly, the input variables (*technical indices*) were normalized to have mean zero and standard deviation of one using:

$$z_t = \frac{r_t - \bar{r}}{\hat{\sigma}_{r_t}}$$

3.3 Evaluation of neural networks

In- sample-evaluations criteria

The structures of the fitted neural networks at the training stages are compared using the following order determination criteria to decide the best networks.

- Akaike information criterion (AIC) defined by:

$$AIC = ln\left[\frac{1}{N}\sum_{t=1}^{N}(r_t - \hat{r}_t)^2\right] + \frac{2k}{N}$$

- Hannan-Quinn information criterion ($HQIF$) defined by:

$$HQIF = ln\left[\frac{1}{N}\sum_{t=1}^{N}(r_t - \hat{r}_t)^2\right] + \frac{k}{N}ln[ln(N)]$$

- Bayesian information criterion (BIC) defined by:

$$BIC = ln\left[\frac{1}{N}\sum_{t=1}^{N}(r_t - \hat{r}_t)^2\right] + \frac{k}{N}ln(N)$$

where k is the number of estimated parameters.

Out-sample-evaluations criteria

Comparisons of the predictive powers of the trained models are determined by the use of the following metrics.

Root mean square error defined by:

$$RMSE = \frac{1}{\tau^*}\left[\sum_{\tau=1}^{\tau^*}(r_\tau - \hat{r}_\tau)^2\right]^{1/2}$$

Mean absolute error defined by:

$$MAE = \frac{1}{\tau^*}\sum_{\tau=1}^{\tau^*}|r_\tau - \hat{r}_\tau|$$

Normalized mean square error defined by:

$$NMSE = \frac{\sum_{\tau=1}^{\tau^*}(r_\tau - \hat{r}_\tau)^2}{\sum_{\tau=1}^{\tau^*}(r_\tau - \bar{r})^2} = \frac{1}{N\sigma_{\tau^*}^2}\sum_{\tau=1}^{\tau^*}(r_\tau - \hat{r}_\tau)^2$$

Directional change statistic defined by:

$$D_{stat} = \frac{1}{N}\sum_{\tau=1}^{\tau^*}b_\tau$$

where $b_\tau = \begin{cases}1, & if\ (r_{\tau+1} - r_\tau)(\hat{r}_{\tau+1} - \hat{r}_\tau) \geq 0 \\ 0, & otherwise\end{cases}$ and τ^* is the number of observations in the test data set and $\{\hat{r}_t\}$.

4.0 Results and Discussions

This section presents discussions and the results obtained in the process of analyzing the data using S-PLUS 6.1 Professional Edition. The following parameters were held constant at their respective values throughout the training process. Maximum number of iteration per fitted neural network: *200*, Tours: *300*, Range (random range from uniform distribution for weight vector selection):[-0.7, +0.7], Absolute tolerance:10^{-4}, Relative tolerance:10^{-8}, and Output type: *Linear*. The *penalty* parameters were varied at the values 0.001, 0.01, 0.05 and 0.10 for each trained neural network model.

4.1 Technical Analysis and Forecasting using Rolling Means as Inputs to the Networks

The hidden layer size was varied from 2 through 6 neurons, and a total of 1500 neural network models were trained for a given value of the penalty parameter,λ. Table 2 shows a summary of the best fitted network models for each value of λ. Based on the reports of the in-sample information criteria, the neural network model $TECH$ $(4-3-1)$ with $\lambda = 0.001$ was chosen as a tentative model. The eigen-values of the Hessian matrix of this neural network are all positive, indicating that the iterations converged to a global minimum. The out-of-sample evaluations reports of the estimated neural network are given in Table 3. The reported $RMSE$, MAE and the $NMSE$ values are quite small, they show that the network performed well in the held-out sample. Similarly, the directional statistic D_{stat} shows that the network was able to predict 45% of positive directional change of the log-returns in the held-out sample.

Table 2: Summary of best trained networks with MA inputs for the different values of the decay, λ.

Best fitted network	Decay (λ)	Size of hidden node	Number of estimated weights	Final sum of squared residuals	R^2	AIC	HQIF	BIC
TECH (4-3-1)	**0.001**	**3**	**19**	**0.69583**	**0.71324**	**-5.898**	**-5.915**	**-5.657**
TECH (4-2-1)	0.01	2	13	0.86795	0.64231	-5.718	-5.73	-5.553
TECH (4-2-1)	0.05	2	13	0.99498	0.58996	-5.582	-5.593	-5.417
TECH (4-2-1)	0.1	2	13	1.0618	0.56243	-5.517	-5.528	-5.352

Table 3: Out-of-sample evaluations of trained TECH (4-3-1) neural network model.

Model	RMSE	MAE	NMSE	D_{stat}
TECH (4-3-1) with λ=0.001	0.01497	0.05685	0.03584	45.455

4.2 Technical analysis and Forecasting using Autoregressive inputs to the Networks

The order of the autoregressive inputs to the nonlinear autoregression, $NLAR(p)$ neural networks weredetermined using $ARIMA$ maximum likelihood estimation with AIC . The best order of the autoregressive inputs to the network is 3 [see Table 4]. Again, the size of the hidden layer of the network was varied between 2 and 6 inclusive for the given values of the decay parameter. The summary of the results obtained in the training process are presented in Tables 5. From this table, network model *TECH (3-3-1)* with λ=0.001, was chosen as a tentative model. The Hessian of this network is positive definite, hence the search for optimal weight vector leads to a global minimum. In Table 6, the out-of-sample evaluations reports are presented. The trained $TECH\ (3-3-1)$ neural network was able to predict 45% of positive directional change in the log-returns as reported by the D_{stat} statistic.

Table 4: *Determining the order of autoregressive inputs for* $TECH\ (3-3-1)$ *neural network.*

$ARMA\ (p,q)$	$nAIC$	$ARMA\ (p,q)$	$nAIC$	$ARMA\ (p,q)$	$nAIC$
ARMA (4,0)	1914.579	**ARMA (3,1)**	**1911.789**	ARMA (2,0)	1934.155
ARMA (3,3)	1914.125	ARMA (3,0)	1922.474	ARMA (1,2)	1934.15
ARMA (3,2)	1911.993	ARMA (2,1)	1928.581	ARMA (1,1)	1932.321

Table 5: Summary of Best Fitted 3-3-1 Network Models using autoregressive inputs

Best fitted model	Number of tours per fit	Decay parameter (λ)	Maximum number of iterations	Number of hidden nodes	Number of estimated weights	AIC	HQIF	BIC
TECH (3-3-1)	**300**	**0.001**	**200**	**3**	**16**	**-5.077**	**-5.091**	**-4.878**
TECH (3-3-1)	300	0.01	200	3	16	-5.011	-5.025	-4.812
TECH (3-2-1)	300	0.05	200	2	11	-4.928	-4.938	-4.792
TECH (3-2-1)	300	0.1	200	2	11	-4.911	-4.921	-4.775

Table 6: Out-of-sample evaluation of the TECH(3-3-1) network with autoregressive inputs

Model	RMSE	MAE	NMSE	D_{stat}
TECH (3-3-1) model with λ=0.001	0.10546	0.09087	1.77797	45.455

4.3 ARIMA time series modeling of the percentage stock market returns

The orders p and q of the $ARMA$ model for the log-returns were determined using the sample ACF and $PACF$ with some experimentation. Figure 2 (see Appendix) displays the sample ACF and PACF of the log-returns. The AIC for combinations of the orders p and q are those shown in Table 4 above. Based on the AIC values, we chose $ARMA(3,1)$ as a tentative model for predicting the log-returns. The diagnostics of the residuals show that autocorrelations and partial autocorrelations of the residuals are within the 95% confidence limits, [Figures not shown]. By reason of this diagnostics, we conclude that our tentative ARIMA model is adequate. Table 7 presents the out-of-sample evaluations report. It shows that the $ARMA(3,1)$ model performs poorly in the held-out sample as compared to the neural network models.

Table 7: Out-Sample Evaluation of ARIMA Fitted Model

Model fitted	RMSE	MAE	NMSE	D_{stat}
$ARMA\ (3,1)$	5.07262	3.68315	0.86545	27.273

4.4 The fitted forecast models

The forecast models were derived by re-estimating the TECH (4-3-1), TECH (3-3-1), and ARIMA (3,0,1) models using data points from January 1985 through December 2010. The re-estimated $TECH\ (4-3-1)$forecast neural network model is:

$$\hat{N}_{1t} = \frac{\exp(-0.06 + 0.2ma1 - 0.01ma3 + 0.01ma6 - 0.03ma12)}{1 + \exp(-0.06 + 0.2ma1 - 0.01ma3 + 0.01ma6 - 0.03ma12)} \quad (16)$$

$$\hat{N}_{2t} = \frac{\exp(0.10 + 0.5ma1 + 0.07ma3 - 0.02ma6 - 0.08ma12)}{1 + \exp(0.10 + 0.5ma1 + 0.07ma3 - 0.02ma6 - 0.08ma12)} \quad (17)$$

$$\hat{N}_{3t} = \frac{\exp(0.18 + 0.19ma1 + 0.03ma3 - 0.01ma6 + 0.02ma12)}{1 + \exp(0.18 + 0.19ma1 + 0.03ma3 - 0.01ma6 + 0.02ma12)} \quad (18)$$

and

$$\hat{r}_{t\ scaled\ TECH\ 431} = -0.32 + 0.92N_{1t} - 0.18N_{2t} + 0.93N_{3t} \quad (19)$$

The time series of the actual log-returns, in-sample forecasts and the residuals of this neural network are presented in Figure 5 at the Appendix.

The re-estimated $TECH$ $(3-3-1)$ forecast neural network model is:

$$\hat{N}_{1t} = \frac{\exp(-5.73 + 0.41r_{t-1} - 0.16r_{t-2} - 0.26r_{t-3})}{1 + \exp(-5.73 + 0.41r_{t-1} - 0.16r_{t-1} - 0.26r_{t-3})} \quad (20)$$

$$\hat{N}_{2t} = \frac{\exp(1.95 - 0.22r_{t-1} + 0.27r_{t-2} + 0.05r_{t-3})}{1 + \exp(1.95 - 0.22r_{t-1} + 0.27r_{t-2} + 0.05r_{t-3})} \quad (21)$$

$$\hat{N}_{3t} = \frac{\exp(-2.53 + 0.21r_{t-1} - 0.16r_{t-2} - 0.07r_{t-3})}{1 + \exp(-2.53 + 0.21r_{t-1} - 0.16r_{t-2} - 0.07r_{t-3})} \quad (22)$$

and

$$\hat{r}_{t\ scaled\ TEC\ 331} = -0.25 - 0.96N_{1t} + 0.78N_{2t} + 1.65N_{3t} \quad (23)$$

The time plots of the actual log-returns, in-sample forecasts as well as the residuals of this neural network are presented in Figure 5 at the Appendix.

While the re-estimated $ARIMA$ (3,0,1) forecast model for the demeaned log-returns is given by:

$$\hat{w}_t = -0.506w_{t-1} + 0.289w_{t-2} + 0.334w_{t-3} + 0.677\hat{\varepsilon}_{t-1} \quad (24)$$

where $w_t = r_t - 0.01738$. The t-values of this model are -4.1257, 4.5826, 6.2159 and 5.4044 respectively, and they are highly significant at conventional test levels. The diagnostics of this ARIMA model presented in Figure 6 show that the ACF and PACF of the residuals fall within the 95% confidence limits. Hence, it can be concluded that the model is adequate. The time plots of the actual and predicted log-returns series are shown in Figure 7 at the Appendix. Table 8 reports the summary of forecast results of the models measured in terms of the out-sample performance metrics over a period of 11 months.

Table 8: Summary of out-of- sample forecast evaluations of the fitted models.

Model Type	RMSE	MAE	NMSE	D_{stat}
TECH (4-3-1)	0.01497	0.05685	0.03584	45.455
TECH (3-3-1)	0.10546	0.09087	1.77797	45.455
ARIMA (3,0,1)	5.07263	3.68315	0.86545	27.273

6.0 Summary and conclusion

The results from Table 8 show that the neural network models performed better than the ARIMA model, indicating their suitability for financial time series forecasting. In terms of the $RMSE$, MAE, $NMSE$, the two neural networks performed better than the ARIMA model since their out-of-sample performance metric values are respectively smaller than those of the ARIMA model. In a similar manner, the directional change statistic, D_{stat}, values of the neural networks are greater than that of the ARIMA model.

From the results obtained in the research, we found that the NSE is not efficient; this confirmed one of the results by Agwuegbo *et al.* (2010). The monthly NSE log-returns series is fractal with long memory, thus it was possible for us to forecast the stock market returns using simple technical analysis indicators rather than using extensive market data. The artificial neural network models were able to predict approximately 45% of the log-returns as reported by the directional change metric as compared to the 27% predicted by the ARIMA model. Though, the hit rates as reported by the D_{stat}statistic for the neural networks are less than 50%; the reason for this may be attributed to the small size of the test data set. For the forecast models developed in the study, particularly, the TECH (4-3-1) proves to be the best in predicting the log-returns, as it was able to mimic the log-returns process precisely and accurately with negligible errors.

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Appendix

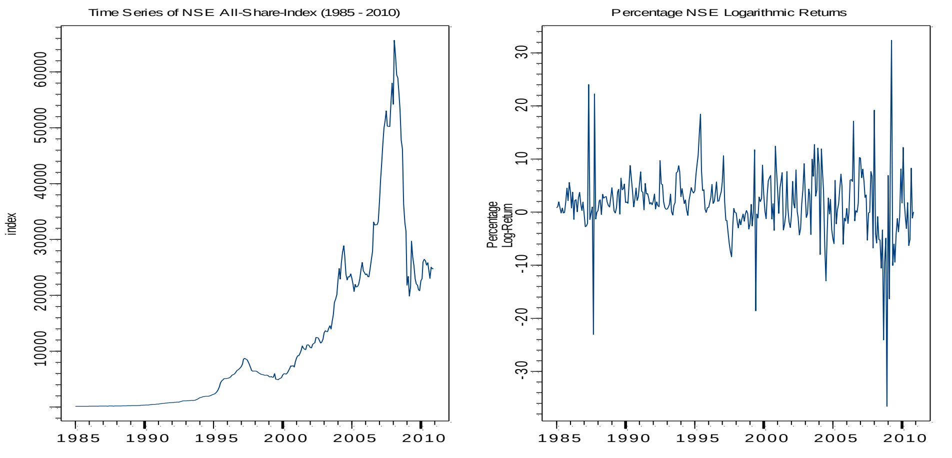

Figure 1: *Time series plots of the NSE All-Share-Index and the Percentage logarithmic returns.*

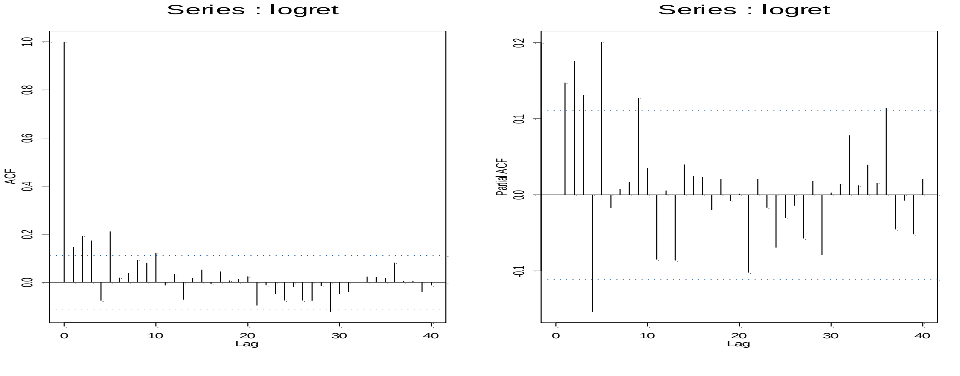

Figure 2: *Sample ACF and PACF of the monthly NSE log-returns*

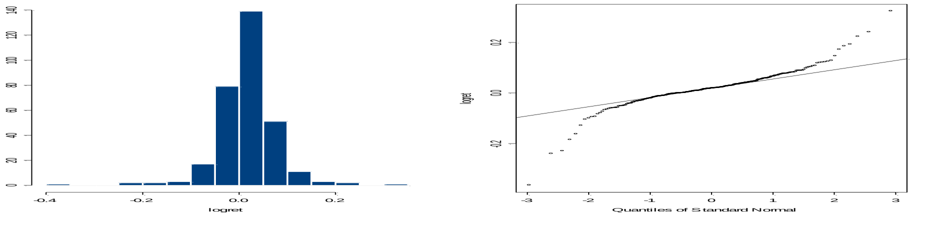

Figure 3: *Histogram and the quantile-quantile normal plot of the log-returns.*

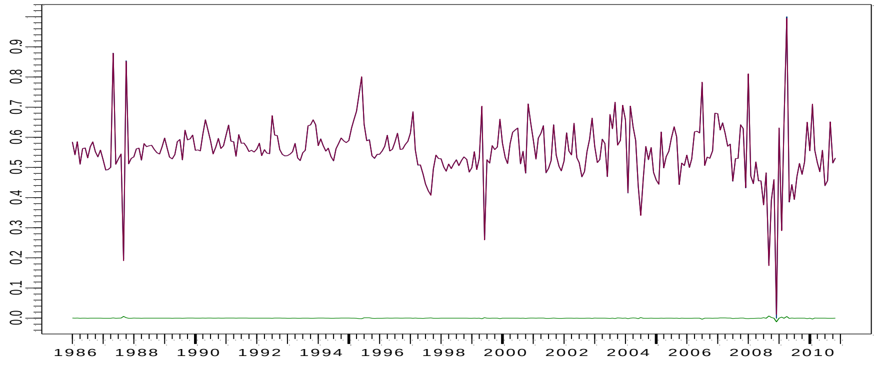

Figure 4: *Time plots of the fitted (red), actual scaled log-returns (blue) and the residuals (green) of re-estimated* $TECH$ $(4-3-1)$ *neural network.*

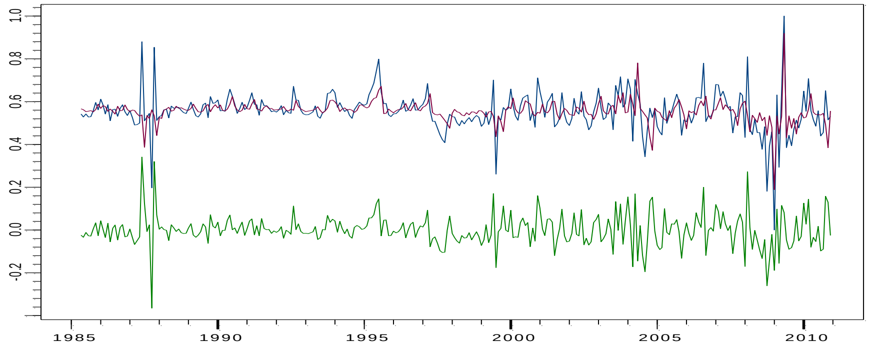

Figure 5: *Time plots of the fitted (red), actual scaled log-returns (blue) and the residuals (green) of re-estimated* $TECH$ $(3-3-1)$ *neural network.*

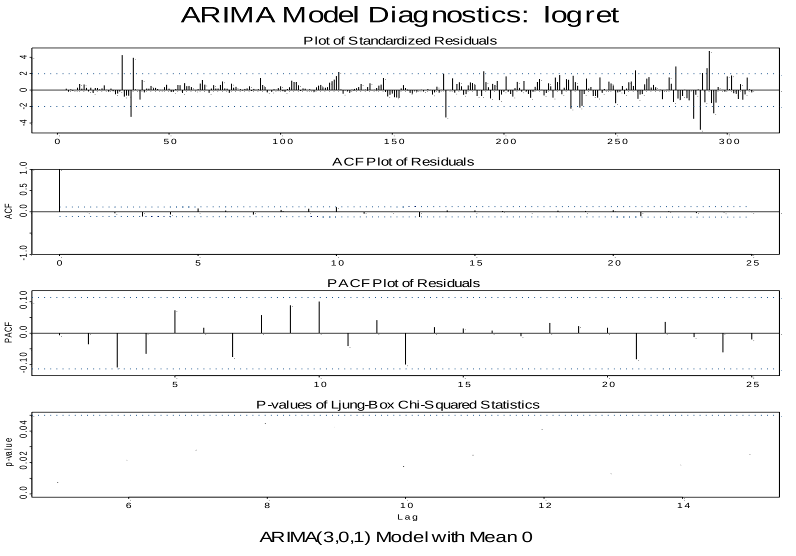

Figure 6: *Diagnostic plots of the re-estimated* $ARIMA(3,0,1)$ *model.*

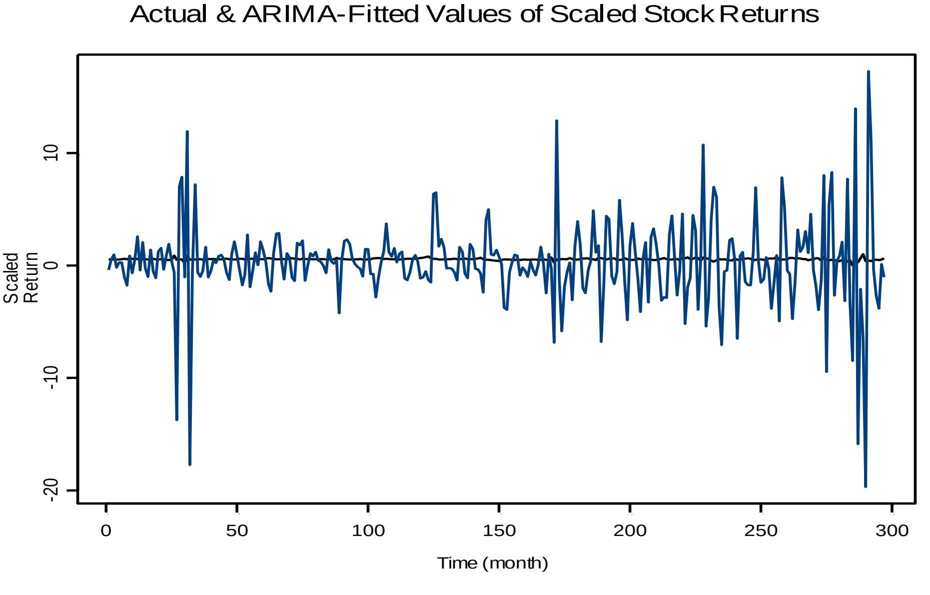

Figure 7: *Time plots* of *actual (in blue) and predicted (in black) log-returns from the ARIMA (3,0,1) model*.

Nexus of Exchange Rate Deregulation and Agricultural Share of Gross Domestic Product in Nigeria

Oyakhilomen Oyinbo [1], Falola Abraham [2] and Grace Z. Rekwot [3]

The kernel of this study was to examine the causal relationship between exchange rate deregulation and the agricultural share of gross domestic product in Nigeria from an econometric perspective using time series data spanning a period of 26 years (1986 – 2011). Data on exchange rate and gross domestic product were analysed using augmented dickey fuller unit root test, unrestricted vector autoregression, pairwise granger causality and vector error correction model. The results showed the existence of unidirectional causality from exchange rate to agricultural share of gross domestic production and also, exchange rate deregulation had negative influence on agricultural share of gross domestic production in Nigeria. This implies that market driven exchange rate policy has been having undesirable influence on the trend in agricultural share of gross domestic production in Nigeria.

Keywords: Agriculture, Exchange rate, Economy, Deregulation, Nigeria

JEL Classification: C32, C50, E52, E58, Q0

1.0 Introduction

The agricultural sector is one of the leading sectors in the Nigerian economy in terms of its contributions to income, employment, foreign exchange earnings and domestic food supply (Omojimite, 2012). Despite the immense potentials of agriculture in Nigeria, food production to meet local demand has been a challenge over the years and as noted by Oparaeke (2009) who posited that if the current food production trend of 1.35 per cent is not increased to tally with or surpass the population growth rate, then the country will be in a for a turbulent future. In a bid to increase food production in Nigeria over the years, several policy reforms have been put in place by successive governments and one of such policy reforms in time past is the Structural Adjustment Programme(SAP) introduced in July 1986 (Oyinbo and Emmanuel, 2012).

[1] Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, Zaria, Kaduna State, Nigeria. Email: ooyinbo@abu.edu.ng
[2] Department of Agricultural Economics and Farm Management, University of Ilorin, Kwara State, Nigeria.
[3] National Animal Production Research Institute, Ahmadu Bello University, Shika-Zaria, Kaduna State, Nigeria.

The Structural adjustment programme aimed at facilitating economic growth as a means of jump-starting the economy towards sustainable economic growth and development. The emergence of Structural adjustment programme in Nigeria embraced exchange rate deregulation and thus, deregulation placed much emphasis on the market forces in determining the prices of goods and services and allocating the resources within the economy (Idowu *et al.,* 2007). The exchange rate over-valuation prior to deregulation helped to cheapen imports of competing food items as well as agro-based and industrial raw materials and the result was rapid expansion in the importation of these goods to the detriment of local production of similar goods (Imimole and Enoma, 2011). This led to the abolition of the fixed exchange rate regime and the introduction of flexible exchange regime via the adoption of Structural adjustment programme. This new exchange rate policy helped to remove the over-valuation problem to the extent that the naira now became under-valued. The movement away from fixed to flexible exchange rate regimes allowing significant depreciation of Naira was aimed at enhancing export by making Nigerian goods cheaper (Shittu *et al.,* 2007).

There has not been a consensus among academic economists regarding the impact of exchange rate variations on economic variables. However, the traditional view is that fluctuations in exchange rates affect relative domestic and foreign prices, causing expenditures to shift between domestic and foreign goods (Obstfeld, 2002). Several economists and policy analysts to mention a few had focused considerable research attention on Nigeria's non-oil trade behaviours; a prominent feature of these studies has been a lack of consensus on the suitability of trade and exchange rate deregulation in the Nigerian case.

Since the inception of exchange rate deregulation in Nigeria, there have been fluctuations in the value of the naira. However, exchange rate of the naira to the US dollars was relatively stable in 2010 (CBN, 2010). The average exchange rate of the naira at the Whole Sale Dutch Auction System (WDAS) segment of the foreign exchange market in 2010 was 150.30 per US dollars; a depreciation of 0.9 per cent compared to the level in 2009. A market driven exchange rate policy is expected to be important in determining the importation of inputs for agricultural production and also, the export of agricultural produce through its influence on prices but it is worth noting that there exists a dearth of empirical information on the relationship between exchange rate deregulation and agricultural gross domestic product in Nigeria which is in line with Petreski (2009), who posited that the relationship between exchange rate and economic growth remains blurred and requires in-depth empirical investigation. This study was therefore, designed with a specific objective to fill the gap in research by providing empirical information on the causal relationship between exchange rate deregulation and agricultural share of gross domestic product in Nigeria. The major thesis of this paper is that there is no relationship between exchange rate and agricultural share of gross domestic product in Nigeria.

2.0 Literature Review

A review of relevant empirical studies (Mundell, 1995, Ghosh *et al.,* 1997; Levy-Yeyati and Sturzenegger, 2002; Bailliu *et al.,* 2003; Talvas, 2003; Eichengreen and Leblang, 2003; Edwards and Levy-Yeyati, 2003; Hernandez-Verme, 2004; Huang and Malhotra, 2004; Cavalho, 2005; Garofalo, 2005; Tyers *et al.,* 2006; Bleaney and Francisco, 2007, Rodrick, 2008; Darvas, 2011; Chen, 2012) has indicated two school of thoughts with regards to the influence of exchange rate on economic growth(gross domestic product) and this is attributed to variations in data periods, models and estimation methods. One school of thought posited that fixed exchange rate policy is significant in influencing economic growth while the other school of thought asserted that market driven exchange rate policy is significant in influencing economic growth.

There are also divergent views on exchange rate in Nigeria. Oriavwote and Omojimite (2012) in a study on empirical investigation of exchange rate pass-through into domestic prices in Nigeria opined that volatility of exchange rate has significant impact on domestic prices in Nigeria than the shocks from domestic price itself and therefore, exchange rate volatility should be given important consideration when implementing policies on stabilizing domestic inflation.

Omojimite (2012) in a study on institutions, Macroeconomic Policy and Growth of Agricultural Sector in Nigeria found out that exchange rate was negative and significant in influencing agricultural production.

Chukuigwe, and Abili, (2008) in a study on econometric analysis of the impact of monetary and fiscal policies on non-oil exports in Nigeria noted that considering the importance of the exchange rate as a major price that affects all sectors of the economy and all economic agents, it is imperative to monitor the movements in the real exchange rate in order to foster competitiveness and improve the supply of exports in the medium to long term and that The Central Bank of Nigeria should continue to intervene in the foreign exchange market to maintain stability.

Okhiria and Saliu (2008) in a study on exchange rate variation and inflation in Nigeria noted that Dutch disease results from an appreciation of the exchange rate, caused by the large inflows of petroleum revenues, which again leads to reduced competitiveness of various non-petroleum sectors of the economy. Dutch disease will often have particularly serious effects on the poor because traditional sectors such as agriculture and other production in rural areas will lose out to imports that become more competitive as a result of currency appreciation.

Enoma (2011) in a study on exchange rate depreciation and inflation in Nigeria noted that theoretically, exchange rate is an important determinant of inflation rate. Although exchange rate depreciation may not directly control inflation, it helps to restructure the price mechanism of both import and export, such that Naira depreciation subtly tends to moderate prices in Nigeria, especially imported price inflation

Alao (2010) in a study on interest rates determination in Nigeria found out that exchange rate adjustment is positive and significant in influencing interest rate spread in Nigeria. The resulting effect on interest rate spread affects agricultural production.

Amassoma *et al.* (2011) in a study on the Nexus of interest rate deregulation, lending rate and agricultural productivity in Nigeria noted that a decline in exchange rate implies reduction in the cost of imported agricultural inputs and consequently stimulating current agricultural output.

Wafure and Nurudeen (2010) in examining the determinants of foreign direct investment in Nigeria the revealed that exchange rate is significant in explaining changes in foreign direct investment and that 1 per cent depreciation in exchange rate causes FDI to increase by approximately 0.02.

Olubanjo *et al.* (2009) in a study on economic deregulation and supply response of cocoa farmers in Nigeria found out that exchange rate have a negative effect on output or cause decrease in output as their magnitudes increase. Unsurprisingly, increased exchange rate signifies Naira appreciation and hence represents price disincentive for local (cocoa) production.

3.0 Methodology

3.1 Description of Data

Time series data on exchange rate (Naira per US Dollar) and agricultural share of real gross domestic product (Naira) extending over the period of exchange rate deregulation (1986 to 2011) were utilized in this study. The data were collected from various issues of Central Bank of Nigeria statistical bulletin and annual reports (CBN, 2008; 2011) and National Bureau of statistics (NBS, 2010).

3.2 Analytical Procedure

Augmented Dickey Fuller (ADF) test, unrestricted vector autoregression (VAR) pairwise granger causality test and vector error correction model were employed using Eviews 7.2 econometrics package to analyse the data. The model of the Augmented Dickey Fuller (ADF) with the constant term and trend is as follows:

$$\Delta Y_t = a_1 + a_2 t + \beta Y_{t-1} + \sum_{i=1}^{n} \gamma_i \Delta Y_{t-1} + \varepsilon_t \qquad (1)$$

Where:

ΔY_t = first difference of Y_t
Y_{t-1} = lagged values of Y_t
ΔY_{t-1} = first difference of Y_{t-1}
β = test coefficient
e_t = white noise
a_1 = constant
a_2 = coefficient of time variable

The null hypothesis ($H_O: \beta = 0$) of the ADF test indicates that the series is not stationary and the alternative hypothesis ($H_1: \beta < 0$) indicates that the series is stationary. If the absolute value of calculated ADF statistic (τ) is higher than the absolute value of the critical values, we reject the hypothesis which shows that the series is stationary. However, if this value is lower than the critical values, the time series is not stationary (Gujarati, 2003). The Granger causality test assumes that the information relevant to the prediction of the respective variables, X and Y, is contained solely in the time series data on these variables. The test involves estimating the following pair of regressions:

$$X_t = \beta_0 + \sum_{i=1}^{p} \beta_i X_{t-i} + \sum_{j=1}^{p} \alpha_j Y_{t-j} + \mu_{1t} \qquad (2)$$

$$Y_t = \gamma_0 + \sum_{i=1}^{p} \gamma_i Y_{t-i} + \sum_{j=1}^{p} \delta_j X_{t-j} + \mu_{2t} \qquad (3)$$

Where:

X_t, Y_t= regressands of models 2 and 3 respectively
β_0, γ_0 = constant terms of models 2 and 3 respectively
$\beta_{i,}$ α_j = coefficients of the regressors of model 2
γ_i, δ_j = coefficients of the regressors of model 3
μ_{1t}, μ_{2t} = error terms of models 2 and 3 respectively

It is assumed that the disturbances μ_{1t} and μ_{2t} are uncorrelated. Thus there is unidirectional causality from X to Y if $\alpha_j = 0$ and $\delta_j \neq 0$. Similarly, there is unidirectional causality from Y to X if $\delta_j = 0$ and $\alpha_j \neq 0$. The causality is considered as mutual (bilateral causality) if $\delta_j \neq 0$ and $\alpha_j \neq 0$. Finally, there is no link between X and Y (independence) if $\delta_j = 0$ and $\alpha_j = 0$.

3.3 Model Specification

To determine the relationship between exchange rate deregulation and agricultural share of gross domestic product in Nigeria, the pairwise granger causality test is modelled as bivariate vector autoregressive (VAR) model as follows:

$$EXR_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i EXR_{t-i} + \sum_{j=1}^{p} \omega_j AGDP_{t-j} + \epsilon_{1t} \qquad (4)$$

$$AGDP_t = \beta_0 + \sum_{i=1}^{p} \beta_i AGDP_{t-i} + \sum_{j=1}^{p} \varphi_j EXR_{t-j} + \epsilon_{2t} \qquad (5)$$

In order to estimate the short-run relationship between the variables, the corresponding error correction equation was estimated as:

$$\Delta lnAGDP_t = c_0 + \sum_{i=1}^{p} c_i \Delta lnEXR_{t-1} + \psi ECM_{t-1} + \epsilon_{3t} \quad (6)$$

where:

EXR_t = Exchange rate in year t (Naira per US Dollar)
$AGDP_t$ = Agricultural share of real gross domestic product in year t (Naira' million)
α_0, β_0, c_0= Constant terms in models 4, 5 and 6 respectively
α_i, φ_j, c_i = Estimated coefficients of exchange rate in models 4, 5 and 6 respectively
$\omega_{j,}\ \beta_i$ = Estimated coefficients of agricultural share of real gross domestic product in models 4 and 5 respectively
$\epsilon_{1t}, \epsilon_{2t,} \epsilon_{3t}$ = Gaussian white noise error terms in models 4, 5 and 6 respectively
p = optimal lag length
Δ = Difference operator
ECM = Error correction term
ln = Natural logarithm

4.0 Results and Discussion

4.1 Descriptive statistics of variables

It is important to examine the summary statistics of the variables under study (exchange rate and agricultural share of gross domestic product). The basic features of exchange rate (EXR) and agricultural share of gross domestic product ($AGDP$) under study are given in Table 1. EXR is positively skewed, platykurtic and the probability value(0.17) of its Jarque Bera statistic(3.50) denotes that its errors are normally distributed. $AGDP$ is positively skewed, platykurtic and its errors are normally distributed based on the Jarque Bera statistic (3.46). The trend in exchange rate and agricultural share of gross domestic product in Nigeria is shown in Figures 1 and 2 respectively.

4.2 Augmented Dickey Fuller Unit root test

The result of the augmented dickey fuller test with the assumption of trend and intercept in Table 2 shows that lnEXR and lnGDP were non-stationary at level form (exhibit random walk) and therefore, needed to be differenced so as to avoid spurious result when the variables are used in their non-stationary form.

Table 1: Descriptive statistics of EXR and AGDP in Nigeria (1986 – 2011)

Statistic	EXR(Naira/US Dollar)	AGDP(Naira' million)
Mean	70.8186	157700.8000
Median	57.3723	111692.4000
Maximum	158.2300	335400.0000
Minimum	2.0200	69608.0600
Std. Dev.	59.4457	87890.6400
Skewness	0.1096	0.7476
Kurtosis	1.2165	2.0208
Jarque-Bera	3.4980	3.4608
Probability	0.1739	0.1772
Sum	1841.2840	4100221.0000
Observations	26	26

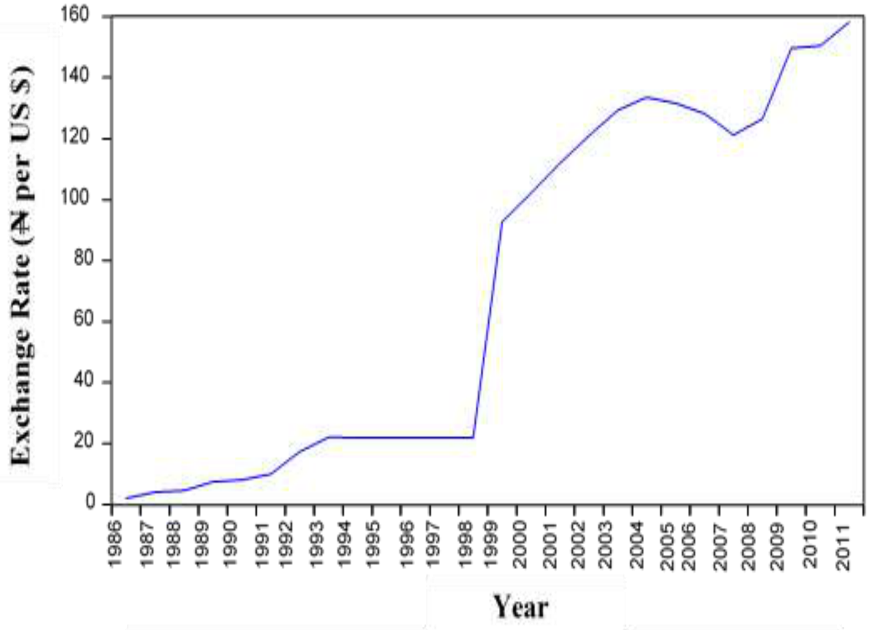

Figure 1: Trend of Exchange Rate in Nigeria (1986 – 2011)

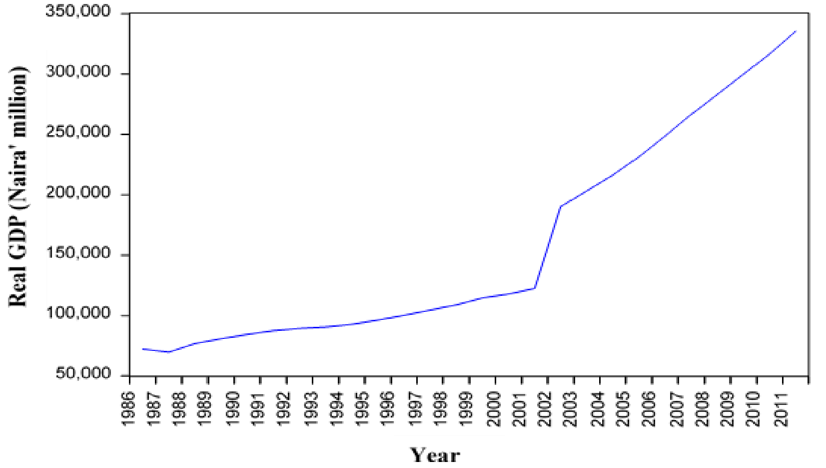

Figure 2: Trend of Agricultural Share of GDP in Nigeria (1986 – 2011)

Table 2: Result of Augmented Dickey Fuller Test

Variable	ADF Statistic	Lag	Test Critical value (5%)	Decision
Level				
lnEXR	-2.016752	0	-3.603202	Non-stationary
lnGDP	-1.873371	0	-3.603202	Non-Stationary
First difference				
ΔlnEXR	-5.247509	0	-3.690814	Stationary
ΔlnGDP	-4.866667	0	-3.612199	Stationary

NB: Lag length selection was automatic based on Schwarz information criterion (SIC)

Table 3: **VAR Lag Order Selection Result**

Lag	LR	FPE	AIC
0	NA	0.064459	2.933882
1	84.62852	0.000860	-1.386750
2	2.881067	0.001067	-1.185864
3	4.347656	0.001185	-1.115459
4	14.64704*	0.000546*	-1.955094*
5	3.039158	0.000660	-1.878057

NB: * indicates lag order selected by the criterion
LR: Likelihood ratio, FPE: Final prediction error, AIC: Akaike information criterion.

4.3 Vector Autoregression (VAR) Lag Order Selection Criteria

Granger causality test is known to be sensitive to lag length (Foresti, 2006; Afzal, 2012, Oyinbo *et al.*, 2012) and therefore, VAR model was fitted to the time series data in order to find an appropriate lag structure for the granger causality test. The result as shown in Table 3 indicates that the optimal lag length is four based on LR, FPE and AIC.

4.4 Granger Causality Test

The result of the granger causality carried out using an optimal lag length of four is given in Table 4. The result indicates that there is unidirectional causality from exchange rate and the agricultural share of gross domestic product in Nigeria over the period of exchange rate deregulation and therefore, the hypothesis that exchange rate does not granger cause agricultural share of gross domestic product is rejected while the hypothesis that agricultural share of gross domestic product granger cause exchange rate is accepted. The result implies that deregulation of exchange rate has been significant in influencing the volume of agricultural share of the Nigerian gross domestic period over the period under study. This could be attributed to the influence of market determined exchange rate on importation of inputs for agricultural production and agricultural exports known to be contributing the largest share of non-oil export and this is in consistent with Enoma (2011), who noted that exchange rate depreciation helps to restructure the price mechanism of both import and export, such that Naira depreciation subtly tends to moderate prices in Nigeria, especially imported price inflation. Therefore, it is imperative for the monetary authority to monitor the trend in exchange rate depreciation so as to avoid excessive devaluation of the naira that could lead to price distortions.

Table 4: Result of Pairwise Granger Causality Test

Null Hypothesis(H_0)	**Obs.**	**F- statistic**	**Prob.**	**Decision**
GDP does not granger cause EXR	22	0.02316	0.9988	Accept H_0
EXR does not granger cause GDP	22	17.8745*	3.E-05	Reject H_0

NB: * Implies significant at 1% probability level

4.5 Vector Error Correction Estimate

The result of the vector error correction as presented in Table 5 contains the long run estimates, short run estimates and diagnostic statistics. The long run estimates revealed that the estimated coefficient of exchange rate was -1.932 and was significant at 1% probability level which implies that exchange rate deregulation had negative influence on the agricultural share of gross domestic product over the period of 1986 to 2011. This result suggests that a unit increase in exchange rate will decrease the agricultural share of gross domestic product by 1.932 *ceteris paribus*. Also, the short run estimates gave similar result in line with the long run estimates as the estimated coefficient of the first lagged value of exchange rate was -0.086291 and significant at 10% probability level.

Table 5: Vector Error Correction Estimates

Variable	Coefficient	Standard Error	t-statistic
Long run estimates			
Constant	19.09639		
lnGDP(-1)	1.000000		
lnEXR(-1)	-1.931569*	0.42364	-4.55946
Short run estimates			
Constant	0.104648	0.03044	3.43775
ΔlnGDP(-1)	-0.085077	0.20132	-0.42260
ΔlnGDP(-2)	-0.160531	0.19827	-0.80967
ΔlnEXR(-1)	-0.086291***	0.05191	-1.66232
ΔlnEXR(-2)	-0.060837	0.05130	-1.18579
ECM(-1)	-0.084327*	0.03075	-2.74218
Diagnostic Statistics			
R-squared	0.331543	Log likelihood	29.64405
Adj. R-squared	0.134938	Akaike AIC	-2.056005
Sum sq. resids	0.102271	Schwarz SC	--1.759789
S.E. equation	0.077563	Mean dependent	0.064118
F-statistic	1.686341	S.D. dependent	0.083393

NB: * denotes $p < 0.1$, *** denotes $p < 0.01$

This implies that agricultural share of gross domestic product will decrease by 0.086291 as exchange rate increases by one unit. The nature of the long run and short run relationship between exchange rate deregulation and agricultural share of gross domestic product could be attributed to excessive devaluation of the naira that could be detrimental to the contribution of agriculture to the gross domestic product through its inflationary effect on trade (agricultural input importation and agricultural product exportation) and investment in the agricultural sector of Nigeria’s economy. This is in line with the opinion that an attempt to over-stimulate the economy by expansionary monetary policy or currency devaluation will result in higher rate of inflation, but no increase in real economic growth (Goldstein, 2002). The error correction coefficient(-0.084327) of the model had the expected negative sign and was significant at 1% confirming the existence of long run relationship between exchange rate and gross domestic product. The error correction coefficient indicates a feedback of about 8% per cent of the previous year's disequilibrium from the long run value of exchange rate.

5.0 Conclusion

Augmented Dickey-Fuller unit root test, unrestricted vector autoregression (VAR) and Pairwise granger causality were employed to analyse the time series data on exchange rate and agricultural share of gross domestic product over the period of economic deregulation in Nigeria in order to achieve the objective of the study. The key finding of this study is the presence of unidirectional causality from exchange rate to gross domestic product over the period under study and also, negative influence of exchange rate on gross domestic product. Therefore, exchange rate deregulation has not been favourable to agricultural production. In the light of this finding, it is recommended that the Central Bank of Nigeria should carefully monitor the movement of the market determined exchange rate. This will ensure that exchange rate deregulation does not become counterproductive through price distortions on agricultural production, trade (agricultural input importation and agricultural produce exportation) and investment in the agricultural sector in line with the Agricultural Transformation Agenda.

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Testing Volatility in Nigeria Stock Market using GARCH Models

Ngozi V. Atoi[1]

The contributions of error distributions have been ignored while modeling stock market volatility in Nigeria and studies have shown that the application of appropriate error distribution in volatility model enhances efficiency of the model. Using Nigeria All Share Index from January 2, 2008 to February 11, 2013, this study estimates first order symmetric and asymmetric volatility models each in Normal, Student's-t and generalized error distributions with the view to selecting the best forecasting volatility model with the most appropriate error distribution. The results suggest the presence of leverage effect meaning that volatility responds more to bad news than it does to equal magnitude of good news. The news impact curves validate this result. The last twenty eight days out-of-sample forecast adjudged Power-GARCH (1, 1, 1) in student's t error distribution as the best predictive model based on Root Mean Square Error and Theil Inequality Coefficient. The study therefore recommends that empirical works should consider alternative error distributions with a view to achieving a robust volatility forecasting model that could guarantee a sound policy decisions.

Keywords: GARCH, TGARCH, EGARCH, PGARCH, Error Distributions, Leverage Effect, News Impact Curve, Forecasting.

JEL Classification: C22, C52, C53

1.0 Introduction

All over the world, capital market segment of the financial market plays a vital role in the process of economic growth, through the mobilization of long term funds for future investment. In Nigeria, for instance, the stock market helps in long term financing of government development projects, serves as a source of fund for private sector long term investment and served as a catalyst during the 2004/2005 banking system consolidation. Market capitalization as a percentage of nominal Gross Domestic Product (Nominal GDP) stood above 100% from 2007 to 2008, reflecting high market valuation and activities. However, according to CBN (2011) statistical Bulletin, the All Share Index

[1] Senior Statistician, Statistics Department, Central Bank of Nigeria (CBN) (email: nvatoi@cbn.gov.ng). The views expressed herein are those of the author and do not necessarily reflect the position of the CBN. The author appreciates the valuable comments by Omotosho, B. S. (Senior Statistician, Statistics Department, CBN) on the first draft of this paper.

(ASI), which shows the price movement of quoted stocks moved from 61,833.56 index points in the first quarter of 2008 to 20,244.73 index points in fourth quarter of 2011, suggesting some level of fluctuations in the stock market, especially since the occurrence of the 2008/2009 financial crisis. Such movements could influence investment decision that can manifest in the real sector of the economy.

An increase or decrease in the value of stock tends to have a corresponding effect on the economy, mostly through the money market. An increase in stock prices stimulates investment and increases the demand for credit, which eventually leads to higher interest rates in the overall economy (Spiro, 1990). High interest rate is a potential danger to the economy since the variance of inflation positively responds to the volatility of interest rate (see Fischer, 1981). Such development could impose challenges to monetary policy formulation and consequently undermine the price stability objective of monetary authorities. Thus, the specification of appropriate volatility model for capturing variations in stock returns is of significant policy relevance to economic managers. More so, reliable volatility model of asset returns aids investors in their risk management decisions and portfolio adjustments.

Engel (1982) argues that an adequate volatility model is the one that sufficiently models heteroscadasticity in the disturbance term and also captures the stylized fact inherent in stock return series such as volatility clustering, Autoregressive Conditional Heteroscadasticity (ARCH) effect and asymmetry. The famous volatility models used in most studies include Autoregressive Conditional Heteroscadasticity and its extensions, such as Generalized ARCH, Threshold GARCH, Exponential GARCH and Power GARCH. In Most cases, first-order GARCH models have extensively been proven to be adequate for modeling and forecasting financial time series (see Bera and Higgins (1993), Hsieh (1991) Olowe (2011), Hojatallah and Ramanarayanan (2011), Eric (2008) and Hansen and Lunda (2004). However, little or no emphasis has been given to appropriate error distribution assumptions for modeling.

The review of relevant literature in Nigeria shows that authors have ignored the contributions of alternative error distributions while modeling stock market volatility. The application of inappropriate error distribution in a volatility model for financial time series could engender mis-specification because of the leptokurtic and autocorrelation characteristics of such series. In fact, Klar *et al.* (2012) note that incorrect specification of the innovation distribution may lead to a sizeable loss of efficiency of the corresponding estimators, invalid risk determination, inaccurately priced options and wrong assessment of Value-at-Risk (VaR).

Thus, this study seeks to bridge the wide gap in literature by applying the commonly used first order GARCH family models on Gaussian, Student's *t* and generalized error distribution (GED) with a view to selecting the best forecasting volatility model with the most appropriate error distribution for the Nigerian stock market during the sample period.

The rest of the study is organized as follows. Section 2 deals with theoretical and empirical literature, while the methodology is presented in section 3. Section 4 discusses the results and section 5 concludes the study.

2.0 Literature Review

2.1 Theoretical

The first break-through in volatility modelling was Engle (1982), where it was shown that conditional heteroskedasticity can be modeled using an autoregressive conditional heteroskedasticity (ARCH) model. ARCH model relates the conditional variance of the disturbance term to the linear combination of the squared disturbance in the recent past. Having realized the potentials ARCH model, studies have used it to model financial time series. Determining the optimal lag length is cumbersome, oftentimes engender overparametrization. Rydberg (2000) argued that large lag values are required in ARCH models, thus the need for many parameters.

However, Bollerslev (1986) and Taylor (1986) independently proposed the extension of ARCH model with an Autoregressive Moving Average (ARMA) formulation, with a view to achieving parsimony. The model is called the Generalized ARCH (GARCH), which models conditional variance as a function of its lagged values as well as squared lagged values of the disturbance term. Although GARCH model has proven useful in capturing symmetric effect of volatility, it is bedeviled with some limitations, such as the violation of non-negativity constraints imposed on the parameters to be estimated.

To overcome these constraints, some extensions of the original GARCH model were proposed. This includes asymmetric GARCH family models such as Threshold GARCH (TGARCH) proposed by Zakoian (1994), Exponential GARCH (EGARCH) proposed by Nelson (1991) and Power GARCH (PGARCH) proposed by Ding *et al*. (1993). The idea of the proponents of these models is based on the understanding that good news (positive shocks) and bad news (negative shock) of the same magnitude have differential effects on the conditional variance.

The EGARCH which captures asymmetric properties between returns and volatility was proposed to address three major deficiencies of GARCH model. They are (i) parameter restrictions that ensures conditional variance positivity; (ii) non-sensitivity to asymmetric response of volatility to shock and (iii) difficulty in measuring persistence in a strongly stationary series. The log of the conditional variance in the EGARCH model signifies that the leverage effect is exponential and not quadratic. The specification of volatility in terms of its logarithmic transformation implies the non-restrictions on the parameters to guarantee the positivity of the variance (M[a]Jose, 2010), which is a key advantage of EGARCH model over the symmetric GARCH model.

Zakoian (1994) specified the TGARCH model by allowing the conditional standard deviation to depend on sign of lagged innovation. The specification does not show parameter restrictions to guarantee the positivity of the conditional variance. However, to ensure stationarity of the TGARCH model, the parameters of the model have to be restricted and the choice of error distribution account for the stationarity. TGARCH model is closely related to GJR-GARCH model developed by Glosten *et al.* (1993).

Ding *et al.* (1993) further generalized the standard deviation GARCH model initially proposed by Taylor (1986) and Schwert (1989) and called it Power GARCH (PGARCH). This model relates the conditional standard deviation raised to a power, d (positive exponent) to a function of the lagged conditional standard deviations and the lagged absolute innovations raised to the same power. This expression becomes a standard GARCH model when the positive exponent is set at two. The provision for the switching of the power increases the flexibility of the model.

High frequency series such as stock returns are known with some stylized facts, common among which are volatility clustering, fat-tail and asymmetry. Thus the traditional assumption of normality in volatility modeling of financial time series could weaken the robustness of parameter estimates. Mandelbrot (1963) and Fama (1965) deduce that daily stock index returns are non-normal and tend to have leptokurtic and fat-tailed distribution. For this reason, Bollerslev (1986) relaxed the traditional normality assumption to accommodate time varying volatility in high frequency data by assuming that such data follows student t-distribution. Furthermore, Bollerslev *et al.* (1994) establish that a GARCH model with normally distributed errors could not be a sufficient model for explaining kurtosis and slowly decaying autocorrelations in return series.

Similarly, Malmsten and Terasvirta (2004) argue that first order EGARCH model in normal errors is not sufficiently flexible enough for capturing kurtosis and autocorrelation in stock returns; however, they suggested how the standard GARCH model could be improved by replacing the normal error distribution with a more fat-tailed error distribution. This is possible because increasing the kurtosis of the error distribution will help standard GARCH model to capture the kurtosis and low autocorrelations in stock return series. Nelson (1991) notes that a student-*t* could imply infinite unconditional variance for the errors; hence, an error distribution with a more fat-tailed than normal will help to increase the kurtosis as well as reduce the autocorrelation of the squared observations. Nelson (1991) assumes that EGARCH model is stationary if the innovation has a generalized error distribution (GED), he therefore recommended GED in EGARCH model.

M^{a}Jose (2010) argued that the stationarity of TGARCH model depends on the distribution of the disturbance term, which is usually assumed to follow Gaussian or student-*t*. Furthermore, as the fat-tailed of the error distribution increases, the leverage effect captured in TGARCH model gets smaller and losses more flexibility. The contributions of error distribution in EGARCH and TGARCH are similar to PGARCH model. However, theory has not suggested a particular error distribution for estimating a PGARCH model, even though some empirical literature had it that PGARCH with a more fat-tail than normal could outperform other GARCH models under certain condition.

2.2 Empirical

Several empirical works have been done since the seminar paper of Engel (1982) on volatility modelling, especially in finance, even though a number of theoretical issue are still unresolved (see Franses and McAleer, 2002). However, Anders (2006) believes that previous research on the effects of error distribution assumptions on the variance forecasting performance of GARCH family models is scarce. Some of the work on volatility modelling estimate a particular GARCH model with one or two error distributions, while some applied a particular error distribution to few ARCH family models to either establish the best forecasting model for conditional variance, the best fitted volatility model or confirm the ability of the models to capture stylized fact inherent in high frequency financial time series. As a background to this study, Appendix 1 summarizes a selection of the literature by foreign authors on the applicability of GARCH family models on different innovation assumptions.

To the knowledge of this study, research on the contribution of error assumptions on volatility modeling in Nigeria is extremely minimal. Available literatures tend to capture the asymmetric properties of financial data without recourse to error distributions. Jayasuriya (2002) examines the effect of stock market liberalization on stock return volatility using Nigeria and fourteen other emerging market data, from December 1984 to March 2000 to estimate asymmetric GARCH model. The study inferred that positive (negative) changes in prices have been followed by negative (positive) changes. The Nigerian session of the result tilted more to business cycle of behaviour of return series than volatility clustering. Ogum *et al.*(2005) apply the Nigeria and Kenya stock data on EGARCH model to capture the emerging market volatility. The result of the study differed from Jayasuriya (2002). Though volatility persistence is evidenced in both market; volatility responds more to negative shocks in the Nigeria market and the reverse is the case for Kenya market.

Dallah and Ade (2010) examine the volatility of daily stock returns of Nigerian insurance stocks using twenty six insurance companies' daily data from December 15, 2000 to June 9 of 2008 as training data set and from June 10 2008 to September 9 2008 as out-of-sample dataset. The result of ARCH (1), GARCH (1, 1) TARCH (1, 1) and EGARCH (1, 1) shows that EGARCH is more suitable in modelling stock price returns as it outperforms the other models in model evaluation and out-of-sample forecast. Okpara and Nwezeaku (2009) randomly selected forty one companies from the Nigerian Stock Exchange to examine the effect of the idiosyncratic risk and beta risk on returns using data from 1996 to 2005. By applying EGARCH (1, 3) model, the result shows less volatility persistence and establishes the existence of leverage effect in the Nigeria stock market, implying that bad news drives volatility more than good news.

3.0 Methodology

3.1 Models of Volatility

The Family of Autoregressive Conditional Heteroskedasticity (ARCH) Models

Every ARCH or GARCH family model requires two distinct specifications: the mean and variance equations. According to Engel, conditional heteroskedasticity in a return series, y_t can be modeled using ARCH model expressing the mean equation in the form:

$$y_t = E_{t-1}(y_t) + \varepsilon_t \tag{1}$$

Such that $\varepsilon_t = \varphi_t \sigma_t$

Equation 1 is the mean equation which also applies to other GARCH family model. $E_{t-1}[\ .\ ]$ is expectation conditional on information available at time t-1, ε_t is error generated from the mean equation at time t and φ_t is a sequence of independent, identically distributed (iid) random variables with zero mean and unit variance. $E\{\varepsilon_t/\Omega_{t-1}\} = 0$; and $\sigma_t^2 = E\{\varepsilon_t^2/\Omega_{t-1}\}$ is a nontrivial positive-valued parametric function of Ω_{t-1}. The variance equation for an ARCH model of order q is given as:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i\, \varepsilon_{t-1}^2 + \mu_t \tag{2}$$

Where α_0>0; $\alpha_i \geq 0$; $i = 1, \ldots, q - 1$ and $\alpha_q > 0$

In practical application of ARCH (q) model, the decay rate is usually more rapid than what actually applies to financial time series data. To account for this, the order of the ARCH must be at maximum, a process that is strenuous and more cumbersome.

Generalized ARCH (GARCH) Model

The conditional variance for GARCH (p, q) model is expressed generally as:

$$\sigma_t^2 = \beta_0 + \sum_{i=1}^{q} \alpha_i\, \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j\, \sigma_{t-j}^2 \tag{3}$$

where p is the order of the GARCH terms, σ^2 and q is the order of the ARCH terms, ε^2. Where β_0>0; $\alpha_i \geq 0$; $i = 1,\ldots,q - 1$; $j = 1,\ldots,p-1$ and $\beta_p, \alpha_q > 0$. σ_t^2 is the conditional variance and ε_t^2, disturbance term. The reduced form of equation 3 is the GARCH (1, 1) represented as:

$$\sigma_t^2 = \beta_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 \sigma_{t-1}^2 \quad (4)$$

The three parameters (β_0 , β_1 and β_2) are nonnegative and $\beta_1 + \beta_2$<1 to achieve stationartiy.

The Threshold GARCH (TGARCH) Model

The generalized specification for the conditional variance using TGARCH (p, q) is given as:

$$\sigma_t^2 = \beta_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{q} \gamma_i I_{t-i} \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 \quad (5)$$

Where $I_{t-i} = 1$ if $\varepsilon_t^2 < 0$ and 0 otherwise.

In this model, good news implies that $\varepsilon_{t-i}^2 > 0$ and bad news implies that $\varepsilon_{t-i}^2 < 0$ and these two shocks of equal size have differential effects on the conditional variance. Good news has an impact of α_i and bad news has an impact of $\alpha_i + \gamma_i$. Bad news increases volatility when $\gamma_i > 0$, which implies the existence of leverage effect in the *i*-th order and when $\gamma_i \neq 0$ the news impact is asymmetric. However, the first order representation is of TGARCH (p, q) is

$$\sigma_t^2 = \beta_0 + \alpha_1 \varepsilon_{t-1}^2 + \gamma_1 I_{t-1} \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \quad (6)$$

Then, good news has an impact of α_1 and bad news has an impact of $\alpha_1 + \gamma_1$.

The Exponential GARCH (EGARCH) Model

The conditional variance of EGARCH (p, q) model is specified generally as

$$log(\sigma_t^2) = \beta_0 + \sum_{i=1}^{q} \left\{ \alpha_i \left| \frac{\varepsilon_{t-i}}{\sigma_{t-i}} \right| + \gamma_i \left(\frac{\varepsilon_{t-i}}{\sigma_{t-i}} \right) \right\} + \sum_{j=1}^{p} \beta_j log\left(\sigma_{t-j}^2\right) \quad (7)$$

$\varepsilon_{t-i} > 0$ and $\varepsilon_{t-i} < 0$ implies good news and bad news and their total effects are $(1 + \gamma_i)|\varepsilon_{t-i}|$ and $(1 - \gamma_i)|\varepsilon_{t-i}|$, respectively. When $\gamma_i < 0$, the expectation is that bad news would have higher impact on volatility. The EGARCH model achieves covariance stationarity when $\sum_{j=1}^{p} \beta_j < 1$. The interest of this paper is to model the conditional variance using EGARCH (1,1) model, which is specified as

$$log(\sigma_t^2) = \beta_0 + \alpha_1 \left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right| + \gamma_1 \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \beta_1 log(\sigma_{t-1}^2) \qquad (8)$$

The total effects of good news and bad news for EGARCH (1,1) are $(1 + \gamma_1)|\varepsilon_{t-1}|$ and $(1 - \gamma_1)|\varepsilon_{t-1}|$, respectively. Failing to accept the null hypothesis that $\gamma_1 = 0$ shows the presence of leverage effect, that is bad news have stronger effect than good news on the volatility of stock index return

The Power GARCH (PGARCH) Model

Ding et al (1993) expressed conditional variance using PGARCH (p, d, q) as

$$\sigma_t^d = \beta_0 + \sum_{i=1}^{p} \alpha_i (|\varepsilon_{t-i}| + \gamma_i \varepsilon_{t-i})^d + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^d \qquad (9)$$

Here, $d > 0$ and $\mathbb{R}^+$, $\gamma_i < 1$ establishes the existence of leverage effects. If d is set at 2, the PGARCH (p, q) replicate a GARCH (p, q) with a leverage effect. If d is set at 1, the standard deviation is modeled. The first order of equation 9 is PGARCH (1, d, 1), expressed as:

$$\sigma_t^d = \beta_0 + \alpha_1 (|\varepsilon_{t-1}| + \gamma_1 \varepsilon_{t-1})^d + \beta_1 \sigma_{t-1}^d \qquad (10)$$

The failure to accept the null hypothesis that $\gamma_1 \neq 0$ shows the presence of leverage effect. The impact of news on volatility in PGARCH is similar to that of TGARCH when d is 1.

3.2 Error Distributions

To further prove that modelling of the return series is inefficient with a Gaussian process for high frequency financial time series, equations 4, 6, 8 and 10 above are estimated with a normal distribution by maximizing the likelihood function

$$L(\theta_t) = -1/2 \sum_{t-1}^{T} (ln2\pi + ln\sigma_t^2 + \frac{\varepsilon_t^2}{\sigma_t^2}) \qquad (11)$$

σ_t^2 is specified in each of the GARCH models.

The assumption that GARCH models follow GED[2] tends to account for the kurtosis in returns, which are not adequately captured with normality assumption. As in (11) above, the volatility models are estimated with GED by maximizing the likelihood function below:

$$L(\theta_t) = -\frac{1}{2}log\left(\frac{\Gamma 1/v^3}{\Gamma(3/v)(v/2)^2}\right) - \frac{1}{2}log\sigma_t^2 - \left(\frac{\Gamma(3/v)\left(y_t - X_t'\theta\right)^2}{\sigma_t^2\Gamma(1/v)}\right)^{v/2} \qquad (12)$$

v is the shape parameter which accounts for the skewness of the returns and $v > 0$. The higher the value of v, the greater the weight of tail. GED reverts to normal distribution if $v = 0$.

In the case of *t* distribution, the volatility models considered are estimated to maximize the likelihood function of a Student's *t* distribution:

$$L(\theta)_t = -\frac{1}{2}log\left(\frac{\pi(r)\Gamma r/2^2}{\Gamma((r+1)/2)^2}\right) - \frac{1}{2}log\sigma_t^2 - \frac{(r+1)}{2}log\left(1 + \frac{\left(y_t - X_t'\theta\right)^2}{\sigma_t^2(r-2)}\right) \qquad (13)$$

Here, r is the degree of freedom and controls the tail behavior. $r > 2$.

Equations 11, 12 and 13 are as specified in the EVIEW 7.2 manual and all estimations done in this study are implemented in the econometric software.

3.3 Data Source, Transformation and Test Procedures

This study uses the daily All Share Index (ASI) for Nigeria, which was obtained from ***www.cashcraft.com***. The stock market index constitutes daily equity trading of all listed and quoted companies in the Nigeria Stock Exchange. The ASI used in this study spans from January 2, 2008 to February 11, 2013, totaling 1,266 data points, out of which 1238 data points (January 2, 2008 to December 31, 2012) are used for model estimation and the remaining 28 data points are used for model validation.

Conditional variance models are fitted to continuously compounded daily stock returns, y_t:

$$y_t = 100(lnK_t - lnK_{t-1}) \qquad (14)$$

[2] See Graham L. Giller (2005): Giller Investment Research Note Number 2003 1222/1 and Eric Zivot (2008) for detailed discussion of GED

Where K_t = current period ASI, K_{t-1} = previous period ASI, y_t = current period stock returns (ASI-RT), and Ω_{t-1} = All stock returns up to the immediate past[3].

The Augmented Dickey Fuller (ADF) (Dickey and Fuller, 1979 and Fuller, 1976) method of unit root test is applied to determine if the daily stock index returns, y_t, is stationary. In the EVIEWs 7.2 where this test is implemented, the ADF is specified as

$$\Delta y_t = \alpha y_{t-1} + x_t' \tau + e_t \tag{15}$$

Where x_t' are optional exogenous regressors which may consist of constant, or a constant and trend. To establish the existence of volatility clustering in the daily stock index returns, y_t, the plot of residuals, $\boldsymbol{\xi_t}$ in the equation:

$$y_t = \kappa + \boldsymbol{\xi_t} \tag{17}$$

tends to shows that prolonged periods of low volatility are followed by prolonged periods of high volatility. κ is a constant and y_t is return series. The Lagrange Multiplier (LM) test for ARCH in the residuals, $\boldsymbol{\xi_t}$ is used to test the null hypothesis that there is no ARCH (Ho: $\pi_l = 0$) up to order q at 5% significant level using the equation below:

$$\xi_t^2 = \psi_0 + \left(\sum_{l=1}^{q} \pi_l \xi_{t-l}^2\right) + \mu_t \tag{18}$$

ψ_0 and μ_t are constant and error term, respectively. The expectation is that there should be no evidence to accept the null for GARCH model to be applicable.

The mean equation of the stationary return series with ARCH effect is specified in a univariate form as:

$$y_t = \rho + \varpi y_{t-1} + \varepsilon_t \tag{19}$$

Where y_t is as defined above, ρ is constant, ϖ is the estimated autoregressive coefficient, y_{t-1} is one period lag of the stock index returns and ε_t is the standardized residuals of the stock index returns at time t.

3.4 Model Selection/Forecasting Evaluation

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[3] See Hojatallah 2011; Hung-Chun Liu (2009) and Eric (2008) for similar usage.

The first order volatility models in equations 4, 6, 8, and 10 above are estimated by allowing ε_t in (19) for each of the variance equation to follow normal, student's t and generalized error distributions. The value of the positive exponent in equation 10 is set at 1, 2 and 4. This process generates eighteen volatility models. Model selection is done using SIC, and the model with the least SIC value across the error distributions is adjudged the best fitted. This selection produces the best four fitted conditional variance models for stock returns.

Another way of evaluating the adequacy of asymmetric volatility models is the ability to show the presence of leverage effect, that equal magnitude of bad news (negative shocks) have stronger impact than good news (positive shocks) on the volatility of stock index returns. The presence of leverage effect among the asymmetric models (equations 6, 8 and 10) is examined by testing the null hypothesis that $\gamma = 0$ at 5% level of significance. Rejection of the null hypothesis implies the presence of leverage effect.

This is further validated with the graph of news impact curve (NIC). The NIC examines the relationship between the news and future volatility of stock returns. The NIC of the best four volatility models are plotted to show the extent they are able to capture the debt-equity ratio. The higher the debt-equity ratio, the greater the risk associated with investment in stock.

The diagnostic test for standardized residuals of the stock returns in each of the four best fitted volatility models is conducted. The tests for remaining ARCH effect and serial correlation using ARCH-LM test and Q-Statistics (Correlogram of Residuals), respectively are conducted. The presence of ARCH effect and serial correlation in the residual of the mean equation (standardized residual) reduces the efficiency of the conditional variance model. Hence, the expectation is that the two null hypotheses that "there is no ARCH effect" and "there is no serial correlation" must not be rejected at 5% significance level. QQ-plot is used to check the normality of the standardized residuals. For a Gaussian process, the points in the QQ-plots will lie on a straight line.

On the predictive ability of volatility models, Clement (2005) proposes that out-of-sample forecasting ability remains the criterion for selecting the best predictive model. Therefore, two out-of-sample model selection criteria (Root Mean Square Error (RMSE) and Theil Inequality Coefficient (TIC)) are applied to evaluate the predictive ability of the four competing models. If σ_t^2

and $\widehat{\sigma_t^2}$ represent the actual and forecasted volatility of stock returns at time t, then

$$RMSE = \sqrt{\sum_{t=T+1}^{T+k} \left(\widehat{\sigma_t^2} - \sigma_t^2\right)^2 \Big/ k} \qquad (20)$$

and

$$TIC = \frac{\sqrt{\sum_{t=T+1}^{T+k} \left(\widehat{\sigma_t^2} - \sigma_t^2\right)^2 \Big/ k}}{\sqrt{\sum_{t=T+1}^{T+k} \left(\hat{\sigma}_t^2\right)^2 \Big/ k}\sqrt{\sum_{t=T+1}^{T+1} \left(\sigma_t^2\right)^2 \Big/ k}} \qquad (21)$$

The forecast sample, $i = 1239, \dots, 1266$. The smaller the RMSE and TIC, the higher the forecasting ability of the model.

4.0 Results

4.1 *Descriptive Statistics*

The ASI was logged to reduce the variance and was transformed to a continuously compounded daily stock returns as in (14) above. The return series was tested to determine the order of integration using ADF in (15) and the result in table 1 shows that the series is stationary at level.

Table 1 Unit Root Test for ASI

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-18.23771	0.0000
Test critical values:	1% level	-3.965494	
	5% level	-3.413454	
	10% level	-3.128769	

MacKinnon (1996) one-sided p-values.

Table 2 describes the summary statistics of the stationary stock returns. The table reveals negative mean daily returns of 0.000594 and the standard deviation which measures the riskiness of the underlying assets was 1.19 per cent. The higher the standard deviation, the higher the volatility of the market and the riskier the equity traded. The 13.1 per cent difference between the minimum and maximum returns shows the level of price variability in equity trading in the NSE over the sample period. Again, considering the very high J-B value (1369.878) and the very small corresponding p-value, the null of normality was rejected for the data. To support the J-B inference, the skewness (0.412140) is greater than 0 (skewness of a normal distribution is 0) and the kurtosis (8.089069) is higher than 3 (kurtosis of a normal distribution is 3). The positive skewness is an indication that the upper tail of the distribution is thicker than the lower tail meaning that the returns rises more often than it drops, reflecting the renewed confidence in the market. Information emanating from the descriptive statistics supports the subjection of the return series to volatility models.

Table 2: Summary Statistics of the Nigeria Stock Returns

Mean	Median	Minimum	Maximum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Prob. Value
-0.0006	-0.0004	-0.060582	0.070724	0.01197	0.41214	8.08907	1369.878	0.0000

Source: Author's computation

The plot of equation (17) above is shown is figure 1 and visual inspection of the plot shows that return series oscillates around the mean value (mean reverting). Volatility of stock returns is high for consecutive period (phase 1) and low for another consecutive period (phase 2). This feature of sustained periods of calmness and sustained periods of high volatility, as indicated in the phases, signifies volatility clustering, a stylized fact financial time series exhibit, a condition necessary for the application ARCH model.

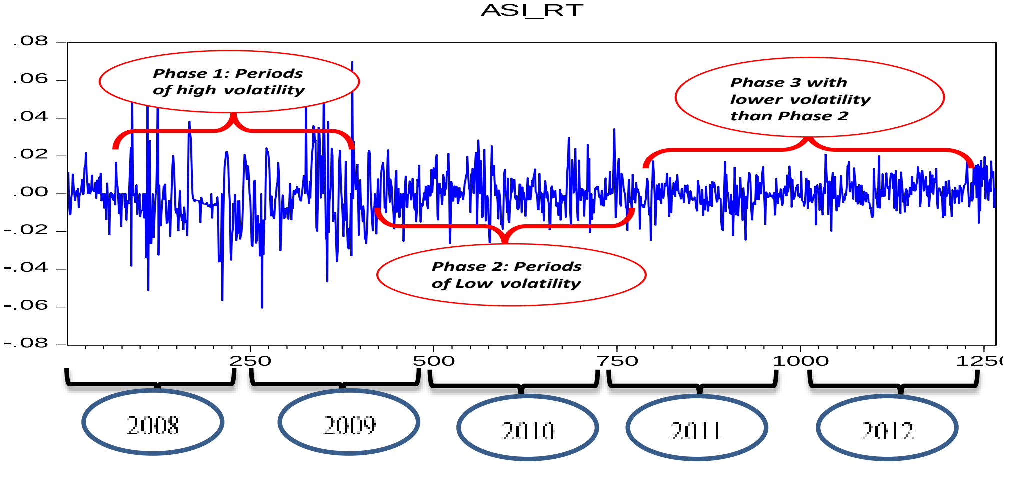

Figure 1: Volatility Clustering of Daily Return Series over the Mean

Table 3 shows the result of the test for ARCH effect when the residual from equation (17) is subjected to equation (18). Given the high values of the F and Chi-Squared statistics and their corresponding small p-values up to lag 10, there is evidence to conclude that there is presence of ARCH effect in the return series, even at 1% significant level.

Table 3

Heteroskedasticity Test: ARCH	**Lag 1**	**Lag 5**	**Lag 10**
F-statistic	140.8878	37.7931	19.09658
Prob. F(1,1234)	0.00000	0.00000	0.00000
Obs*R-squared	126.6557	164.5309	166.5393
Prob. Chi-Square(1)	0.00000	0.00000	0.00000

4.2 Model Selection

The presence of ARCH effect with other established stylized fact of this series gave credence to the estimation of GARCH family models with the three error distributions to determine the best volatility forecasting model. Table 4 presents the results of the eighteen estimated volatility models. The parameter estimates are significant at 5%, except the intercepts for GARCH (1, 1) and TGARCH (1, 1) in normal distribution. The power parameter, d in PGARCH (1, d, 1) is varied with 1, 2 and 4, in the three error distributions which also produced 9 PGARCH models with all the parameters being significant at 5% significant level, except the mean of PGARCH (1, 2, 1) and PGARCH (1, 4, 1) with normal distribution.

From the eighteen models, GARCH (1, 1), PGARCH (1, 1, 1) and EGARCH (1, 1) in Student's *t* error distribution and TGARCH (1, 1) in GED were selected for forecasting. This result is presented in table 5 alongside the percentage improvement of the four volatility models in normal (Gaussian) distribution by student's *t* and generalized error distributions (Non-Gaussian).

From table 5, it is clear that the Student's *t* error distribution improved the fitness of first order GARCH, TGARCH, EGARCH and PGARCH models with normal error assumption by 10.47, 10.48, 11.14 and 11.10 per cent, respectively. Similarly, the generalized error assumption improved the adequacy of the models with Gaussian processes by 9.00, 12.01, 9.53 and 9.50 per cent. Student's *t* error distribution improved most of the models.

Table 4: Estimation Results of First Order GARCH Family Models

Models	Equations	Model Parameter	Normal Distribution Coefficients	P-Value	SIC	Student's *t* Distribution Coefficients	P-Value	SIC	Generalised Error Distribution Coefficients	P-Value	SIC	Min SIC across error Distr
GARCH (1, 1)	Mean	Intercept	-0.0002650	0.2691		-0.0003690	0.0790		-0.0004390	0.0281		
		AR	0.4082560	0.0000		0.4399340	0.0000		0.4500600	0.0000		
	Variance	Intercept	0.0000127	0.0000	-6.474551	0.0000123	0.0000	**-6.579245**	0.0000131	0.0000	-6.564504	-6.579245
		ARCH	0.2985320	0.0000		0.3329500	0.0000		0.3311220	0.0000		
		GARCH	0.6157230	0.0000		0.6020320	0.0000		0.5821430	0.0000		
TGARCH (1, 1)	Mean	Intercept	-0.0003750	0.1444		-0.0004460	0.0360		-0.0005250	0.0094		
		AR	0.4042400	0.0000		0.4386200	0.0000		0.4475640	0.0000		
	Variance	Intercept	0.0000125	0.0000	-6.47096	0.0000122	0.0000	-6.575741	0.0000128	0.0000	**-6.591049**	-6.591049
		ARCH	0.2468430	0.0000		0.2700760	0.0000		0.2638490	0.0000		
		Asymmetric	0.0949270	0.0042		0.1374750	0.0305		0.1402950	0.0263		
		GARCH	0.6213960	0.0000		0.6008190	0.0000		0.5864200	0.0000		
EGARCH (1, 1)	Mean	Intercept	-0.0004860	0.0403		-0.0005240	0.0127		-0.0006140	0.0020		
		AR	0.4365760	0.0000		0.4537820	0.0000		0.4663750	0.0000		
	Variance	Intercept	-2.0735230	0.0000	-6.469073	-1.7131680	0.0000	**-6.580517**	-1.9597760	0.0000	-6.564378	-6.580517
		ARCH	0.5441790	0.0000		0.5231960	0.0000		0.5461540	0.0000		
		Asymmetric	-0.0385470	0.0143		-0.0521490	0.0411		-0.0572110	0.0318		
		GARCH	0.8203100	0.0000		0.8571910	0.0000		0.8336180	0.0000		
PGARCH (1, 1, 1)	Mean	Intercept	-0.0005050	0.0281		-0.0005680	0.0066		-0.0006280	0.0015		
		AR	0.4337550	0.0000		0.4487550	0.0000		0.4623100	0.0000		
	Variance	Intercept	0.0014610	0.0000	-6.467674	0.0012530	0.0000	**-6.578679**	0.0013950	0.0000	-6.562637	
		ARCH	0.2956470	0.0000		0.2962110	0.0000		0.3065360	0.0000		
		Asymmetric	0.0604330	0.0377		0.1058960	0.0462		0.1006160	0.0486		
		GARCH	0.6380080	0.0000		0.6611390	0.0000		0.6340750	0.0000		
PGARCH (1, 2, 1)	Mean	Intercept	-0.0003750	0.1438		-0.0004470	0.0356		-0.0005260	0.0092		
		AR	0.4042930	0.0000		0.4386790	0.0000		0.4476710	0.0000		
	Variance	Intercept	0.0000125	0.0000	-6.470964	0.0000122	0.0000	-6.575792	0.0000128	0.0000	-6.561083	-6.578679
		ARCH	0.2924890	0.0000		0.3358460	0.0000		0.3306900	0.0000		
		Asymmetric	0.0813050	0.0039		0.1037100	0.0254		0.1070100	0.0214		
		GARCH	0.6212920	0.0000		0.6002820	0.0000		0.5859410	0.0000		
PGARCH (1, 4, 1)	Mean	Intercept	-0.0003600	0.1576		-0.0004310	0.0429		-0.0005000	0.0130		
		AR	0.3922250	0.0000		0.4391570	0.0000		0.4454010	0.0000		
	Variance	Intercept	9.54E-10	0.0000	-6.460128	1.15E-09	0.0000	-6.562321	1.04E-09	0.0000	-6.549927	
		ARCH	0.2086550	0.0000		0.3187750	0.0000		0.2767710	0.0000		
		Asymmetric	0.0721440	0.0016		0.0884480	0.0208		0.0911740	0.0169		
		GARCH	0.5275620	0.0000		0.4306310	0.0000		0.4476800	0.0000		

Therefore, the specification of these volatility models with Gaussian process is not adequate enough to capture the variability in stock in Nigeria. Its application could lead to mis-specification as other non-Gaussian processes could contribute more to the fitness of these models than the Gaussian processes. The graphical representation of conditional variance of stock market returns is shown in Figures 4a to 4d.

Table 5: Model Fit and Improvement of Non-Gaussian Process over Gaussian Process

First Order GARCH Models	Schwarz Information Criterion (SIC)			Percentage Improvement of Gaussian Process by Non-Gaussian Process	
	Normal Distribution	Student's *t* Distribution	Generalized Error Distribution	Student's *t* Distribution	Generalized Error Distribution
GARCH (1, 1)	-6.474551	**-6.579**	-6.564504	10.47	9
TGARCH (1, 1)	-6.47096	-6.575741	**-6.591**	10.48	12.01
EGARCH (1, 1)	-6.469073	**-6.581**	-6.564378	11.14	9.53
PGARCH (1, 1, 1)	-6.467674	**-6.579**	-6.562637	11.1	9.5

Source: Author's Computation

4.3 Parameter Estimates of GARCH Family Models

The appropriate signs (as indicated in section 3.1 above) and statistical significance asymmetric parameters at 5% in table 4 confirm the existence of leverage effect indicating that the volatility does not respond to equal magnitude of positive and negative shocks equally. The ARCH and GARCH terms in the models explain the volatility persistence of stock market returns. Table 6 presents the impact of news on volatility of stocks in the best fitted asymmetric volatility models, and the volatility persistence arising from the parameter estimates of the four best models.

Table 6: News Impact and Volatility Persistence

	ASYMMETRIC MODEL			SYMMETRIC MODEL
	TGATCH	EGARCH	PGARCH	GARCH
Error Distribution	**GED**	**Student's *t***	**Student's *t***	**Student's *t***
Good News Impact	*0.2638*	*0.9479*	*0.2962*	-
Bad News Impact	*0.4041*	*1.0521*	*0.4021*	-
Volatility Persistence	*0.8503*	*0.8572*	*0.9044*	*0.935*

Author generated

The three asymmetric first order GARCH models in table 6 clearly indicate that bad news have more impact on volatility than good news. This is validated in the graph of NIC in figures 2a to 2d, showing the responsiveness of future volatility in stock returns to current period news (shocks). The news is determined by the residuals of the models. Visual inspection of the NIC shows that volatility generated by PGARCH (1, 1, 1) model responds to news more than the volatility generated by other asymmetric models. For instance, as shown in the NIC, the volatility response to the same magnitude of negative and positive shocks in periods 6 and 8 are (3.87, 2.53) and (6.88, 4.50) for PGARCH; (3.52, 2.30) and (6.25, 4.08) for TGARCH; and (1.36, 1.24) and (1.86, 1.66) for EGARCH. The implication of this is that, it takes longer time for shock in the stock market to die out with PGARCH (1, 1, 1). Again, the positive slop of the NIC of the asymmetric models measures the level of confidence in the market. The upward trend of the NIC on the positive side of the shocks depicts increasing confidence in the stock market in Nigeria. The NIC for GARCH (1, 1) shows a perfect symmetry to shocks. This is also an indication of a well fitted model. This result is similar to most research findings such as Ai (2011), Eric (2008), Hojatallah (2011).

The volatility persistence of stock returns is captured in table 6. The sum of the ARCH and GARCH coefficients in the first order GARCH and TGARCH model are 0.9350 and 0.8503. Also, the GARCH coefficient for EGARCH is 0.8572 while $(\alpha_1 + \beta_1 + (-\gamma/2))$ for PGARCH (1, 1, 1) is 0.9044. In all, volatility persistence is greater than 0.5 and close to unity, an indication shock to the market dies out very slowly. However, the persistence of volatility is highest with the PGARCH (1, 1, 1) model as it is closest to 1 (see Olowe, 2011 for similar results), meaning that it accounts for volatility persistence more as most literatures have confirmed that the volatility persistence is very close to 1.

4.4 Diagnostics

The null hypothesis that there is no remaining ARCH effect in the models is accepted at 5% significance level, as shown in table 7.

The conformity of the residuals to homoscedasticity is an evidence of good volatility models because ARCH effect has been adequately accounted for. Again, serial correlation test results, using Q-Statistics (Correlogram of Residuals) is presented in appendix 2. The probability values of the Q-statistics for all lags are higher than 0.05, confirming that there is no serial correlation in the residuals of the estimated models at 5% significance level. Also, few points on the QQ-plots of the residuals in figure 3 fell outside the straight line, especially at the extreme which is maintaining the consensus that the standardized residuals are not normally distributed. Judging from the diagnostic checks, the best four variance equations qualify for forecasting.

Table 7: Heteroskedasticity Test for Four best fitted ARCH Family models

	Heteroskedasticity Test: ARCH	Lag 1	Lag 5	Lag 10	Lag 15
GARCH (1, 1) Student *t*	F-statistic	0.00026	0.53109	0.34009	0.29263
	Prob. F(1,1234)	0.98720	0.75290	0.97020	0.99610
	Obs*R-squared	0.00026	2.66269	3.42215	4.43163
	Prob. Chi-Square(1)	0.98720	0.75180	0.96970	0.99590
TARCH (1, 1) GED	F-statistic	0.01079	0.47498	0.30736	0.30412
	Prob. F(1,1234)	0.91730	0.79510	0.97950	0.99510
	Obs*R-squared	0.01080	2.38189	3.09358	4.60500
	Prob. Chi-Square(1)	0.91720	0.79420	0.97910	0.99500
EARCH (1, 1) Student *t*	F-statistic	0.28828	0.45583	0.26900	0.29239
	Prob. F(1,1234)	0.59140	0.80920	0.98770	0.99610
	Obs*R-squared	0.28868	2.28605	2.70837	4.42795
	Prob. Chi-Square(1)	0.59110	0.80830	0.98750	0.99600
PARCH (1, 1) Student *t*	F-statistic	1.37977	0.69492	0.41468	0.41986
	Prob. F(1,1234)	0.24040	0.62730	0.94020	0.97400
	Obs*R-squared	1.38046	3.48174	4.17012	6.34833
	Prob. Chi-Square(1)	0.24000	0.62620	0.93930	0.97330

Author's Computation

4.5 Forecast Performance

The result of 28 trading days out of sample forecast of stock returns used in determining the predictive abilities of the four models using the loss function in equations 20 and 21 is presented in Table 7.

On the basis of RMSE and Theil, PGARCH (1, 1, 1) model is selected as it yielded the least forecast error. This result is in consonance with Eric (2008). The covariance proportion of Theil statistics suggests that 87.73% of the remaining unsystematic forecasting error was accounted for. This is closely followed by GARCH (1, 1) model, with 89.22% of the unsystemic error being accounted for. The TGARCH (1, 1) is the next and the least competing model is the EGARCH (1, 1). It is worthy to note that the closeness of the forecast evaluation statistics in terms of RMSE and Theil coefficient justifies the adequacy of the conditional volatility models considered.

Table 7: Loss Function

LOSS FUNCTION (LF)	GARCH	TGARCH	EGARCH	PGARCH	MIN LF
Root Mean Square Error	0.011414	0.01149	0.011511	***0.011365***	0.011365
Mean Absolute Error (MAE)	0.009507	0.00957	0.009585	***0.009465***	0.009465
THEIL Coefficient	0.000552	0.000556	0.000557	***0.00055***	0.00055
Covariance Proportion (CP)	0.892234	0.887468	0.890113	***0.877263***	0.877263

Source: Author's Computation.

5.0 Conclusion

This study examined the applicability of first order GARCH family models alongside three alternative error distributions and the common features of stock market returns in Nigeria. Using the daily closing data of Nigerian stock exchange to model the volatility of stock returns, GARCH (1, 1), PGARCH (1, 1, 1) and EGARCH (1, 1) with Student's *t* error distribution and TGARCH (1, 1) with GED were selected to be the four best fitted models based on Schwarz Information Criterion. Thus, Student's *t* error distribution improved the fitness of first order GARCH, TGARCH, EGARCH and PGARCH models with normal error assumption by 10.47, 10.48, 11.14 and 11.10 per cent, respectively, while the generalized error assumption improved the adequacy of the models with Gaussian processes by 9.00, 12.01, 9.53 and 9.50 per cent. This corroborates previous studies that Gaussian process is inadequate for volatility modellinig.

The asymmetric parameters of these models show the evidence of leverage effect in stock returns, implying that stock returns volatility in the Nigerian capital market does not have equal response to the same magnitude of positive and negative shocks. The graph of NIC validates the volatility response to shocks, which reveals that future volatility in stock returns responds to bad news than it does to the same magnitude of good news. Shocks in the stock market return series are more persistence with PGARCH (1, 1, 1) in student's *t* distribution. The out-of-sample forecasting evaluation result adjudged

PGARCH (1, 1, 1) with student's *t* error distribution as the best predictive model based on Root Mean Square Error and Theil Inequality Coefficient.

Given the level of risk associated in investment in stocks, investors, financial analyst and empirical works should consider alternative error distributions while specifying predictive volatility model as less contributing error distributions implies incorrect specification, which could lead to loss of efficiency in the model. Also, investors should not ignore the impact of news while forming expectations on investment.

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Appendix 1: Selection of Previous Studies on Volatility Modelling

Author	**Objective**	**Data Type/ Frequency**	**Period of Study**	**Estimation Technique**	**Best Competing Model**	**Remarks**
Hamilton and Susmel (1994)	To determine the best volatility model for capturing regime change.	US Stock Returns/Weekly	July 3, 1962 to Dec. 29, 1987	Markov-Switching ARCH (SWARCH) and GARCH Models	SWARCH with Student'*t*	The study established very high volatility persistence and leverage effects and
Franses and Ghijsels (1999)	To propose new methods for economic analysis of outlier contaminated multivariate ARCH series	US NASDAQ and NYSE returns series/Weekly	1980 to 2006	GARCH models on Student'*t* , Normal and GED.	GARCH models with Student'*t*	Robust estimator is needed to cope with the outlying retruns during the 1987 stock market crsh in the US
Anders (2006)	To investigate GARCH forecasting model performance	S&P 500 Indx return series/intraday	Jan. 2, 1996 to Dec. 30, 2002	GARCH models in nine different error distributions	GARCH models with Student'*t*	Leptokurtic error distribution in GARCH significantly outperform GARCH in Normal error.
Yeh and Lee (2000)	To examine investors response to unexpected returns and information transmission in China Stock market.	Shanghai B-index and Shenzhen B-Share index return series	May 22, 1992 to August 27, 1996	TGARCH model		Impact of good news on future volatility is greater than impact of bad news of equal magnitude
Lee et al (2001)	To examine time series features of China Stock returns and volatility	Shanghai A & B and Shenzhen A & B Index return	Dec. 12 1990 to Dec. 31 1997 & Feb. 21, 1992 to Dec. 31, 1997 for Shanghai A & B. Sept. 30, 1992 to Dec. 31, 1997 & Oct. 6, 1992 to Dec. 31 1997 for Shenzhen A & B	Variance Ratio Test, GARCH, EGARCH and GARCH-M		Reandom walk hypothesis is rejected. Strong evidence of time-varying volatility, leverage effect and volatility persistence are established. No relationship between expected return and expected risk.
Friedmann and Sanddprf-Kohle (2002)	To analyze volatility dynamics in Chinese stock maerkets	Domestic A-Sahres index and Foreign B-Share index	May 22, 1992 to Sept. 16, 1999	EGARCH and TGARCH on GED	Similar result from EGARCH and TGARCH	High significant of trading days on volatility. News impact is invariant with EGARCH
Ai (2011)	To examine Chinese stock market volatility and the asymmetriceffect of market news on volatility	Shenzhen and Sheanghai stock exchange composite index	Jan. 2, 1997 to Aug. 31, 2007	GARCH, TGARCH and Nonparametric (NP) model	NP model outperform GARCH TGARCH models with Gaussian process	TGARCH and GAARCH models with Student'*t* are superior to NP

Source: Author's Compilation

Appendix 2: Serial Correlation Test Results (Correlogram of Residuals) of the Four Best Fitted Volatility Models

Lag	AC	PAC	Q-Stat	Prob	AC	PAC	Q-Stat	Prob
	GARCH (1, 1)				**TGARCH (1, 1)**			
1	0.015	0.015	0.2779	0.598	0.011	0.011	0.1395	0.709
2	0.015	0.015	0.5696	0.752	0.011	0.011	0.3014	0.86
3	0.021	0.021	1.138	0.768	0.018	0.018	0.719	0.869
4	0.002	0.001	1.141	0.888	0	-0.001	0.7191	0.949
5	0.032	0.032	2.4285	0.787	0.031	0.031	1.9388	0.858
99	-0.002	-0.019	98.286	0.501	-0.007	-0.023	94.932	0.597
100	-0.003	-0.011	98.294	0.53	-0.002	-0.013	94.937	0.624
101	0.029	0.042	99.415	0.526	0.026	0.039	95.821	0.627
102	0.019	0.026	99.896	0.54	0.02	0.026	96.338	0.639
197	0.02	-0.008	208.44	0.275	0.019	-0.01	206.42	0.308
198	-0.024	-0.016	209.28	0.278	-0.025	-0.017	207.32	0.31
199	-0.005	-0.007	209.31	0.294	-0.004	-0.007	207.35	0.328
200	0.002	-0.017	209.32	0.311	0	-0.018	207.35	0.346
	EGARCH (1, 1)				**PGARCH (1, 1, 1)**			
1	0.001	0.001	0.0018	0.967	-0.003	-0.003	0.0116	0.914
2	0.011	0.011	0.1535	0.926	0.011	0.011	0.1571	0.924
3	0.019	0.019	0.5911	0.898	0.022	0.022	0.765	0.858
4	-0.001	-0.001	0.5928	0.964	-0.002	-0.002	0.7698	0.942
5	0.03	0.029	1.6816	0.891	0.032	0.031	2.0375	0.844
99	-0.008	-0.025	93.107	0.648	-0.008	-0.027	94.8	0.601
100	-0.001	-0.011	93.109	0.674	0.001	-0.008	94.802	0.628
101	0.027	0.038	94.076	0.674	0.027	0.037	95.809	0.627
102	0.018	0.025	94.499	0.689	0.014	0.022	96.067	0.647
197	0.019	-0.009	201.71	0.394	0.021	-0.009	201.6	0.396
198	-0.025	-0.016	202.6	0.396	-0.022	-0.015	202.32	0.402
199	-0.008	-0.009	202.69	0.414	-0.007	-0.006	202.38	0.42
200	0.002	-0.017	202.69	0.434	0.002	-0.014	202.39	0.439

Figures 2a to 2d: News Impact Curves of Volatility Models

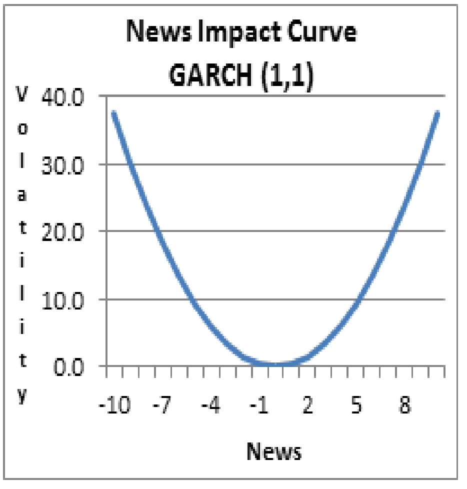

Figure 2a

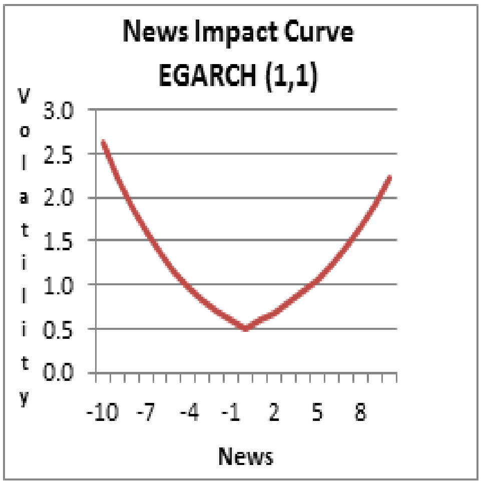

Figure 2b

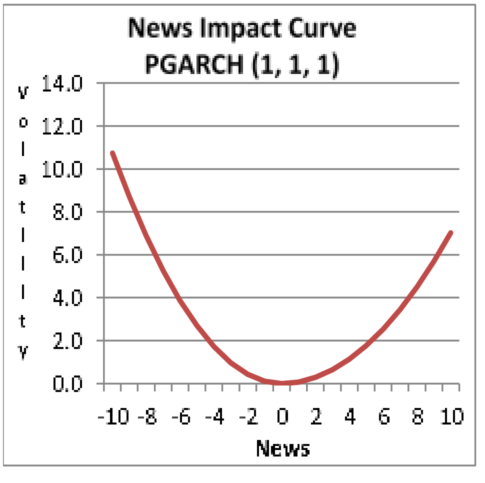

Figure 2c

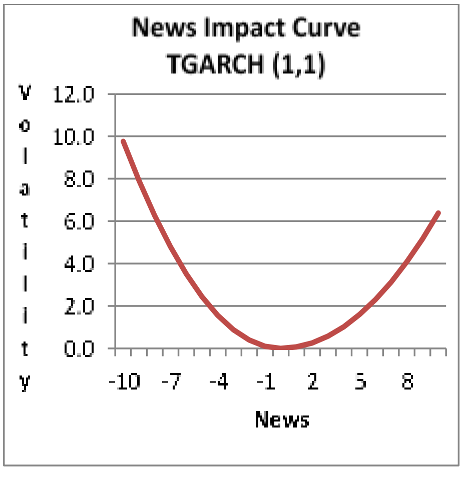

Figure 2d

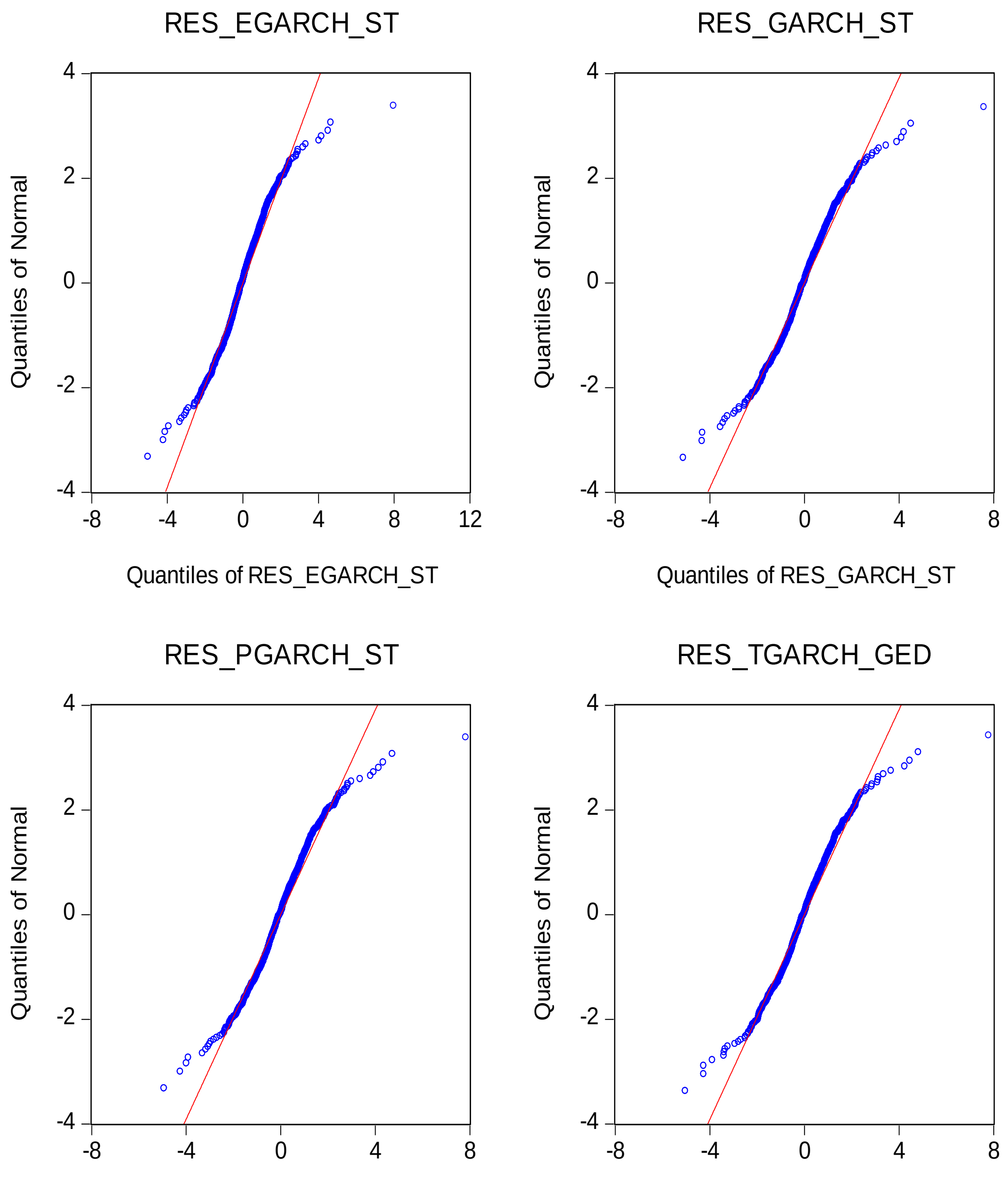

Figure 3: QQ-plots of the Standardized Residuals

Figures 4a to 4d: Graphical Representation of Conditional Variance of Stock Market Returns

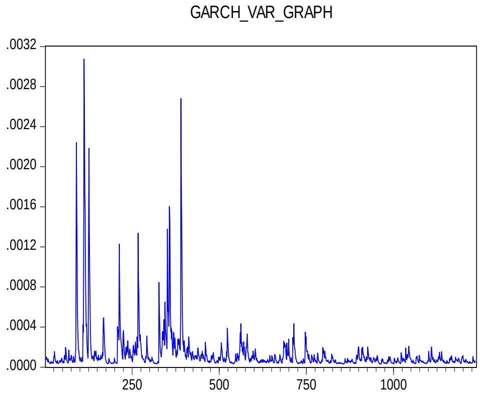

Fig. 4a

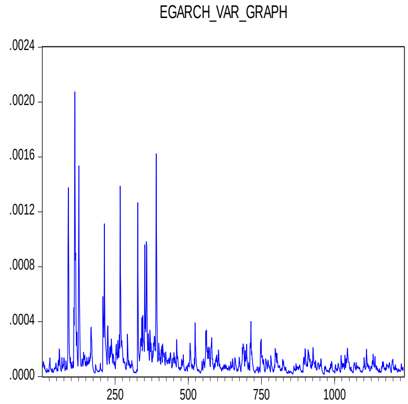

Fig. 4b

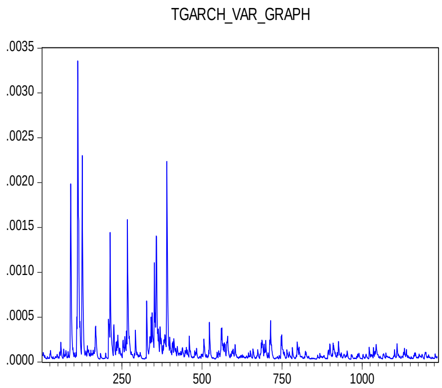

Fig. 4c

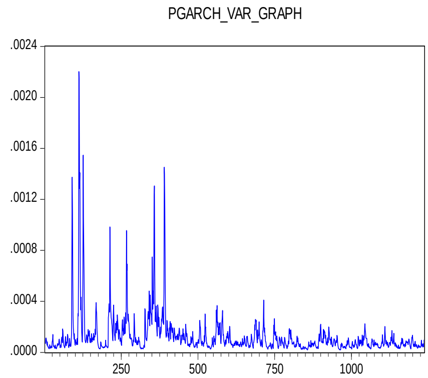

Fig. 4d

The Balance Sheet Channel of Monetary Policy Transmission: Evidence from Nigeria[1]

[2] **Olorunsola E. Olowofeso, Abiodun S. Bada, Kufre J. Bassey and Kumafan S. Dzaan**

This paper assesses the existence of a balance sheet channel of monetary policy transmission in Nigeria by examining whether variation in the official interest rate, with respect to the 2007- 2008 global financial crisis, feeds through to the deposit money banks (DMBs) balance sheets, and ultimately reflects in output and prices. Using quarterly macroeconomic data and stock from 2002 to 2012, the study employs an ordinary least squares (OLS) and autoregressive (VAR) framework to investigate the linkages between policy, DMB balance sheet, output and price. The results reveal the existence of a balance sheet channel in Nigeria with a significant impact of DMBs balance sheet composition on output growth and price. However, output and price did not react homogeneously to changes in monetary policy variations due to the global financial crisis.

Keywords: Balance sheets Channel; Deposit Money Bank; Financial Crisis; Monetary Policy; Output; Price

JEL Classification: E31, E44, E52, E58

1.0 Introduction

Balance sheet channel defines the role and the financial position of a commercial bank in the transmission mechanism of monetary policy. It arises as official interest rates generate variations in capital and interest income which have an effect on micro and aggregate expenditure, output and prices of economic mediators, given that they affect the balance sheet items of the accounts of commercial banks directly (Boivin *et al.*, 2010).

According to Bacchetta and Ballabriga (2000), there are at least three proposed views of the role of banks in monetary transmission. First is the standard *money view,* where bank loans have no special role: here, monetary shocks affect output through changes in monetary aggregates. The second view is the *narrow credit channel or the bank lending channel*, where

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[1] The views expressed in this paper are that of the authors and do not reflect the position of the Central Bank of Nigeria.

[2] Statistics Department, Central Bank of Nigeria, Abuja. Emails: oeolowofeso@cbn.gov.ng; asbada@cbn.gov.ng; kjbassey@cbn.gov.ng; and ksdzaan@cbn.gov.ng.

monetary policy changes directly affect bank's balance sheet with reduction in bank loans, which in turn affect output: – here, output changes are directly caused by changes in bank loans. And the third view is the *broad credit channel* or *the balance sheet channel:* here, monetary policy affects interest rates and output in a way similar to the money channel or influences output via a different channel.

In Nigeria, DMBs always show greater sensitivity during periods of tight or loosed monetary policy with greater effect on those that are potentially financially-constrained. Hence, based on the balance sheet theory[3], where the status of balance sheets affects the economy's response to monetary and other shocks (Melander, 2009; Kashyap and Stein, 1994), the study builds on the assumption that aggregate DMBs' balance sheet variables change with policy rate, and also reflects on output and prices. Focus is on examining how variation in the official interest rate, feeds through to the DMBs balance sheets, and ultimately reflects in output and prices, with specific recourse to the 2007- 2008 global financial crisis. The results of this expedition are expected to enunciate on the possible existence or otherwise of a balance sheet channel of monetary policy transmission in Nigeria.

The rest of the paper is so structured that the second section described the evolution and characteristics of monetary policy and DMBs balance sheet to the global financial crisis. The third section presents the literature review on DMBs response and other related studies on the balance sheet channel. Section four presents the study methodology, while the fifth section presents the results of the investigations. The concluding remarks and policy implication are given in section six with valid references of similar studies.

2.0 Stylized Fact on Monetary Policy and DMBs Balance Sheet in Nigeria

It is argued that a change in official interest rates may either weaken or strengthen bank's balance sheet, reflect in aggregate demand and, ultimately, in output and prices(Allen *et al.* 2002). It is also anticipated that financial crisis occurs when there is a plunge in demand for financial assets[4]. In

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[3] An economy's resilience to a range of shocks, including financial shocks, hinges in part on the composition of the country's stock of liabilities and assets (see Allens *et al.*, 2002).

[4] The deterioration of Financial Institutions' Balance Sheets was one of the major causes of the financial crisis (Soludo, 2009). If the state of banks' balance sheets is compromised, the

Nigeria, DMBs are generally known to play a major role in the financial markets activities as they are well positioned to engage in information-producing activities which produce productive investments for the economy. Howbeit, they are also influenced by the adjustment of the Central Bank of Nigeria's (CBN) target for a short-term nominal interest rate. This influence does reflect not only in the volume of the DMBs' activities but also in the composition of their assets and liabilities[5].

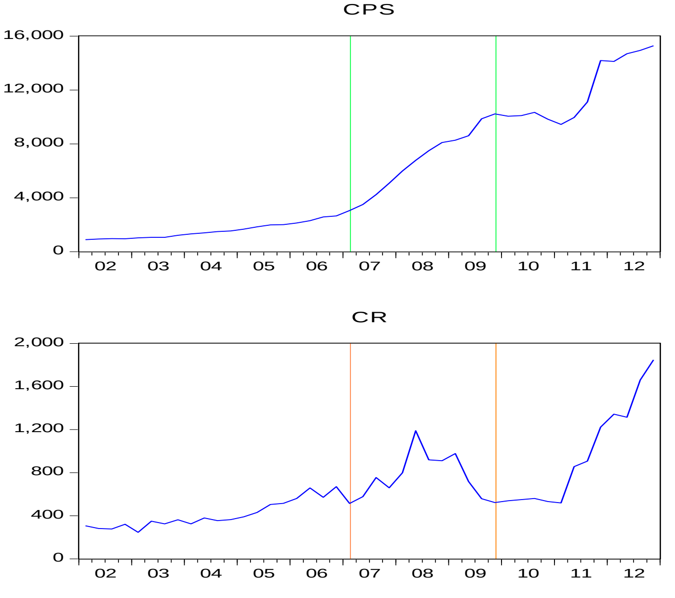

Figure 1: DMBs Balance Sheet Characteristics before, during and after the Crisis
***Source**: Central Bank of Nigeria Statistical Bulletin.*
***(Note:** Balance sheets positions is proxied by both credit to private sector (CPS) and capital reserve (CR) from 2002 – 2006; 2007 – 2009 and 2010 – 2012)*

Thus, during the global financial crisis that started in 2007, there was widespread credit contraction, causing financial institutions in various countries to tighten their credit standards in light of deteriorating balance sheets at the first quarter of 2008 and by the fourth quarter of 2008, the spilled

balance sheets are likely to suffer substantial contractions in their capital. These would therefore lead to decline in lending, and consequently result in a decline in investment spending, thereby slowing down economic activity (http://www.slidefinder.net/F/Financial_Crises/5965800).

[5] Banks might not lend out to private sector even if they have a good risk, thereby resulting in a drop in cash flow. Hence, adverse selection and moral hazard problems may become more severe, impacting lending, investment, and overall economic activity.

over effect spread into consumer and other credits (Sanusi, 2010). Albeit, it could be seen from Figure 1 that there was rather a positive influence on the DMBs lending where credit to private sector (CPS) expanded though with a gradual contraction in the capital reserve (CR) from the first quarter of 2009 up to the fourth quarter. These were not unconnected with the cuts in interest rate and injections of liquidity as some of the varying measures taken by the Nigerian Central Bank to restore liquidity, as well as the fiscal stimulus packages that stimulated aggregate demand (see, for example, Soludo, 2009).

3.0 Review of Literature

In the aftermath of the 2007 financial crisis, Ajakaiye and Fakiyesi (2009) reported that the gravity and depth of the crisis in the banking sector were not fully certified by citing some indicators as evidence. The cited indicators include bank lending that witnessed growth of about 60.9%, indicating that Nigerian banks were doing well in the face of the crisis. But Olowe (2011) rejected the hypothesis of asymmetry and leverage effect after investigated the volatility of interbank call rates in Nigeria.

Aliyu (2012) reported that the Nigeria's stock market reacted to the monetary policy shocks over the period January, 2007 to August, 2011, showing a destabilizing effect on Nigerian stock exchange's returns through an unanticipated component of policy innovations on broad money (M2) and monetary policy rate (MPR).

Atuanya and Obodo (2012) reported also that Nigeria was facing complex bank lending crisis and went further to expressed the claim by financial analysts that Nigerian banks aversion to lending to the real sector was a complex problem with no easy solutions, and that finding a way for DMBs to lend innovatively to Nigerian businesses had become a hard nut to crack. Perhaps the lending increased during the crisis and dropped afterwards due to CBN intervention, but whether or not it reflected on output and prices was still an opened problem.

There are several other empirical studies that have investigated bank- and firm-balance sheet channels independently and in combination. See, for example, Bernanke and Blinder (1992), Kashyap and Stein (2000), Kishan and Opiela (2000), Jayaratne and Morgan (2000), Ashcraft (2006), Gan (2007), Khwaja and Mian (2008), Black *et al.* (2009), Chaney *et al.* (2009), among others, on the bank; Gertler and Gilchrist (1994) and Bernanke *et al.*

(1996), among others, on the firm side, as well as Jiménez *et al.*(2011) on both.

Some of these studies approached the issue by looking at the relationship between money and output, and bank loans and output either through correlations or Granger-causality tests (King, 1986 and Ramey, 1994), or by examining the role of bank loans using autoregressions (see Bernanke and Blinder, 1992).

Cappelletti *et al.* (2011) used banks' balance sheet assets and liabilities to examine how crisis impacted on interbank funding relationships. The analysis showed that the crisis had a clear negative impact on interbank funding, though there was no drastic fall in the overall interbank activity.

Shabbir (2012), following the theoretical setup presented by Bernanke and Gertler (1995), used data of non-financial listed firms over a period of 1999 – 2010 to investigate the effectiveness of balance sheet channel of monetary transmission mechanism in Pakistan.

Angelopoulou and Gibson (2007) examined the sensitivity of investment to cash flow using a panel of UK firms in manufacturing with a view to shedding some light on the existence of a balance sheet channel or financial accelerator. In addition to examining the impact of cash flow in different subsamples based on company size or financial policy (dividend payouts, share issues and debt accumulation), they also investigated the extent to which investment becomes more sensitive to cash flow in periods of monetary tightness.

Allen *et al.* (2002) designed an analytical framework for understanding crises in emerging markets based on examination of stock variables in the aggregated balance sheet of a country and the balance sheets of its main sectors (assets and liabilities).

Bacchetta and Ballabriga (2000) provided systematic evidence on the evolution of banks' balance sheets and output in response to a monetary shock by examining 13 European countries in addition to the US.

Mínguez (1997) opined that monetary policy effects on the soundness and composition of the private non-financial sector balance-sheet and on its cash-flow can affect the willingness of credit institutions to lend to those agents, which emphasizes the role of asymmetric information in financial markets, since borrowers have an informational advantage over lenders concerning their quality as agents demanding loanable funds.

Following Bacchetta and Ballabriga (2000), we considered the balance sheet channel with expectation that monetary tightening will reduce DMB's cash flow, thereby magnifying the impact of monetary policy on output and prices.

4.0 Methodology

The existence and importance of balance sheet channel in Nigeria is considered in this study using statistical and econometric techniques. Thus, we evaluated the balance sheet channel in three procedures. These methods sought to provide systematic evidence on the progress of output and price in relation to variations in policy rate, given the 2007 -2008 global financial crisis in Nigeria.

First, we analyzed the impact of the crisis on those segments of the DMBs activities which are more exposed to counter party risk. *A priori*, the composition of the DMBs balance sheets is expected to change as monetary policy stance changes, thereby impacting in output and price. Thus, we adapted a standard regression model:

$$Y_i = \beta_1 + \beta_2 X_{2i} + \cdots + \beta_k X_{ki} + u_i \quad (1)$$

$$= \boldsymbol{X}'_i \beta + u_i, \ i = 1, \cdots, n \quad (2)$$

where $X_i = [1, X_{2i}, \cdots, X_{ki}]'$ is a $k \times 1$ vector of explanatory variables, $\beta = (\beta_1, \cdots, \beta_k)'$ is a $k \times 1$ vector of coefficients, and u_i is a random error term.

Assumption 1: We assumed that the classical assumptions of the linear regression model in Equation (1) hold:

$$Y_i = \boldsymbol{X'}_i \hat{\beta} + \hat{u}_i, \quad i = 1, \cdots, n \quad (3)$$

where $\hat{\beta} = (\boldsymbol{X'X})^{-1}\boldsymbol{X'Y}$; $\hat{u}_i = Y_i - \boldsymbol{X'}_i\hat{\beta}$; $\hat{\sigma}^2 = \frac{\hat{u}'\hat{u}}{n-k}$ and $var(\hat{\beta}) = \hat{\sigma}^2(\boldsymbol{X'X})$.

Under this assumption, we considered the influences of DMBs' balance sheets variables (using credit to private sector (CPS) and capital reserves (CR) as proxies) and policy rate (MPR) on output and price (see also Özlü and Yalçın, 2010). The dependent variables in the regression equation – Industrial Production Index (IPI), and Consumer Price Index (CPI), were employed as proxies for output and price, respectively. The representative models explaining the variables are as shown in Equations (6) and (7).

We introduced a time period dummy D to reflect the variations in monetary conditions. This dummy was constructed based on MPR variations due to external shocks and the global financial imbalances believed to have ended up with a contraction in the overall economic activity of some countries. The dummy variable took the value of 1 when the data referred to the loose period $(i.e., when\ t = 2007Q1 - 2008Q1, and\ 2008Q3 - 2011Q3)$ and zero for the tight period, and was interacted with all the regressor variables in the models. This was to allow us examine the existence of balance sheet channel via the relation of MPR variations from a tight to a loose period on output and price. Recall that the DMBs' balance sheets variables are theoretically believed to vary with MPR homogeneously.

Assumption 2: The classical assumptions of the linear regression model in Equation (1) do not hold:

Under this assumption, several residual diagnostics statistical and econometric tests were carried out following Bacchetta and Ballabriga (2000) and Agha *et al.* (2005) to examine the dynamics of the balance sheet channel of transmission mechanism in Nigeria. All the five variables were incorporated into a VAR system where the variance-covariance matrix of the VAR system was diagonalized using a triangular orthogonalization scheme called Choleski scheme (see also Lin, 2008). Generally, this scheme relies on a particular ordering of variables and has the advantage that shocks to the VAR system can be identified as shocks to the endogenous variables.

Thus, a multivariate VAR with n variables and k lags over time t was considered as follows:

$$Y_t = \sum_{k=1}^{K} Z^{-1}(\beta^k Y_{t-k} + \mu_t) \qquad (4)$$

$$= \sum_{k=1}^{K} A^k Y_{t-k} + \mu_t \qquad (5)$$

where Y_t is a $n \times 1$ column vector of observations at time t on all the five variables (*IPI, CPI, CPS, CR, MPR); $A^k \equiv Z^{-1}\beta^k$* is the matrix coefficients to be estimated. This implies that $ZY_t = \sum_{k=1}^{K} \beta^k Y_{t-k} + \varepsilon_t$ where $Z\ is\ a\ n \times n$ contemporaneous coefficient matrix; $\beta^k\ is\ a\ n \times n$ matrix polynomial in the lag operator k while $\varepsilon_t\ is\ a\ n \times 1$ column vector of random disturbances assumed to be non autocorrelated over time.

The model representations of the variables of interest using the logarithm of all the variables except the policy rate were obtained as:

$$LIPI_{it} = f(LCPS_{it}, LCPS_{it} * D_i, LCR_{it}, LCR_{it} * D_i, MPR_{it}, MPR_{it} * D_i) \quad (6)$$

$$LCPI_{it} = f(LCPS_{it}, LCPS_{it} * D_i, LCR_{it}, LCR_{it} * D_i, MPR_{it}, MPR_{it} * D_i) \quad (7)$$

following assumption 1, and

$$Y_t = f(IPI_t, CPI_t, CPS_t, CR_t, MPR_t) \quad (8a)$$

following assumption 2.

Secondly, we examined the response of other variables that can influence the balance sheet channel of transmission mechanism to a shock to MPR, which include the GDP growth rate (GDPG), changes in CPI (P), growth rates of credit to private sector (CPSG) and net credit to government (NCGG), as well as the prime lending rate (PLR). The model representation is given under assumption 2 as:

$$X_t = f(GDPG_t, P_t, CPSG_t, NCGG_t, PLR_t, MPR_t) \quad (8b)$$

4.1 Diagnostic Tests

Prior to the VAR system analysis, the time series properties of the variables were determined using some statistical and econometric tests. Under assumption 2, the Augmented Dickey Fuller (ADF) test was conducted using a standard equation of the form:

$$\Delta Y_t = \beta_1 + \beta_{1t} + \alpha Y_{t-1} + \gamma \sum_{t=1}^{n} \Delta Y_{t-1} + \varepsilon_t \quad (9)$$

In other word, a unit root test was carried out on the coefficient of Y_{t-1} in the regression for the existence of unit root in variable Y_t. The unit root test was conducted in two cases: with intercept only and with intercept and trend, to take into account the impact of trend in the series (Table 4).

A Lagrange Multiplier (LM) statistic of the form:

$$LM = T^{-2} \sum_{i=1}^{T} S\,(t)^2 / f_0 \qquad (10)$$

was also carried out for residual serial correlation, where T is the sample size, S(t) is the partial sum of residuals, and f_0 is an estimator of the residual spectrum at frequency zero.

Other econometric tests included the multivariate extensions of the Jarque-Bera residual normality test (Jarque and Bera, 1980), which compared the third and fourth moments of the residual's distribution to those from the normal distribution based on the estimated moments of the residuals given by $\mu_i = 1/T \sum_{t=1}^{T} \varepsilon_t^i, \;\; i = 1,2,\cdots$; and such that

$$T\left[\frac{\mu_3^2}{6\mu_2^3} + \frac{1}{24}\left(\frac{\mu_4}{\mu_2^2} - 3\right)^2 + \frac{3\mu_1^2}{2\mu_2} - \frac{\mu_3\mu_1}{\mu_2^2}\right] \sim \chi_{(2)}^2 \qquad (11)$$

where μ_1 is the estimated mean of the residuals, μ_2 is the estimated variance, μ_3 is the third moment that measures skewness, and μ_4 is the fourth moment that measures kurtosis.

Cumulative sum of squares (CUSUM) tests were also carried out to validate parameter stability in the estimation of Equations 6-7, while a variance decomposition and impulse response functions that traced the effects of a shock to one endogenous variable on to the other variables in the VAR system was used to evaluate the overall influence of monetary policy on output and price for the periods under consideration. This test gave the expected time path of the dependent variable(s) that would result when a shock is added to a model in steady state.

4.2 Data and the Choice of Variables

In this study, we considered the following five variables: DMBs capital reserves, *CR;* DMBs credit to private sector, *CPS;* monetary policy rate, *MPR;* industrial production index, *IPI;* and consumer price index, *CPI,* as balance sheet channel variables following several authors in the literature. Further variables like the GDP growth rate (GDPG), changes in CPI (P), growth rates of credit to private sector (CPSG) and net credit to government (NCGG), as well as the prime lending rate (PLR) were also considered for robustness check. All quarterly data were extracted from the CBN statistical bulletins of 2002Q1 – 2014Q1.

5.0 Empirical Results and Discussion

5.1 Statistical Analysis

The results of the regression estimates are presented in Tables 1 – 3. The

percentage variations of output and price explained by the impact of MPR variations from a tight to a loose period and the response of CPS and CR was given by the $R^2 = 0.638$ and 0.967, respectively, while the proportion of the variability that was due to DMBs balance-sheets specific components was explained by the adjusted $R^2 = 0.579$ and 0.960, respectively.

Table 1: Regression Estimate for LIPI Model

Dependent Variable: LIPI				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCPS	0.155469	0.057138	2.72093	0.0099
CPS_D	-0.12409	0.081837	-1.516251	0.138
LCR	-0.22645	0.094363	-2.399798	0.0216
CR_D	0.179304	0.122106	1.468428	0.1504
MPR	0.023921	0.006316	3.787457	0.0005
MPR_D	-0.01806	0.021081	-0.856865	0.397
C	4.778752	0.27202	17.56767	0.0000
R-squared	0.638355	Mean dependent var		4.866042
Adjusted R-squared	0.57971	S.D. dependent var		0.095725
S.E. of regression	0.062058	Akaike info criterion		-2.57658
Sum squared resid	0.142495	Schwarz criterion		-2.29273
Log likelihood	63.68469	Hannan-Quinn criter.		-2.47131
F-statistic	10.88504	Durbin-Watson stat		0.885468
Prob(F-statistic)	0.000001			

Table 2: Regression Estimates for LCPI Model

Dependent Variable: LCPI				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCPS	0.327293	0.065856	4.969823	0.0000
CPS_D	0.061409	0.094324	0.651047	0.519
LCR	0.024356	0.108761	0.223941	0.824
CR_D	-0.142039	0.140737	-1.009251	0.3194
MPR	-0.02078	0.00728	-2.854526	0.007
MPR_D	0.02602	0.024298	1.070886	0.2912
C	1.820313	0.313524	5.805973	0.0000
R-squared	0.965619	Mean dependent		4.364705
Adjusted R-squared	0.960044	S.D. dependent var		0.357831
S.E. of regression	0.071527	Akaike info		-2.29257
Sum squared resid	0.189296	Schwarz criterion		-2.00872
Log likelihood	57.4366	Hannan-Quinn		-2.18731
F-statistic	173.1965	Durbin-Watson stat		0.833753
Prob(F-statistic)	0.0000			

The statistical significance of the regression was captured by the F-statistics of 10.88 in Table 2 and 173.19 in Table 3 which are high enough to reject the null hypothesis of non-significance of the estimation parameters. These results indicate the existence of balance sheet channel but also establish non significance impact of the global financial crisis on output and price through DMBs' balance sheets in Nigeria. The non-significant impact of the crisis was in consonance with Ajakaiye and Fakiyesi (2009). In particular, the existence of balance sheet channel was underscored following the statistically significant effect of CPS, CR and MPR on output, as well as CPS and MPR on price. This also implies that the variations in MPR influence economic response indirectly.

Before drawing conclusions from the estimated regressions, a stability test was conducted to make sure that the assumptions of the classical linear regression model were satisfied. The tests results indicated no episode of instability in the variables used as the residual variance remained generally stable within a 5 percent critical band (Figures 1 and 2).

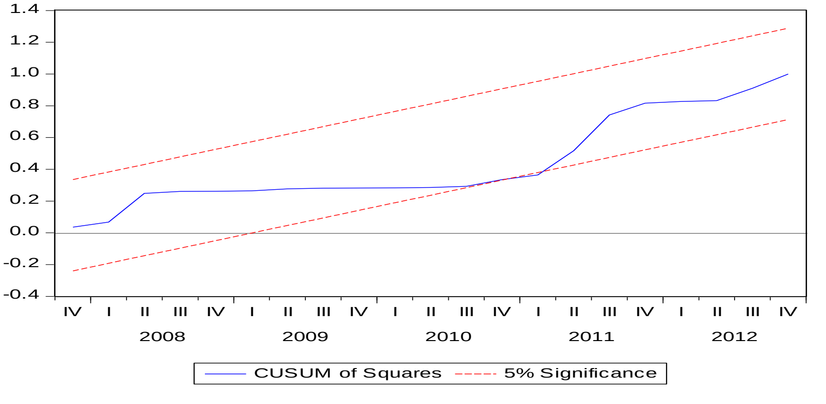

Fig. 1: Stability Test for IPI Model

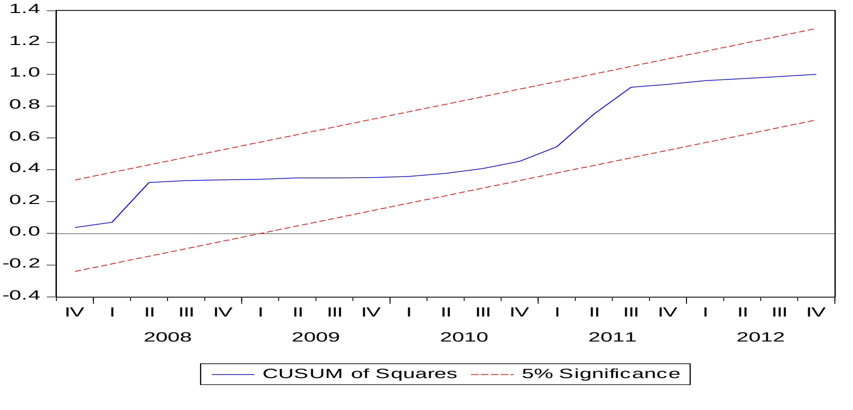

Fig. 2: Stability Test for CPI Model

This, by theoretical affirmation shows that the regression estimates $\hat{\beta}$ are consistent and asymptotically distributed with $var(\hat{\beta}) = \hat{\sigma}^2(\boldsymbol{X'X})$.

Table 3: Regression Estimates for GDPG Model

Dependent Variable: GDPG				
	Coefficient	Std. Error	t-Statistic	Prob.
LCPS	3.946122	4.557644	0.865825	0.3916
CPS_D	0.218329	0.148898	1.466296	0.1502
LCR	-0.169099	0.123148	-1.37314	0.1772
CR_D	-0.00043	0.000574	-0.74784	0.4588
MPR	0.000502	0.023063	0.021779	0.9827
MPR_D	0.229049	0.293479	0.780463	0.4396
C	-0.102465	0.189966	-0.53939	0.5925
R-squared	0.136566	Mean dependent var		6.310545
Adjusted R-squared	0.01021	S.D. dependent var		3.588876
S.E. of regression	3.570508	Akaike info criterion		5.51733
Sum squared resid	522.6895	Schwarz criterion		5.790214
Log likelihood	-125.4159	Hannan-Quinn criter.		5.620453
F-statistic	1.080803	Durbin-Watson stat		1.706527
Prob(F-statistic)	0.389812			

5.2 Econometric Analysis

In examining the dynamic relation of MPR and the balance sheet variables via the VAR system, necessary econometric analyses were carried out. Firstly, the result of the ADF test used in examining the time series properties of the data showed that all the variables in the balance sheet channel (IPI, CPI, CPS, CR, and MPR) were integrated of order one, I(1) at both the five per cent and one per cent significance levels with and without trend except for CPS for the case of intercept with trend as shown in Table 4.

Although the system contained integrated or even cointegrated variables, ordinary least squares (OLS) was used in the context of potential long-run relationships (see also, Bacchetta and Ballabriga, 2000). Nevertheless, there was no issue of simultaneity.

Table 4: Unit Root Tests of the Selected Variables (2002:1 – 2012:4)

VARIABLE	ADF	1%	5%
CPI	-7.104094 (-7.053643)	-3.596616 (-4.192337)	-2.933158 (-3.520787)
CPS	-3.988816 (-3.954063)	-3.596616 (-4.192337)*	-2.933158 (-3.520787)
CR	-7.750726 (-7.745467)	-3.596616 (-4.192337)	-2.933158 (-3.520787)
IPI	-7.274252 (-7.375808)	-3.596616 (-4.192337)	-2.933158 (-3.520787)
MPR	-5.215923 (-5.787492)	-3.596616 (-4.192337)	-2.933158 (-3.520787)

*: Significant at 1%

Table 5: VAR Lag Order Selection Criteria (2002:1 – 2012:4)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-28.85433	NA	3.74e-06	1.692717	1.903827	1.769047
1	187.7009	368.1439*	2.62e-10*	-7.885045*	-6.618386*	-7.427061*
2	202.7999	21.89352	4.57e-10	-7.389994	-5.067785	-6.550357
3	229.0533	31.50408	5.05e-10	-7.452664	-4.074905	-6.231373

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

A parsimonious lag order of 1 was also determined as the appropriate number of lags to be included in the VAR equation as shown in Table 5, and the null hypothesis of no serial correlation at lag order up to $k = 12$, was rejected while the data followed a distribution that features leptokurtosis arising from the asymmetries in the financial markets.

The VAR estimates in Table 6 shows a significant linkage among the variables defining, in part, the existence of balance sheet channel in Nigeria.

Table 5: VAR Lag Order Selection Criteria (2002:1 – 2012:4)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-28.85433	NA	3.74e-06	1.692717	1.903827	1.769047
1	187.7009	368.1439*	2.62e-10*	-7.885045*	-6.618386*	-7.427061*
2	202.7999	21.89352	4.57e-10	-7.389994	-5.067785	-6.550357
3	229.0533	31.50408	5.05e-10	-7.452664	-4.074905	-6.231373

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Table 6: VAR Estimates (2002:1 – 2012:4)

Vector Autoregression Estimates					
	DLIPI	DLCPI	DLCPS	DLCR	DMPR
DLIPI(-1)	0.804730	0.034947	0.165045	-0.24673	5.930483
	(0.13016)	(0.08210)	(0.14462)	(0.47851)	(2.88586)
	[6.18258]	[0.42566]	[1.14124]	[-0.51562]	[2.05502]
DLCPI(-1)	0.006399	0.911783	-0.051374	0.663651	1.141667
	(0.09583)	(0.06045)	(0.10648)	(0.35232)	(2.12480)
	[0.06677]	[15.0836]	[-0.48247]	[1.88368]	[0.53731]
DLCPS(-1)	0.018412	0.034153	0.891966	-0.05351	-0.96676
	(0.03656)	(0.02306)	(0.04062)	(0.13441)	(0.81061)
	[0.50360]	[1.48099]	[21.9577]	[-0.39812]	[-1.19263]
DLCR(-1)	-0.03283	-0.00878	0.170830	0.726561	0.943997
	(0.03784)	(0.02387)	(0.04204)	(0.13911)	(0.83894)
	[-0.86758]	[-0.36796]	[4.06333]	[5.22308]	[1.12523]
DMPR(-1)	0.003300	-0.0001	-0.018518	0.021179	0.743077
	(0.00512)	(0.00323)	(0.00569)	(0.01884)	(0.11359)
	[0.64417]	[-0.03110]	[-3.25304]	[1.12445]	[6.54153]
C	0.938651	0.018070	-0.489686	0.278158	-29.031
	(0.61711)	(0.38925)	(0.68566)	(2.26868)	(13.6823)
	[1.52104]	[0.04642]	[-0.71418]	[0.12261]	[-2.12179]
R-squared	0.777253	0.992937	0.997214	0.874966	0.927773
Adj. R-squared	0.746316	0.991956	0.996827	0.857601	0.917742
Sum sq. resids	0.084540	0.033635	0.104364	1.142559	41.55747
S.E. equation	0.048459	0.030566	0.053842	0.178151	1.074418
F-statistic	25.12368	1012.196	2577.324	50.38456	92.48604
Log likelihood	70.77689	90.13190	66.35294	16.09697	-59.373
Akaike AIC	-3.08461	-4.00628	-2.873949	-0.48081	3.112999
Schwarz SC	-2.83638	-3.75804	-2.625711	-0.23257	3.361238
Mean dependent	4.862217	4.365887	8.256825	6.352928	11.50000
S.D. dependent	0.096213	0.340805	0.955889	0.472100	3.746136
Determinant resid covariance (dof adj.)		1.43E-10			
Determinant resid covariance		6.62E-11			
Log likelihood		194.2292			
Akaike information criterion		-7.82044			
Schwarz criterion		-6.57925			

5.3 Variance Decomposition

Table 7a: Variance Decomposition for Output and Price, 2002:1 – 2012:4

$$Y_t = f(IPI_t, CPI_t, CPS_t, CR_t, MPR_t)$$

Variance Decomposition of DLIPI: 2002:1 - 2012:4

Period	S.E.	DLIPI	DLCPI	DLCPS	DLCR	DMPR
1	0.048459	100	0.0000	0.0000	0.0000	0.0000
2	0.063433	99.17083	0.004929	0.001462	0.591937	0.230847
3	0.072748	98.25416	0.027687	0.001387	1.274156	0.442613
4	0.07915	97.53098	0.075941	0.00148	1.823561	0.568036
5	0.083704	97.00673	0.151078	0.003952	2.214067	0.624177
6	0.086983	96.62847	0.250149	0.010117	2.472522	0.63874
7	0.089346	96.34599	0.367778	0.020329	2.633126	0.632776
8	0.091042	96.12356	0.497537	0.034221	2.725349	0.619338
9	0.092248	95.93861	0.632891	0.050977	2.772	0.605522
10	0.093098	95.77808	0.767842	0.069548	2.789947	0.594584

Variance Decomposition of DLCPI:2002:1 - 2012:4

Period	S.E.	DLIPI	DLCPI	DLCPS	DLCR	DMPR
1	0.030566	0.000537	99.99946	0.0000	0.0000	0.0000
2	0.041347	0.162479	99.61786	0.095865	0.123296	0.000504
3	0.048545	0.489111	98.91398	0.352435	0.216754	0.02772
4	0.053871	0.868537	97.97406	0.790875	0.240413	0.126119
5	0.058047	1.20369	96.83719	1.415681	0.219219	0.324222
6	0.061472	1.435873	95.51868	2.216604	0.197646	0.631193
7	0.064397	1.547229	94.02012	3.170705	0.221542	1.0404
8	0.066997	1.552713	92.33891	4.24497	0.329476	1.53393
9	0.069394	1.488043	90.47715	5.399688	0.548201	2.086921
10	0.071676	1.397424	88.44783	6.592456	0.890727	2.67156

$$Y_t = f(CPI_t, IPI_t, CPS_t, CR_t, MPR_t)$$

Variance Decomposition of DLCPI:

Period	S.E.	DLCPI	DLIPI	DLCPS	DLCR	DMPR
1	0.030158	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.040833	99.59662	0.191821	0.106639	0.104733	0.000189
3	0.047982	98.85877	0.556609	0.379629	0.182038	0.022951
4	0.053289	97.88238	0.974518	0.833650	0.198267	0.111185
5	0.057460	96.71503	1.344277	1.469115	0.177814	0.293762
6	0.060884	95.37773	1.604614	2.273526	0.162930	0.581199
7	0.063808	93.87522	1.735905	3.223172	0.196985	0.968719
8	0.066402	92.20577	1.751999	4.285455	0.316314	1.440461
9	0.068787	90.37029	1.688272	5.421948	0.545936	1.973551
10	0.071049	88.37888	1.589470	6.592024	0.897762	2.541859

Variance Decomposition of DLIPI:

Period	S.E.	DLCPI	DLIPI	DLCPS	DLCR	DMPR
1	0.047876	0.000104	99.99990	0.000000	0.000000	0.000000
2	0.062863	0.001927	99.25509	1.07E-06	0.491275	0.251706
3	0.072258	0.013309	98.42857	0.000799	1.061911	0.495414
4	0.078766	0.040814	97.77938	0.004154	1.523971	0.651686
5	0.083440	0.086647	97.31623	0.011272	1.853439	0.732417
6	0.086840	0.149519	96.99196	0.022574	2.071725	0.764221
7	0.089322	0.226043	96.76006	0.037847	2.207197	0.768855
8	0.091126	0.311854	96.58642	0.056437	2.284605	0.760687
9	0.092429	0.402376	96.44876	0.077429	2.323223	0.748216
10	0.093363	0.493337	96.33354	0.099803	2.337349	0.735973

Table 7a presents the forecast error variance decompositions (FEVD) for each variable at forecast horizons which gives an insight of the share of fluctuations in a given variable that are caused by different shocks. The columns represent the percentage of the variance due to each shock, with each row summing up to 100 percent. Changing the order of the variables could greatly change the results of the impulse response analysis. Howbeit, we estimate two possible alternative orderings and compare the results. The results indicate, in the first case, that, for the study period, 95.8 per cent of the total variation in output was mainly accounted for by its own shock after 10 quarters and was followed by CR with 2.8 per cent, while price and MPR explained 0.77 and 0.60 per cent, respectively. In the second case, the interest rate shock accounts for about 0.74 percent of the fluctuations in output, with its own shock accounting for most of the rest.

Table 7b: Variance Decomposition for Output and Price, 2002:1 – 2014:1

Variance Decomposition of GDPG:							
Period	S.E.	GDPG	P	NCGG	CPSG	PLR	MPR
1	3.5705	100.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	3.7098	96.9078	2.2248	0.5787	0.0083	0.2292	0.0513
3	3.7638	94.1972	4.4301	0.6271	0.0326	0.6052	0.1078
4	3.7992	92.8773	5.4240	0.6231	0.0665	0.8699	0.1392
5	3.8159	92.3483	5.7488	0.6179	0.1010	1.0309	0.1532
6	3.8223	92.1387	5.8267	0.6195	0.1306	1.1258	0.1587
7	3.8248	92.0419	5.8363	0.6250	0.1536	1.1826	0.1607
8	3.8260	91.9860	5.8336	0.6313	0.1703	1.2177	0.1612
9	3.8268	91.9483	5.8315	0.6371	0.1818	1.2400	0.1612
10	3.8274	91.9214	5.8314	0.6418	0.1895	1.2547	0.1612

Variance Decomposition of P:							
Period	S.E.	GDPG	P	NCGG	CPSG	PLR	MPR
1	3.0798	1.1372	98.8629	0.0000	0.0000	0.0000	0.0000
2	4.0243	10.0125	83.0917	6.4866	0.1628	0.2417	0.0048
3	4.4374	15.2108	77.2213	6.7686	0.4493	0.3365	0.0136
4	4.5965	17.1756	74.5129	6.9847	0.8038	0.4913	0.0316
5	4.6530	17.6669	73.3161	7.1326	1.1732	0.6585	0.0528
6	4.6753	17.6746	72.7081	7.2276	1.5147	0.8039	0.0711
7	4.6877	17.5920	72.3293	7.2774	1.8066	0.9107	0.0840
8	4.6967	17.5298	72.0570	7.2979	2.0439	0.9798	0.0916
9	4.7038	17.5001	71.8517	7.3022	2.2312	1.0195	0.0954
10	4.7095	17.4921	71.6964	7.2989	2.3760	1.0397	0.0969

Cholesky Ordering: GDPG P NCGG CPSG PLR MPR

Again, the FEVD of price shows that 88.5 per cent of the variation was accounted for by its own shock while CPS explained 6.59 per cent, MPR explained 2.67 while output and CR explained 1.40 and 0.90 per cent, respectively. The implication of these results in both cases is that, comparatively, interest rate innovations are relatively strong determinant of fluctuations in economic activity with respect to price than output in the balance sheet channel in Nigeria.

The existence of the balance sheet channel, though not as significantly as was expected, could also be accounted for by the dual innovations of capital reserves for output and credit to private sector to prices.

5.4 Impulse Response Functions

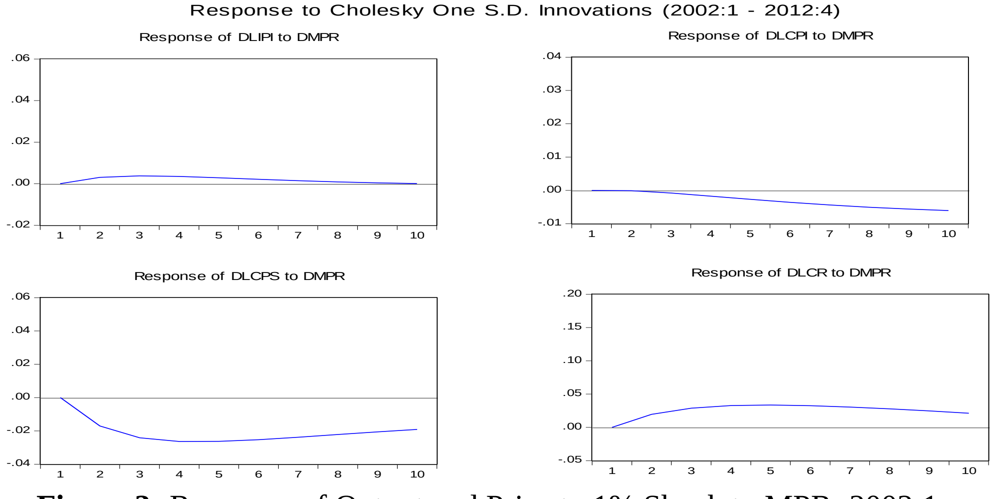

Figure 3: Response of Output and Price to 1% Shock to MPR: 2002:1 – 2012:4: $Y_t = f(IPI_t, CPI_t, CPS_t, CR_t, MPR_t)$

Theoretically, a shock to MPR via the balance sheet channel is expected to lead to rise in output and price, all things being equal. For the period 2002 to 2012, a positive shock to MPR led to a positive but low impact in output growth with a sluggish speed of adjustment to equilibrium in both ordering. However, a shock to MPR has a negative impact on price in both ordering from quarter 3 while it was at equilibrium initially from quarter 1 to 2. Also interesting in the results is that a positive shock to MPR also led to a positive impact on the DMBs' capital but negative on the volume of loan to private sector. The implication of these results is that the variations in official policy rate affect prices more than the output growth. This, may be due to the fact the private sectors may raise funds from other financial sectors other than the bank. This make the balance sheet channel in Nigeria not significant with respect to DBMs' balance sheet only.

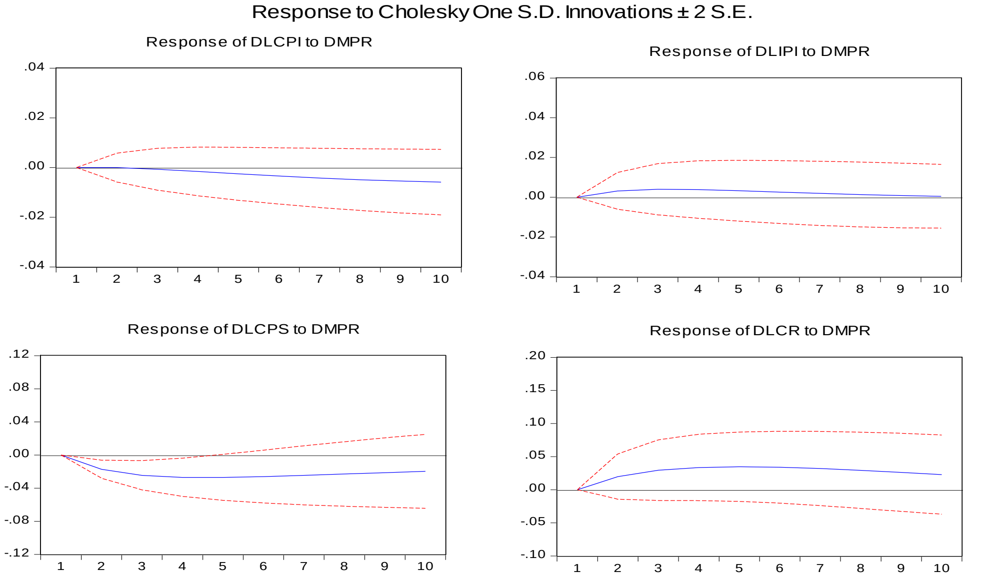

Figure 4: Response of Output and Price to 1% Shock to MPR

6.0 Conclusion and Policy Implication

Unlike traditional analysis, which is based on the examination of flow variables (such as current account and fiscal balance), this study considered the balance sheet approach and focused on the examination of credit to private sector and capital reserves of DMBs' balance sheet. From this perspective, the paper sought to establish the existence and relevance of banks' balance sheet channel in Nigeria, as well as examining the dynamic relation between monetary policy and DMBs' balance sheet components with respect to output and price effects due to the 2008 global financial crises. The salient facts shown in the analysis are as follows: (i) MPR variations influence economic activity indirectly through its impact on the value of DMBs' assets which translated into a gradual reduction in price pressures that eventually reduced the overall price level with a lag; (ii) there is no specific significant effect of the DMBs' balance sheet on output and price from expansionary monetary policy as a result of the global financial crises; and (iii) DMBs balance sheet variables (CPS and CR) did not react homogeneously to variations in monetary policy given the information asymmetries in credit markets that they face during the bank crisis.

The implication of these results is that monetary policy influences output and price indirectly by affecting the DMBs balance sheet composition since they are the primary source of loanable funds to some firms. In other words, the effects of a monetary contraction will be magnified by the reduction in loans supplied by DMBs, and ultimately amplifies the demand-side effects on expenditure decisions of the private sector if there is no external intervention. Hence, the extent to which a balance-sheet channel can be significance in Nigeria depends on the substitutability between internal and external sources of DMBs funds.

Looking forward, improvements in using more than DMBs' balance-sheets are essential steps for unclogging the wheels of balance sheet transmission mechanism and improving the mechanism of monetary policy in Nigeria.

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Relationship between Money Supply and Government Revenues in Nigeria

[1]Yakubu Musa, Umar Usman and Aminu Bello Zoramawa

The insights on the long run relationship amongst money supply and government revenues are of significant importance for monetary-fiscal policy formulation in a developing country like Nigeria. Taking into account the vital importance of these two variables, we empirically analyzed the long-run relationships and dynamic interactions between the money supply (broad money M2) and government revenues in Nigeria using an Autoregressive Distributed Lag (ARDL) bounds testing approach. The study spans the period 1970 to 2010. From the results, it is evident that there is the existence of a long run relationship between money supply and revenues when money supply is made the dependent variable. When revenue was made the dependent variable, no evidence of a long run relationship was found. This indicates that changes in government revenues in the past have significantly affected the money supply as macroeconomic indicator in the country economy. The estimated coefficient of revenues has a positive and significant impact on money supply. A 1% increase in revenues leads to approximately 0.96% increase in the Money supply at long run. The sign of the short-run dynamic impacts of these variables are significant and have the correct sign. The error correction mechanism (ECM) is estimated as -0.17 and -0.28%, this means that government revenue and money supply have significant short term effect.

Keywords: Money supply, Government revenues, ARDL, Cointegration.

JEL Classification: E51, E63, H2

1.0 Introduction

The achievement of macroeconomic goals namely full employment, stability of price level, high and sustainable economic growth, and external balance, that has existed for longer , has been a policy priority of every economy whether developed or developing given the susceptibility of macroeconomic variables to fluctuations in the economy. The realization of these goals undoubtedly is not automatic but requires policy guidance. This policy guidance represents the objective of economic policy. Fiscal and monetary policy instruments are the main instruments of achieving the macroeconomic

[1]Department of Mathematics (Statistics), Usmanu Danfodiyo University, Sokoto. Email: ykmtm2000@yahoo.com ; +2347030168606

targets. There exists a consensus in the literature that an adequate and effective macroeconomic policy is critical to any successful development process aimed at achieving high employment, sustainable economic growth, price stability, long–viability of the balance of payments and external equilibrium **(**Omitogun and Ayinla, 2007). This, therefore, suggests that the significance of stabilization policy (fiscal and monetary policies) cannot be overemphasized in any growth oriented economy.

Fiscal (tax/revenue) and monetary (money supply) policies are the tools through which an economy is regulated by the government or the respective central bank. The objectives of monetary and fiscal policies in Nigeria are wide-ranging. These include increase in Gross Domestic Product (GDP) growth rate, reduction in the rates of inflation and unemployment, improvement in the balance of payments, accumulation of financial savings and external reserves as well as stability in Naira exchange rate (CBN). Generally, both fiscal and monetary policies seek at achieving relative macroeconomic stability.

In Nigeria, the overriding objective of monetary policy (money supply) is price and exchange rate stability. The monetary authority’s strategy for inflation management is based on the view that inflation is essentially a monetary phenomenon. Because targeting money supply growth is considered as an appropriate method of targeting inflation in the Nigerian economy, the Central Bank of Nigeria (CBN) chose a monetary targeting policy framework to achieve its objective of price stability. With the broad measure of money (M2) as the intermediate target, and the monetary base as the operating target, the CBN utilized a mix of indirect (market-determined) instruments to achieve it monetary objectives. These instruments included reserve requirements, open market operations on Nigerian Treasury Bills (NTBs), liquid asset ratios and the discount window (IMF Country Report, 2003).

Government expenditures in Nigeria have in the main consistently exceeded government revenues throughout most of the past decades since 1970 except for 1971, 1973-74, 1979, and 1995-96 periods. The government's purportedly commitment in pursuing rapid economic development programmes as embodied in various developmental plans in Nigeria largely accounts for the fiscal deficits incurred. The expanded role of the public sector resulted in rapid growth of government expenditures. Government budget deficits over the years have not impacted positively on the economy. Such fiscal deficits tend to reduce national savings which invariably affect economic development. The options available to the government to stimulate economic growth in this situation are to reduce government expenditures or raise revenues through increase in tax. These two options can help to reduce the budget deficit(s).

The relationship between monetary policy (money supply) and Fiscal policy (taxation and/or revenue) has been widely researched and the results have been relatively mixed. Establishing the long run relationship between the money supply and revenues would assist policy makers to trace any source of imbalances in the economy. Consequently, this study investigates the long run relationship between money supply and revenues in Nigeria for the period 1970 to 2010.

The paper has five main sections. Following the introduction is the review of related literature. Section 3 describes the methodology of estimation adopted for the study, section 4 presents the empirical results and findings while the last section contains the concluding remark.

2.0 Literature Review

The relative impact of fiscal (tax/revenue) and monetary (money supply) policy has been studied extensively in many literatures. Examples include, but not limited to, Friedman and Meiselman (1963), Shapiro and Watson (1988), Blanchard and Quah (1989), Chari *et al*. (1991), Clarida and Gali (1994), Ansari (1996), and Reynolds, (2000). Chowdhury, *et al*. (1986), Chowdhury (1988), Cardia (1991), Chari and Kehoe (1998), and Feldstein, (2002) have examined the impact of fiscal and monetary policies on various aggregates.

However, the bulk of theoretical and empirical research has not reached a conclusion concerning the relative power of fiscal and monetary policy to effect economic growth. Some researchers find support for the monetarist view, which suggests that monetary policy generally has a greater impact on economic growth and dominates fiscal policy in terms of its impact on investment and growth [Ajayi, 1974; Elliot, 1975; Batten and Hafer, 1983], while others argued that fiscal stimulates are crucial for economic growth [Chowdhury et al., 1986; Olaloye and Ikhide, 1995]. However, Cardia (1991) found that monetary policy and fiscal policy play only a small role in varying investment, consumption, and output.

Mohammad and Amirali (2010) in their paper, empirically examines the factors determining Iran's oil revenues using the time series data for 1970-2008. The error correction version of ARDL procedure is then employed, to specify the short – and long-term determinants of Iran oil export revenues in the presence of structural breaks. The model finds that factors such as oil production, oil price, and oil proved reserves have long run effects on Iran oil export revenues. Based on empirical findings obtained we conclude that, in the long –term, the effects of variables such as. Domestic oil consumption and world oil production are negative.

Prasert and Chukiat (2008), investigate the short-term and long-term relationships between international tourism demand and the most popular explanatory variables such as GDP, jet fuel prices, the exchange rate, exchange rate risk, and temperature during 1997(Q1)-2005(Q2). The autoregressive distributed lag (ARDL) approach to cointegration was utilized to estimate international tourism demand in Thailand. The short-term and long-term relationships results indicated that growth in income, the high jet fuel prices, exchange rate variations, exchange rate risk, and temperature in Thailand affected the number of international visitor arrivals to Thailand.

Syed *et al.* (2010) investigates the comparative effect of fiscal and monetary policy on economic of Pakistan using ARDL approach to cointegration. The cointegration result suggests that both monetary and fiscal policy have significant and positive effect on economic. The coefficient of monetary policy is much greater than fiscal policy which implies that monetary policy has more concerned with economic growth than fiscal policy in Pakistan. The implication of the study is that the policy makers should focus more on monetary policy than fiscal to enhance economic growth. The role of fiscal policy can be more effective for enhancing economic growth by eliminating corruption, leakages of resources and inappropriate use of resources. However, the combination and harmonization of both monetary and fiscal policy are highly recommended.

Despite their demonstrated efficacy in other economies as policies that exert influence on economic activities, both policies have not been sufficiently or adequately used in Nigeria (Ajisafe and Folorunso, 2002).

In Nigeria, Okpara (1988) found a very poor and insignificant relationship between government expenditure and prices. Olubusoye and Oyaromade (2008) analyzing the source of fluctuations in inflation in Nigeria using the frame work of error correction mechanism found that the lagged consumer price index (CPI) among other variables propagate the dynamics of inflationary process in Nigeria. The level of output was found to be insignificant but the lagged value of money supply was found to be negative and significant only at the 10% level in the parsimonious error correction model.

Folawewo and Osinubi (2006) examined the efficacy of monetary policy in controlling inflation rate and exchange instability. The analysis performed was based on a rational expectation framework that incorporates the fiscal role of exchange rate. Using quarterly data spanning over 1980- 2000 and applying times series test on the data used, the study showed that the effects of monetary policy in influencing the finance of government fiscal deficit through the determination of the inflation-tax rate affects both the rate of inflation and exchange rate, thereby causing volatility in their rates. The study revealed that inflation affects volatility in its own rate, as well as the rate of real exchange.

Elijah (2011) estimated the relationship between public expenditure, private investment and agricultural output growth in Nigeria over the period 1970-2008. The bounds test and Autoregressive distributed lag (ARDL) modeling approach was used to analyze both short- and long-run impacts of public expenditure, private investment (both domestic investment and foreign direct investment) on agricultural output growth in Nigeria. Results of the error correction model show that increase in public expenditure has a positive influence on the growth of the agricultural output. However, foreign investment has insignificant impact in the short run. Hence, it is recommended that policymakers should combined both private and public investment in a complementary manner to ensure that both short run and long run productivity of the agricultural sector is not undermined.

Phillips (1997) critically analyzed the Nigerian fiscal policy between 1960 and 1997 with a view to suggesting workable ways for the effective implementation of Vision 2010. He observed that budget deficits have been an abiding feature in Nigeria for decades. He noted that except for the period 1971 to 1974, and 1979, there has been an overall deficit in the federal Government budgets each year since 1960 to date. The chronic budget deficits and their financing largely by borrowing, he asserted, have resulted in excessive money supply, worsened inflationary pressures, and complicated macroeconomic instability, resulting in negative impact on external balance, investment, employment and growth. He, however, contended that fiscal policy will be an effective tool for moving Nigeria towards the desired state in 2010 only if it is substantially cured of the chronic budget deficit syndrome it has suffered for decades.

Ajisafe and Folorunso (2002) investigated the relative effectiveness of monetary and fiscal policy on economic activity in Nigeria using co-integration and error correction modeling techniques and annual series for the period 1970 to 1998. The study revealed that monetary rather than fiscal policy exerts a greater impact on economic activity in Nigeria and concluded that emphasis on fiscal action by the government has led to greater distortion in the Nigerian economy.

Adenikinju and Olofin (2000) focused on the role of economic policy in the growth performance of the manufacturing sectors in African countries. They utilized panel data for seventeen African countries over the period 1976 to 1993. Their econometric evidence indicated that government policies aimed at encouraging foreign direct investment, enhancing the external competitiveness of the economy, and maintaining macroeconomic balance have significant effects on manufacturing growth performance in Africa.

3.0 Methodology

This paper employed time series data from 1970 to 2010. The data include broad money supply, and total government revenues, and were all sourced from Central Bank of Nigeria Statistical Bulletins 2009 and 2010.

First, the time series characteristics of the variable are investigated. The purpose is to determine the order of integration. The paper conducted unit root test on the variables included in the regression by employing the Dicky-Fuller generalized least square (DF-GLS) test developed by Elliot *et al.* (1996) and Ng-Perron test following Ng and Perron (2001). The DF-GLS test is a modification of ADF test while Ng-Perronis the modification of Phillips-Perron (PP) test. The objective here is to determine the underlying properties of the process that generated the present results and discussion of the analysis, while conclusion is presented based on the time series variables employed. The choice of the DF-GLS and Ng and Perron (2001) modified unit root test is based on the fact that the tests are more suitable for small samples than the traditional tests of ADF and PP test.

Secondly, the paper examines the relationship between the Money supply and total government revenues. Such an exercise will provide an understanding of the interactions among the variables in the system. Thirdly, the paper proceeds further to test the long-run (cointegration) relationship between the variables used in the model by employing the (ARLD) bounds testing approach to cointegration proposed by Pesaran *et al.* (2001).

The paper adopted the Autoregressive Distributed Lag (ARDL) bound test used extensively by Pesaran and Pesaran (1997); Pesaran and Smith (1998) and Pesaran *et al*. (2001). This technique has a number of advantages over Johansen cointegration techniques. First, whereas the Johansen techniques require large data sample, a luxury that most developing economies do not have, the ARDL model is the most useful method of determining the existence of cointegration in small samples (Ghatak and Siddiki, 2001)

The second advantage of ARDL approach is that while other cointegration techniques require all of the regressors to be of the same order, the ARDL approach can be applied whether the variables in the regression are purely of I(I) and/or purely I(0) or a mixture of both. This implies that the ARDL approach avoids the pre-testing problem associated with standard cointegration, which requires that the variables be already classified into I(I) (Pesaran *et al*., 2001).

Thirdly, the ARDL approach to cointegration is preferable to the Johansen approach because it avoids the problem of too many choices that are to be made in Johansen method. These include the treatment of deterministic elements, the order of VAR and the optimal lag length to be used. Finally, in the ARDL approach variables could have different lag length, whereas in the Johansen method this is not permissible.

The ARDL approach requires two steps. In the first step, the existence of any long run relationship among the variables of interest is determined by using the F-test. The second stage requires the estimation of the long run relationship between dependent and explanatory variables and to determine their values, thereafter the short run elasticity of the variables with the error correction representation of the ARDL model. The purpose of applying the ECM version of the ARDL is to determine the speed of adjustment to equilibrium.

3.1 Model Specification

The relationship between Money supply and total government revenue can either run from money supply to revenue or revenue to money supply. Thus, there are two possible functional forms as:

$$MSP = f(REV) \quad (1)$$

$$REV = f(MSP) \quad (2)$$

To empirically analyze the above functional forms, the ARDL model specification is used to show the long-run relationships and dynamic interactions between money supply and government revenue using Autoregressive Distributed Lag (ARDL) co-integration test popularly known as the bound test.

The ARDL model specifications of the functional relationship between broad money supply and total government revenue as expressed by Equations (1) and (2) are:

$$\Delta LMSP = \alpha_0 + \beta_1 LMSP_{t-1} + \beta_2 LREV_{t-1} + \sum_{i=1}^{k} \delta_{1i} \Delta LMSP_{t-i} + \sum_{i=1}^{k} \delta_{2i} \Delta LREV_{t-i} + \varepsilon_t \quad (3)$$

$$\Delta LREV = \theta_0 + \lambda_1 LREV_{t-1} + \lambda_2 LMSP_{t-1} + \sum_{i=1}^{k} \phi_{1i} \Delta LREV_{t-i} + \sum_{i=1}^{k} \phi_{2i} \Delta LMSP_{t-i} + \mu_t \quad (4)$$

where:

LMSP = Log of money supply
LREV = Log of total government revenue
K = lag length for the unrestricted error-correction model (UECM)
Δ = first differencing operator
ε and μ = white noise disturbance error terms

The bound test approach for the long-run relationship between the money supply and government revenue is based on the Wald test (F statistic), by imposing restrictions on the long-run estimated coefficients of one period lagged level of the money supply and revenues to be equal to zero, that is, H_0: $\beta_1 = \beta_2 = 0$ for equation 3 and H_0: $\lambda_1 = \lambda_2 = 0$ for equation 4. Then the calculated F-statistic is compared to the tabulated critical value in (Pesaran, 2001). The explanatory variables are assumed to be integrated of order zero, or I(0) for values of the lower bound, while the upper bound values assumed that they are integrated of order one, or I(1). Therefore, the decision rule is that if computed F-statistic falls below the lower bound value, I(0), the null hypothesis (no co-integration) cannot be rejected. Contrarily, if the computed F-statistic exceeds the upper bound value, I(1) then it can be concluded that money supply and government revenue are co-integrated.

The long-run and short-run parameters of Equations (3) and (4) were then estimated once a cointegration relationship had been established. The co-integrating long-run relationship was estimated using the following specifications:

$$LMSP = \alpha_0 + \beta_1 LMSP_{t-1} + \beta_2 LREV_{t-1} + \varepsilon_t \qquad (5)$$

$$LREV = \theta_0 + \lambda_1 LREV_{t-1} + \lambda_2 LMSP_{t-1} + \mu_t \qquad (6)$$

However, to restore equilibrium immediately may not be possible because of the speed of adjustment. This could be caused by the lags and adjustment process used to capture changes in any of the factors affecting money supply or revenue overtime. Hence, the error correction model was used to capture the speed of adjustment of money supply model and government revenue model. These models are expressed below as:

$$\Delta LMSP = \alpha_0 + \sum_{i=1}^{k} \delta_{1i} \Delta LMSP_{t-i} + \sum_{i=1}^{k} \delta_{2i} \Delta LREV_{t-i} + \delta_3 \varepsilon ct_{t-1} + \varepsilon_t \qquad (7)$$

$$\Delta LREV = \theta_0 + \sum_{i=1}^{k} \phi_{1i} \Delta LREV_{t-i} + \sum_{i=1}^{k} \phi_{2i} \Delta LMSP_{t-i} + \phi_3 \varepsilon ct_{t-1} + \mu_t \quad (8)$$

where:

εct_{t-1} = the error correction term lagged for one period
δ and ϕ = the coefficients for measuring speed of adjustment in equations(7) and (8).

3.0 Empirical Results

Before proceeding with the econometric estimations, it is required to investigate the integration properties of the used variables in order to avoid the problem of spurious regression. Consequently, the variables for their stationary properties are examined by means of the DF-GLS and Ng-Perron unit root tests. The tests for the variables in levels are presented in Table 1. The results suggest that, all variables are non-stationary in levels and stationary when tested in first difference form, providing evidence that all examined variables are integrated of order one I(1).

3.1 ARDL bound test result for Equations (3) and (4)

The results of the bounds test for equations 3 and 4 are presented in Table 2. The Computed F-Statistic for Equation is 5.0530. This value exceeds the upper bounds critical value of 4.9520 at the 10% significance level. This implies that money supply and government revenues are co-integrated. The computed F- Statistic for Equation is 1.7298 which is lower than the lower bounds critical values and upper bound critical values. This means that the null hypothesis of no co-integration cannot be rejected. Based on this, we inferred that no long run relationship run from government revenues to money supply.

As shown in Table 2, there is cointegration running from money supply to government revenues while there is no evidence of co-integration running from revenues to money supply. Therefore, equation (5) was estimated to explore the long run relationship running from money supply to government revenues. The result obtained is contained in Table 3. From Table (3), it is revealed that the estimated coefficient of government revenue has a positive and significant impact on money supply. A 1% increase in government revenue leads to approximately 0.96% increase in the Money supply.

Table 1: DF-GLS and Ng-Perron Unit Root Test

Variables	**Constant**		**Constant & trend**	
	DF-GLS	Ng-Perron (MZa)	DF-GLS	Ng-Perron (MZa)
	t statistic	t statistic	t statistic	t statistic
LMSP	0.006852	-1.03238	-1.724226	-5.38181
LREV	0.15576	0.34191	-2.346559	-8.70879
Test critical values (5%) DF-GLS = -1.949319 Ng-Perron =-8.10000			Test critical values (5%) DF-GLS = -3.19000 Ng-Perron = -17.3000	
*MacKinnon (1996) * Ng-Perron (2001, Table 1)			* Elliott-Rothenberg-Stock (1996, Table 1) * Ng-Perron (2001, Table	
- Lag length for DF-GLS tests are decided based on Modified Akaikes information criteria (AIC) -Ng-Perron test lag length are decided based on Modified AIC and AR spectral- GLS detrended spectra				

Table 2: Testing for existence of a level relationship among the variables in the ARDL model

Equation 3 [ARDL(2,0)]				
F-statistic	95% lower bound	95% upper bound	90% lower bound	90% upper bound
5.0530	5.2844	6.0484	4.2436	4.9520
Equation 4 [ARDL(1,2)]				
F-statistic	95% lower bound	95% upper bound	90% lower bound	90% upper bound
1.7298	5.2844	6.0484	4.2436	4.9520

The results of the short-run dynamic coefficients in equation (7) are presented in Table 4. The sign of the short-run dynamic impacts of government revenues on money supply is positive and significant. The error correction mechanism (ECM) is estimated as -0.17 with probability value of 0.000. Hence, the ECM is highly significant and has the correct sign. This means that approximately

17% of the discrepancy in the previous year is adjusted for by the current year.

Table 3: Results of Long -run Relationship (Equation (5))

Regressor	coefficient	Standard error	T-ration	Prob.
LREV	0.96124	0.037598	25.5663	0.000*
C	1.2709	0.50558	2.5137	0.017**

Notes: (*) and (**) indicates 1% and 5% significance level
R-Squared: 0.98806 Durbin Watson Statistic : 2.0272 and Prob (F-Statistic): 0.000.

Table 4: Results of the ARDL Short-run Relationship (Equation (7))

Regressor	coefficient	Standard error	T-ration	Prob.
ΔLMSP1	0.23323	0.13070	1.7845	0.083
ΔLREV	0.16600	0.035581	4.6655	0.000
ECM(-1)	-0.17270	0.036608	-4.7175	0.000

R-Squared: 0.46062 , Adjusted R-squared: 0.41303, Durbin Watson Statistic : 1.9519 and Prob (F-Statistic): 0.000.

Though the bound test results for equation (4) reveal that government revenue as the dependent variable does not co-integrate with money supply, however, the short run dynamic coefficient between the two variables was estimated. The results from this estimation is presented in Table 5.The sign of the short-run dynamic impacts of money supply on government revenues is positive and significant. The error correction mechanism (ECM) is estimated as -0.28 with probability value of 0.076. Again, the ECM is significant and has the correct sign. This means that approximately 28% of the discrepancy of the previous year is adjusted for by the current year.

The diagnostic statistics as shown in Tables 6 and 7 are quite good. There is no evidence of serial autocorrelation, the Ramsey's RESET test using the square of the fitted values are satisfied. The normality test proved that the error term is normally distributed. Based on the regression of squared residuals on squared fitted values, there no heteroskedasticity.

Table 5: Results of the ARDL Short-run Relationship (Equation (8))

Regressor	coefficient	Standard error	T-ration	Prob.
ΔLMSP	1.3544	0.44811	3.0226	0.005
ΔLMSP1	-0.63148	0.41550	-1.5198	0.138
ECM(-1)	-0.27939	0.15266	-1.8302	0.076
R-Squared: 0.25775 , Adjusted R-squared: 0.16778, Durbin Watson Statistic : 2.0272 and Prob (F-Statistic): 0.018.				

Table 6: Diagnostic Tests Autoregressive Distributed Lag Estimates ARDL(2,0)

Dependent variable is LMSP

Test Statistics	LM Version	F Version
A: Serial Correlation	CHSQ(1) = 0.070824[.790]	F(1,33) = 0.061620[.805]
B: Functional Form	CHSQ(1) = 1.1054[.293]	F(1,33) = 0.98870[.327]
C: Normality	CHSQ(2) = 0.42332[.809]	Not applicable
D: Heteroscedasticity	CHSQ(1) = 0.7148E-3[.979]	F(1,36) = 0.6772E-3[.979]

A: Lagrange multiplier test of residual serial correlation
B: Ramsey's RESET test using the square of the fitted values
C: Based on a test of skewness and kurtosis of residuals
D: Based on the regression of squared residuals on squared fitted values

Table 7: Diagnostic Tests Autoregressive Distributed Lag Estimates ARDL(1,2)

Dependent variable is LREV

Test Statistics	LM Version	F Version
A: Serial Correlation	CHSQ(1) = 0.027296[.869]	F(1,33) = 0.023002[.880]
B: Functional Form	CHSQ(1) = 0.44647[.504]	F(1,33) = 0.38045[.542]
C: Normality	CHSQ(2) = 1.1961[.550]	Not applicable
D: Heteroscedasticity	CHSQ(1) = 0..086729[.768]	F(1,36) = 0.082352[.776]

A: Lagrange multiplier test of residual serial correlation
B: Ramsey's RESET test using the square of the fitted values
C: Based on a test of skewness and kurtosis of residuals
D: Based on the regression of squared residuals on squared fitted values

A stability test of the long run and short run coefficients using the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMQ) was performed. As observed by Bahmani-Okooee (2001), the stability of the regression coefficients is evaluated by stability tests, and stability tests can show whether or not the regression equation is stable over time. This stability test is appropriate in time series data, especially when one is uncertain when change might have taken place. The null hypothesis is that the coefficient vector is the same in every period.

CUSUM and CUSUMQ statistics are plotted against the critical bound of 5 per cent significance. As noted by Bahmani-Oskooee and Wing NG (2002), if the plot of these statistics remains within the critical bound of 5 per cent significance level, the null hypothesis, which states that all coefficients in the error correction model are stable, cannot be rejected.

The plots of the recursive residuals are presented in Figures 1, 2, 3 and 4. As shown in the graphs, the plots of CUSUM and CUSUMQ residuals are within the boundaries. This implies that the parameters of the models have remained stable within its critical bounds.

Figure 1: Plot of cumulative sum of recursive residuals (dependent variable LMSP: ARDL (2,0))

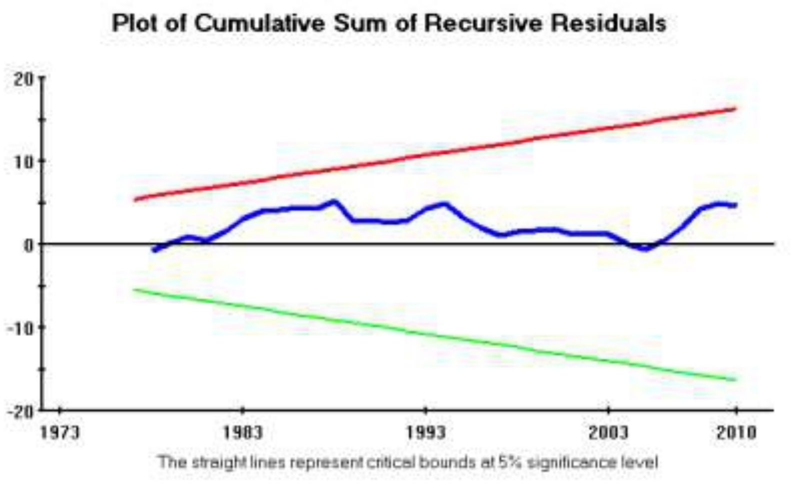


Figure 2: Plot of cumulative sum of squares of recursive residuals (dependent variable LMSP:ARDL (2,0))

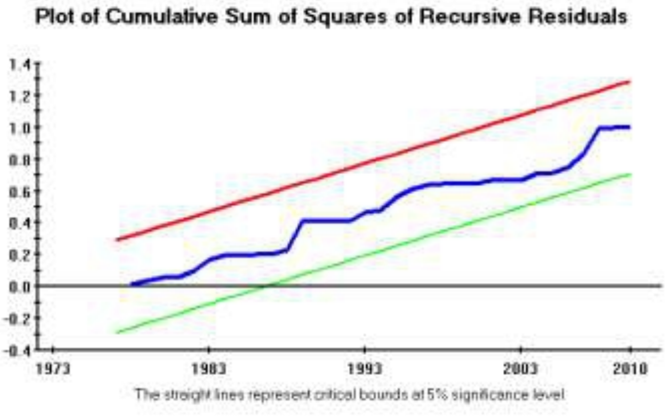


Figure 3: Plot of cumulative sum of recursive residuals (dependent variable LREV:ARDL(1,2))

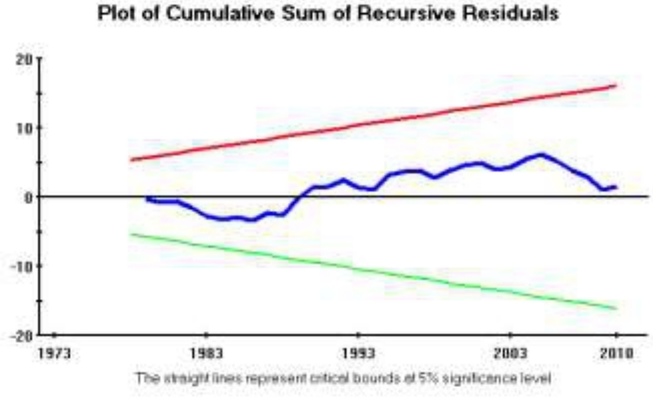
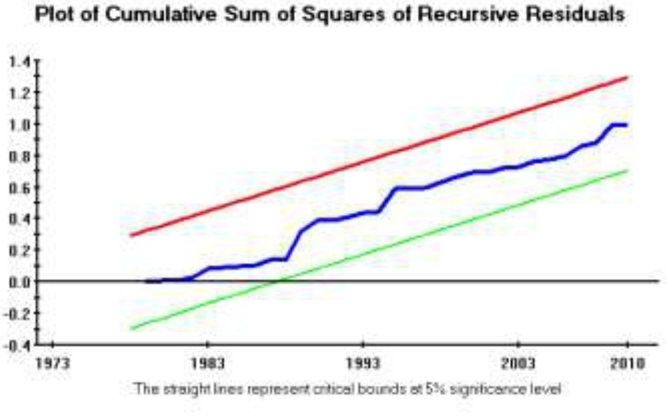


Figure 4: Plot of cumulative sum of squares of recursive residuals (dependent variable LREV:ARDL(1,2))



4.0 Summary and Conclusion

The purpose of this study was to analyze long and short run relationship between money supply and government revenues in Nigeria. The study adopted the ARDL bounds testing co-integration approach to investigate the long -run and short -run relationships between money supply and government revenues in two different functional forms. The results show that there is a co-integration relationship between money supply and revenues in the first functional form where money supply was the dependent variable. The results also indicate that government revenue has a positive and significant impact on money supply.

In contrast, the results for the second functional form where government revenue was the dependent variable show no evidence of long run relationship between government revenues and money supply. But a short- run relationship between the two variables was found in the two functional forms. Summarily, the results obtained indicate that it was revenue that was driving money supply in Nigeria. The implication of these findings is that, the government revenue has an impact on the money supply in the country economy. We recommend that the policy makers should regulate more ways to avoid corruption into oil and non-oil revenues generated, since it has significant impact into Nigerian economy.

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Cointegration Analysis of Public Expenditure on Tertiary Education and Economic Growth in Nigeria

Japheth T. Torruam,[1] Moses A. Chiawa[2] and Cyprian C. Abur[3]

The paper investigates the Impact of public expenditure on tertiary education and economic growth in Nigeria using time series data for the period 1990-2011.The econometric methodology employed was cointegration and error correction technique. The study concludes that public expenditure on tertiary education has positive impact on economic growth in Nigeria. The study recommended that government and private sectors should partner by mobilizing resources to furnish tertiary institutions and equip them with adequate facilities in order to enhance tertiary education development for sustainable economic growth.

Keywords: Public Expenditure, Economic Growth, Cointegration, Development

JEL Classification: 011

1.0 Introduction

The role of education as human resource development in an economy has been underscored in many studies. Education, as a key component of human capital formation is recognized as being vital in increasing the productive capacity of people. Education, especially at the tertiary level, contributes directly to economic growth by making individual workers more productive and indirectly by leading to the creation of knowledge, ideas, and technological innovation (Larocque, 2008).

Public expenditure is an important instrument for a government to control the economy. Economists have been well aware of its effects in promoting economic growth. The general view is that public expenditure either recurrent or capital expenditure, notably on social and economic infrastructure can be growth-enhancing although the financing of such expenditure to provide essential infrastructural facilities-including transport, electricity,

[1]Mathematics/Statistics/Computer Science Department, Federal University of Agriculture, Makurdi, Nigeria
[2]Mathematics Department, Benue State University Makurdi, Nigeria
[3]Economics Department, Kwararafa University Wukari, Nigeria

telecommunications, water and sanitation, waste disposal, education and health-can be growth-retarding (Olukayode, 2009).

Nigeria today is experiencing a critical manpower development handicap occasioned by the fact that the number of prospective students seeking for admission into tertiary institutions is projected at over 1.2 million (JAMB, 2001). But only about 20% of this numbers actually secure admission to such institutions. The unfortunate expectation of both parents and students are apprehensive of any new initiative in the management of tertiary institutions to mean introduction of tuition fees. In spite of the introduction of tuition fees, there still exist difficulties on the part of tertiary institutions management to meet their internal fund generation quota despite the huge government expenditure on tertiary education. Most of the evidences in the human capital growth regression analysis are cross-country regression analysis of developing countries and OECD countries.

To the best of our knowledge, there is no study yet to empirically assess the direct effect of education, especially the tertiary education on economic growth in Nigeria. The findings from this study should havea strong implication on education, especially tertiary education policy in Nigeria.The proper understanding of the relationship between public expenditure on tertiary education and economic growth will enable policy makers to formulate and implement proper policies that may help in utilizing the human resources of the country efficiently.

Thus, the purpose of this study is to empirically re-examine the relationship between public expenditure on tertiary education and economic growth in Nigeria; and determine the direction of the relationship. Though the goal of the study is similar to those of previous studies in this area of research (Omotor, 2004; Olukayode, 2009; Ighadaro and Okriakhi, 2010; Loto, 2011).

2.0 Literature Review

The relationship between government expenditure and economic growth has continued to generate series of controversies among scholars in economic literature. The nature of the impact is in conclusive. While some authors believed that the impact of public expenditure on economic growth is negative or non-significant (Taban, 2010; Vu Le and Suruga, 2005), others believed that the impact is positive and significant (Alexiou, 2009; Belgrave and Craigwell, 1995).

The theoretical relationship between government expenditure and economic growth is well-documented in the literature and therefore it will only be briefly discussed here. There are two major divergent theories in economics concerning the relationship between government expenditure and economic growth. Wagner's and Keynes approach. The Wagner's approach introduces a model that public expenditures are endogenous to economic development. While Keynesian macroeconomic theory has generally assumed that increased government expenditure tends to lead to high aggregate demand and in turn, rapid economic growth.

Adedeji *et al*. (1998) studied the impact of government spending and economic growth in Nigeria and the results obtained based on regressions used and panel techniques suggested that government spending is positively related with economic growth in the European Union countries. Chiawa *et al.* (2012) targeted on the causal relationship between government expenditure and economic growth in Nigeria by using the time series data from 1970 to 2008., they found in their study that total expenditure does not cause the growth of Gross Domestic Product (GDP), which is incompatible with the Keynesian's theory, but the growth of GDP does cause the increase in total public expenditures which is compatible with Wagner's law.

The long run relationship between education expenditure and economic growth was investigated by Babatunde and Adefabi (2005) in Nigeria between 1970 and 2003 through the application of Johansen cointegration technique and vector error correction methodology. Their findings reveal that the Johansen cointegration result establishes a long run relationship between education and economic growth. Aigbokhan *et al.* (2007) investigated the causal relationship between public expenditures and economic growth covering the time series data 1974-2002. They also found mixed evidence on their empirical results, i.e., some results support Wagner's Law while others verify Keynesian's theory.

Allege and Ogunrinola (2005) in their study on government expenditure and economic growth in Nigeria concluded that government has played an important role in economic development of the country. Appleton and Teal (1998) carried out a study titled "Human Capital Expenditure and Economic

Growth: A Disaggregated Analysis for Developing Countries" this study found out that the share of government capital expenditure in GDP is positively and significantly correlated with economic growth, but current expenditure is insignificant. This study is limited to public expenditure on tertiary institutions in Nigeria during the period 1990-2011.

3.0 Methodology

To empirically re-examine the relationship between government spending on the economic growth in Nigeria and determine the direction of the relationship, we followed the standard procedure of time series analysis. First, we applied the commonly used Augmented Dickey-Fuller (ADF) unit root tests to determine the variables' order integration. Briefly stated, a variable is said to be integrated of order d, written 1(d), if it requires differencing d times to achieve stationarity. Thus, the variable is non-stationary if it is integrated of order 1 or higher. Classification of the variables into stationary and nonstationary variables is crucial since standard statistical procedures can handle only stationary series.

Moreover,there also exists a possible long-run co-movement, termed cointegration, among non-stationary variables havingthe same integration order. Accordingly, in the second step, we implemented a VAR-based approach ofcointegration test suggested by Johansen (1988) and Johansen and Juselius (1990). Appropriately, the testprovides us information on whether the variables, particularly measures of economic growth and human capitalvariables are tied together in the long run. The technique of cointegration, Error Correction Model (ECM) is employed.

3.1 Source of Data

This study uses annual series of real gross domestic product (RGDP), capital expenditure on education (CEE), recurrent expenditure oneducation (REE), enrolments into tertiary institutions (TERE) and the number of tertiary graduates (GRAD) in Nigeria for the period of 1990-2011 drawn from publications of the Central Bank of Nigeria (CBN); National Bureau of Statistics (NBS); National Youth Service Corp (NYSC) annual report.

3.2 Model Specification

In an attempt to determine the impact of human capital development for economic growth in Nigeria, it is ideal to develop a model to justify the relationship that exists between the variables. The framework for this study has its basis on the Wagner's law approach which states that national income causes government expenditure and Keynesian approach which states that public expenditure causes national income. In both approaches the focus is only to the unidirectional causal grow thmodels.Therefore, the model for this study is stated as:

$$\log(RGDP_t) = \beta_0 + \beta_1 \log(CEE_t) + \beta_2 \log(REE_t) + \beta_3 \log(TERE_t) + \beta_4 \log(GRAD_t) + \mu_t$$

where $\beta_i > 0$ $(i = 1, \ldots, 4)$ are parameters to be estimated; $\mu_t$is the error term.

4.0 Results

4.1 Unit Root Tests

The results regarding the order of integration of the series have been determined by Augmented Dickey Fuller (ADF) test. The calculated t-values from ADF tests on each variable are reported in Table 1.

Table 1: Results of Unit Roots Tests using Augmented Dickey Fuller (ADF)

Variable	Level	First Difference
RGDP	1.6166	-2.101
CEE	2.7575	-2.114
REE	2.2837	-2.0224
GRAD	4.2192	-2.0121
TERE	2.4292	-2.019

Note: Critical values in levels and first difference at 5% are -1.96 and -1.86 respectively.

Table 1 presents the results of Augmented Dickey Fuller (ADF) test, both in levels and first differences. In the case of the levels of the series, the null-hypothesis of the non-stationarity cannot be rejected for all the series. Therefore, all the series are non-stationary which implies that these series have unit root at level, but stationary after the first difference.

4.3 Cointegration Test

Recall that all the variables are I(1), as evident from the unit root test. In order to capture the extent of cointegration among the variables, the multivariate Johansen based cointegration methodology were conducted and the results are shown in Table 2.

Table 2: Johansen Cointegration Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05Critica Value	Prob.
None *	0.6683	60.3818	50.0146	0.0000 **
At most 1 *	0.4852	42.4746	28.4812	0.0000**
At most 2 *	0.4048	23.5436	15.4322	0.0000**
At most 3	0.2710	4.5601	5.6643	0.5100
At most 4	0.8223	0.4327	3.8414	0.7556

Note: (*) denotes rejection of the hypothesis at 5% significance level. Trace test indicates 3 cointegrating eqn(s) at the 0.05 significance level. (**) denotes p values <0.05.

Table 2 indicates that the dependent variable RGDP is cointegrated with CEE, REE, TERE and GRAD. The results indicate that the dependent and independent variables are both cointegrated and have long run relationship with one another. The trace test results in Table 2 shows that there are three (3) long-run equilibrium relationships of the variables (i.e. $r = 3$).

4.4 Regression Results

Table 3: Parsimonious Error Correction Estimation Results: Dependent Variable Dlog($RGDP_t$)

Variables	Estimated Coefficient	t-Statistic	Probability
Dlog(CEE_{t-1})	1.3443	4.2804	0.0001
Dlog(REE_{t-2})	2.3529	2.5681	0.0124
Dlog($GRAD_{t-1}$)	1.3524	3.1985	0.0214
Dlog($TERE_t$)	1.3584	4.2973	0.0013
μ_{t-1}	-0.6515	-3.7544	0.0021
C	5.5806	3.2145	0.6322
R-Squared= 0.8074			
Adjusted R- Squared= 0.7689			
F.Statistic = 21.07			
D.W. = 1.99			

The results in Table 3 indicate that the coefficients are correctly signed and statistically significant. The coefficient of the Error Correction Model (ECM) term has a negative sign and is statistically significant. This is an indication that there exist long run relationship between real GDP growth rate and the explanatory variables and its takes more years to attain equilibrium. Therefore, 65% disequilibrium in the previous period is corrected in the current period.

The adjusted R^2 is 77 % which imply that 77 percent of the variations in real GDP growth can be explained by the explanatory variables while the remaining 23 percent variations are attributed to other factors outside the model. The F-statistics of 21.07 indicates that the explanatory variables are important determinants of the GDP growth rate in Nigeria. The result revealed that the amount of government expenditure on tertiary educationsignificantly influence output per worker growth while foreign input is also a very importantdeterminant of productivity growth through the adaptation of foreign technology. Our result is inagreement with that of Loening (2002) who conducted a similar research for Guatemala.

In order to achieve maximum economic growth, government expenditure on education needs to be given more priority. Investing in education offers high return in terms of economic growth. This means that increasing expenditure on education services does not only have a large impact on poverty per naira spent, but also produces greater growth in human productivity. This is because as more people get good education, they will increase their productivity. This implies that shifting resources from low-productivity sectors, such as general administration to education, will generate economic growth in the country.

5.0 Conclusion

The study concluded that human capital development contributes positively to economic growth in Nigeria. However, Nigeria is confronted by most of the problems that could limit the capacity of expansion in human capital development to stimulate growth such as under-employment, low absorptive capacity, and shortage of professionals, regional imbalances and brain-drain. This means that if Nigeria is to achieve sustainable economic growth rate, it is of utmost importance for the country to reposition herself as a potent force through the quality of her products from the tertiary school systems as well as making her manpower relevant in the highly competitive and globalized economy through a structured and strategic planning of her educational institutions.

Based on the results obtained in this study, it is recommended that government and private sectors should join hands by mobilizing resources to furnish tertiary institutions and equip them with adequate facilities, libraries, laboratory equipment, computers and modern instructional materials in order to improve the quality of education and enhance human capital development, labor productivity and ensure sustainable growth and development. Factors responsible for drop-out rate from tertiary institutions needs to be addressed through effective synergy between post-primary and technical institutions. Government should continue to provide enabling environment by ensuring macroeconomic stability that will encourage increased investment in human capital by individuals and the private sector. Regular closure of tertiary institutions due to strikes, cult activities, and excesses of student unions, etc. should be addressed by the relevant authorities.

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Determinants of Economic Growth in Nigeria

Kazeem B. Ajide[1]

*This paper investigates the role of Frazer Economic Freedom Index on FDI-growth relationship over the period spanning 1980 through 2010 using annual time series data. A Multivariate Regression approach was employed to estimate augmented growth models. Quite intriguingly, the impact of disaggregated economic freedom over aggregated composite index was found profoundly revealing. Emanated results show that the same set of variables like labour, life expectancy, degree of openness and economic freedom are factors affecting the level of economic growth in both but at different levels of significance. However, the estimates of disaggregated components of economic freedom data show that the size of government (**negative effects)** and freedom to trade internationally (**positive effects**) appears as significant out of five variables making the composite (aggregated) index. The following are therefore suggested for policy applications: curbing unfettered liberalization in the degree of openness, improving and strengthening of the components of economic freedom index, specifically, through reduction in excessive government intervention and that more budgetary allocations should be channeled towards health delivery schemes and education promoting activities since the likelihood of elongating life expectancy is in tandem with such exercises.*

Keywords: Economic Freedom, FDI, Economic Growth, Multivariate Regression Approach

JEL Classification: CO1, E22, O43

1.0 Introduction

One of the most fundamental economic issues that have received extensive attention in the economic literature to date centers on: what causes economic growth? Why do countries grow faster than the other? What are the causes of disproportionate rates of growth across countries? Are factors causing differential growth rates country-specific? Attempts at answering these questions have spawned an avalanche of reasons as factors, ranging from economic, social, cultural, political and more recently, institutional reasons have been included. What can be inferred from the diverse causative factors as highlighted in the literature aptly accentuates lack of consensus and general inconclusiveness of growth causal factors. Despite these divergences, the impact of foreign direct investment (FDI, hereafter) on growth remains in large part an empirical regularity. The channel through which FDI impacts is

[1]Department of Economics, Faculty of Social Sciences, University Of Lagos, Akoka, Lagos. Email: Kazeemajide@gmail.com, Mobile Number: +234-8058446863

transmitted has also stimulated another round of queries that has consequently added a new strand of literature into FDI-growth repository.

Examples of such mediating channels in the literature abound and they include: absorptive capacity of the receiving country (in terms of domestic economy's trade policy, quality of human capital, physical capital accumulation, see Balasubramanyam *et al.* (1996); Borensztein *et al.* (1998) and De Mello(1997) for detail narratives and level of financial sector sophistication (see Alfaro *et al.*, 2004; Durham, 2004; and Ang, 2008)). Amid the identified and various channels which mediate between FDI-growth nexus, the impact of economic freedom (a very key component of institutional quality variables) has so far been less recognized or at best receives limited consideration. Notwithstanding, it has been widely acknowledged among growth analysts that a country which enjoys more economic freedom tends to attract more FDI inflows and growth faster than country that is being denied enjoying the same freedom.

Economic freedom, according to Heritage Foundation has been defined as 'the absence of government coercion or constraint on the production, distribution, or consumption of goods and services beyond the extent necessary for citizens to protect and maintain liberty itself'. Economists have long accorded greater importance to freedom to choose and supply resources, competition in business, free trade with others and secure property rights as representing important ingredients needed for achieving economic development. Several empirical works, however, have shown the importance of economic freedom in explaining cross-country differences in economic performance [see an excellent survey by de Haan *et al.* (2006)].

Further, empirical studies have shown that countries vary in the ways and manners by which economic freedoms are exercised and implemented. Observably, in the developed nations, economic freedom is undeniably a public good as can be observed from unfettered enjoyment of it among and/or between the various economic agents, but contrariwise, lacking and even if exists, scarcely enjoy by various economic agents from the developing countries' counterpart. By implication, economic freedom as a bundle of goods or services in these countries is essentially luxurious in nature. Arguably, countries within sub-Saharan region in particular are seen operating on the negative and extreme end of economic freedom continuum thus raising pertinent issue about economic woes befalling the region.

Nigeria, like any other Africa countries has witnessed a series of violations in socio-politico-economic freedoms over the years. This is particularly the case during the military era which accounted greatly to the political annals of the country. With the emergence and enthronement of the democratic dispensation, a pocket of violations were still observed in virtually all facets of human lives in the country but with some signs of respite. With this background information about the backlog of violations, the paper is, therefore, interested in unraveling the extent to which economic freedom interacts with FDI to generate the desired economic growth.

The novelty of the study stands out on a number of fronts. First, though voluminous works have been conducted on economic freedom and economic growth with foreign direct investment as an intervening variable, we are not aware of any study that has specifically examined the tripartite relationship involving FDI, economic freedom and economic growth for Nigeria. Second, most studies on economic freedom were largely cross-sectional in nature. Examples include: Bengoa and Sanchez-Robles (2003), Javorcik (2004), Kapuria (2007), among others. Empirical studies on FDI-economic freedom-growth relationship are hard to come by or at best limited particularly with respect to country-specific studies.

The rest of the paper is structured as follows. Section 2 contains a succinct review of the literature on the economic freedom and economic growth linkage. Section 3 attempts stylized facts about economic freedom –economic growth in the Nigerian context, while section 4 gives a conceptual framework on which the study is based and section 5 describes the empirical model and dataset. The results are presented and discussed in section 6. The seventh and final section succinctly concludes.

2.0 Literature Review

This section attempts an apt overview of previous empirical studies on FDI inflows, economic freedom and economic growth in order to provide a compelling context for subsequent discussions on the theme.

A vast amount of literature exists on the connection between FDI and economic growth in both the developed and developing countries alike with varying emanated empirical outcomes generated ranging from positive, negative and /or at best mixed. One of the main sources of divergences in results mostly stems from mediating mechanism[2] by which effects of FDI spillovers on the receiving countries are impacted. Observably, several factors like trade policy regime, quality of human resources, level of domestic financial sector sophistication, which were collectively housed under absorptive capacity of the receiving country, and more recently institutional quality were suggested as predisposing the host country to reaping the growth benefits[3] of FDI (see detailed narratives in the following studies: Blomstrom, *et al.*, 1992; Borensztein *et al.*, 1998; Balasubramanyam, *et al.*, 1996; Alfaro, *et al*., 2004; Durham, 2004; and Ang, 2008).

Summarily, in the light of the foregoing, three distinct strands of literature can be filtered from the ensuing research efforts so far conducted and these are namely: those that found significant positive impact of FDI on growth (see Ndikumana and Verick (2008), Sylwester (2005) and Lumbila (2005)). Second, are those that established contrary results (Dutt, 1997; Fry, 1993; Hermes and Lensink, 2003) while the last category suggest that the effect of FDI on economic growth, depends on whether the country has minimal level of absorptive capacity. A line by line critical assessment of the empirical outcomes of the first two categories seems too direct thus raising doubts to be casted on the previous research findings. As a consequence and more inventively, focus has been shifted to the third category, which appears albeit, indirect but promising since it encourages the use of multivariate framework which controls for more intervening variables as opposed to bivariate nature of the first-two empirical outcomes.

Realizing the importance of controlling for other conditioning variables in FDI-growth space, subsequent research efforts however, have been shifted to institutional quality given its current global impacts on growth. Specifically, the economic freedom of institutional factors and its role on economic growth has been in sharp focus. The category of empirical studies in this regard include Ayal and Karras (1998); Heckelman and Stroup (2000); Carlson and Lundstrom (2001). However, that strand of literature that craft a role for economic freedom in the FDI-growth space is at best rudimentary. The basic

[2] UNCTAD (1999) found that FDI either had a positive or negative impact on output, depending on the variables that are entered alongside it in the test equation.

[3] Transfer of new technology, innovation, marketing and managerial skills, international best practices etc

argument of most of the studies is that the potential investors' decision to invest in a foreign country is usually hinge on the state of the country's economy as well as the presence of a well-coordinated institutional arrangement. Thus, relating to the latter strand are studies like: Bengoa and Sanchez-Robles (2003), Levina (2011) that specifically examined the tripartite relationship within the context of cross-country empirical investigation. Hence, a terse presentation of empirical literature on the tripartite relationship is pursued in what follows.

Bengoa and Sanchez-Robles (2003) study explored the connection between economic freedom, FDI and economic growth using panel estimation methodology on the sample of 18 Latin-America countries over the period 1970-1999.They used Fraser and Institute index of economic freedom. The results show that countries with higher index have more inflows of FDI and thus have greater growth rates. Using both Fixed Effects and first-difference GMM estimation, Levina (2011), investigated the relationship between foreign direct investment, economic freedom and economic growth. The GMM estimation of dynamic model showed that both of the variables foreign direct investment and economic freedom positively influence the economic growth. However, when employing the decomposed component of economic freedom index, two (namely Business and Monetary Freedoms) out of ten components were found to have had impact on the economic growth.

Pourshahabi *et al.* (2011), also investigated the relationship between Foreign Direct Investment (FDI), economic freedom and growth in OECD countries during 1997-2007. Panel data Method is used to estimate two models. The first model was applied to investigate the factors that stimulate FDI and the second one was applied to find the growth factors in OECD members. The results of first model indicated that Human Capital, Market Size, Political Stability and Inflation have positive and significant impact on FDI in these set of countries. However, the effect of Economic Freedom on FDI in OECD countries is positive, but it is not significant. As to the second model they found that Foreign Direct Investment, economic freedom, Government Consumption Expenditure, public investment and Human Capital lead to growth in these countries. However, inflation and external debt have negative effect on growth but this negative effect is not significant for inflation.

Apparently, empirical attempts at investigating the tripartite relationship among FDI inflows, economic freedom and economic growth are still at its infancy. Also, most of the typically scanty empirical attempts have been, in the main, conducted at the cross-country levels, thus, making it quite difficult to extrapolating to country-specific cases. This study therefore is filling the void by specifically conducting a tripartite relationship between FDI inflows, economic freedom and economic growth for Nigeria; this remains the focus of this paper.

3.0 Stylized Facts about Foreign Direct Investment, Economic freedom and Economic Growth in Nigeria

Foreign direct investment inflows have been one of the major development financing options often rely upon by the developing countries particularly countries within the Africa sub-Saharan region to drive their stunted economies to a sustainable growth trajectory. However, in the recent times, the debates have shifted to including the degree of economic freedom as an important mediating link towards attaining the growth success. Nigeria, like many other Africa countries, has been enjoying the torrent of foreign direct investment inflows from the developed countries subject to availability of certain economic fundamentals of which economic freedom forms an integral part. Economic freedom, according to Frazer Institutes is made of five components which include size of government (SG); legal structure and security of property rights (LS); access to sound money (AM); freedom to trade internationally (FT); and regulation of credit, labor, and business (RG). The diagrams below show the trends of economic freedom components, aggregate economic freedom, total foreign direct investment and real gross domestic product.

From Figure1, of the components of economic freedom, legal structure and security of property rights seems to be at the lowest and directly followed by gaining of access to sound money while the remaining three components have been moving at par with one another. In fact, the country scored above average virtually in every components, that is 5 out of 10 (being the highest) beginning from 2000 up till 2009. Of the components, access to sound money nosedived close to unity in 1995. Comparatively, the movement of regulation of credit, labour and business smoothen out consistently over the period of review.

In aggregate terms, Figure 2 shows that consistent pattern of growth in economic freedom movement was recorded over the period of review but with some noticeable troughs between 1990-1995, which can be attributed partly to the fall in both the size of government and access to sound money. Correspondingly in Figure 3, there have been positive inflows of FDI into the country except for 1980 when negative value was recorded. However, between 2004 and 2008, Nigeria experienced some remarkable improvements in the inflows of FDI but later plummeted after financial crises of 2008 occasioned by subprime mortgage crisis which started in 2007 in the US housing sector.

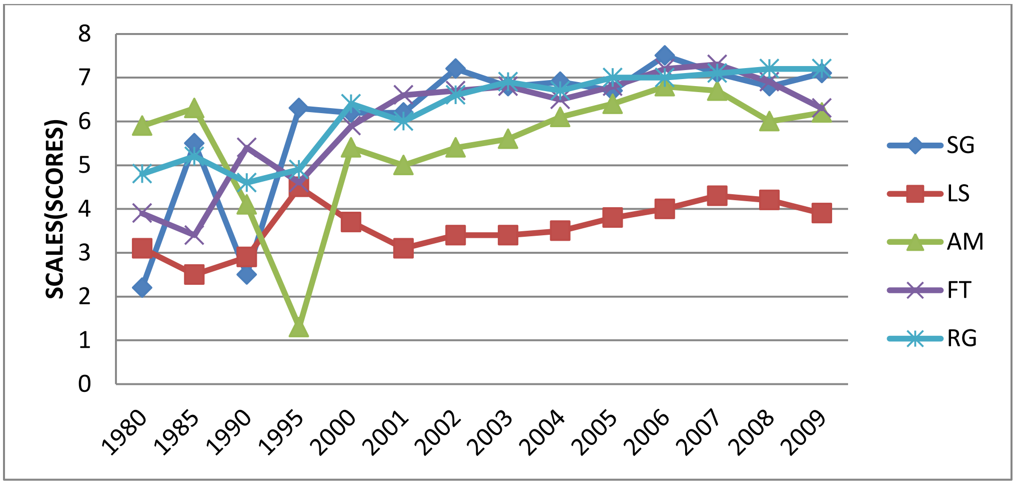

Figure1: Trends of Components of Economic Freedom for Nigeria

Source: Underlying data are obtained from World Development Indicator, Data, 2012.

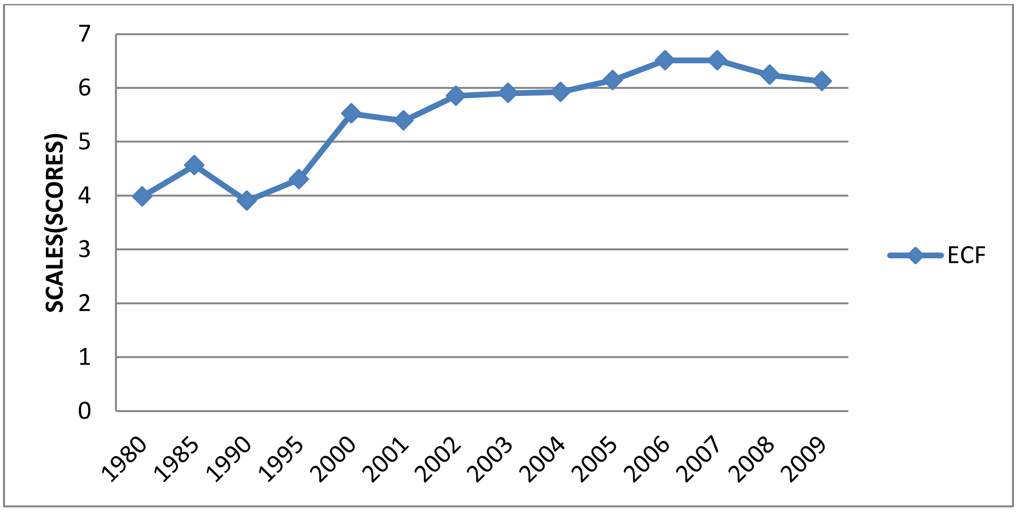

Figure 2: Trend of Economic Freedom for Nigeria

Source: Underlying data are obtained from World Development Indicator, Data, 2012.

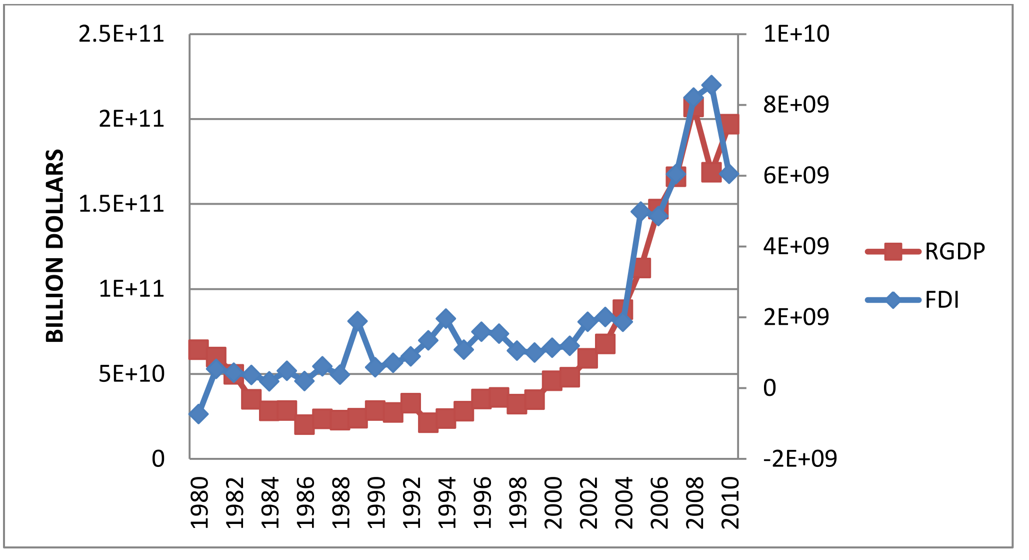

Figure 3: Trend of Movements in Real GDP and Aggregate Foreign Direct Investment in Nigeria

Source: Underlying data are obtained from World Development Indicator, Data, 2012.

4.0 The Basic Conceptual Framework

Within the neoclassical growth framework of Solow (1956) the impact of FDI on the growth rate of output was highly constricted owing to diminishing returns to physical capital. As such, a level effect rather than a rate effect could only be exerted on the output per capita. In effect, the flow of FDI has no appreciable impact on growth rate of output in the long run. Thus, with neoclassical models, FDI as a veritable engine of growth was seriously undermined. However, with exposition on new growth theory, FDI is capable of affecting both the level as well as rate of growth of output per capita. Literature has clearly delineated on how FDI may potentially enhance the growth rate of per capita income in the host country.

Apart from factors like existence of human capital resources, absorptive capacity of the host country, good trade policies, size of the market and a host of other factors that had earlier been explained. The importance of economic freedom has been well stressed in the emerging FDI literature. Economic freedom, according to Heritage Foundation has been defined as ‘the absence of government coercion or constraint on the production, distribution, or consumption of goods and services beyond the extent necessary for citizens to protect and maintain liberty itself'.

Economists have long accorded greater importance to freedom to choose and supply resources, competition in business, free trade with others and secure property rights as representing important ingredients needed for achieving economic development. According to Frazer economic freedom index, there are five major components of index and these include are size of government, expenditures, taxes, and enterprises; legal structure and security of property rights; access to sound money; freedom to trade internationally and regulation of credit, labour, and business.

Figure 4 presents the conceptual framework which illuminates the mechanics through which FDI indirectly impacts on growth through the economic freedom.

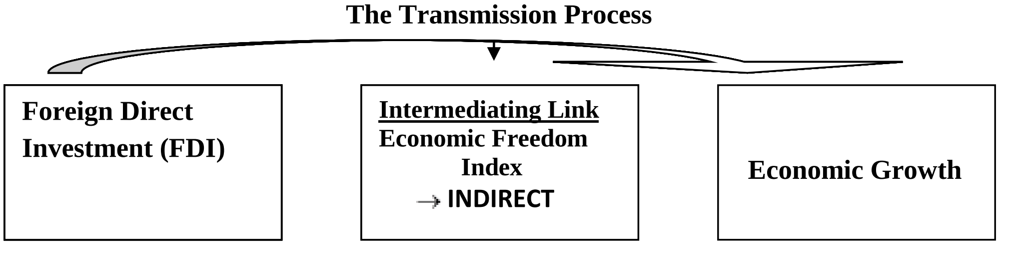

Figure 4: Conceptual framework
Source: Author's conceptualization

5.0 Methodology

This section contains the specification of the relationship between FDI and growth via economic freedom index. Also, the description and measurement of the variables used in the empirical analysis is presented.

5.1 Variables and Model Description

We assume a simple production function where the factors of production in the economy determine the level of economic output. This is summarized as:

$$Y = f(K, L) (1)$$

Where Y measures economic growth (proxy with real GDP), K denotes the amount of capital (measured by Gross Fixed Capital Formation), and L denotes the amount of labor (measured by total population). Following the work of Rivera-Batiz (2004) and N'Zue (2011), we consider a Cobb-Douglas type of production (although restrictive) which is specify as follows;

$$Y = AL^{\alpha}K^{\beta} \quad (2)$$

Where L and K are as previously defined and A is parameter that captures the effects of other factors of production. Technically speaking, A is a measure of Total Factor Productivity (TFP) but it is through it that the study intends to capture the impacts of both FDI and economic freedom on economic growth. Traditionally, changes in A are thought to captures technological changes Solow (1956) but these may not necessarily be due to technology. The effects of other factors like war, natural disaster, and economic reforms may also stems from A channels. On the basis of this, we therefore specify an explicit model with some other control variables, and thus we have:

$$Y = f(CAP, LAB, FDI, ECF, LE, OPN, FIV) \quad (3)$$

Where FDI, a foreign direct investment (measured by net inflow of foreign direct investment), economic freedom denoted by ECF and is measured using Fraser Economic Freedom Index. The index quantifies forty-two data points in five broad areas: size of government (SG); legal structure and security of property rights (LS); access to sound money (AM); freedom to trade internationally (FT); and regulation of credit, labor, and business (RG) into a composite score on a scale of 0 to 10, with 10 representing the highest degree of economic freedom (see Gwartney *et al.*, 2011). LE is a life expectancy at birth, (measuring the quality of Human Capital Development)[4] and FIV which is a financial variable, measures the level of domestic financial sector sophistication. This is measures by domestic credit to private sector as a percentage of GDP. The above specification does not have several other variables that some empirical works like Alfaro *et al*. (2004) and Durham (2004) have included because the EF index already captures most of the other variables such as government consumption, inflation and black market premium.

[4] There are other measures like secondary and tertiary enrolment rates and health expenditures etc

Explicitly, in an estimable form, equation (3) is re-written as:

$$RGDP = \omega_0 + \omega_1 CAP + \omega_2 LAB + \omega_3 FDI + \omega_4 ECF + \omega_5 LE + \omega_6 OPN + \omega_7 FIV + \varepsilon \quad (4)$$

To remove variances inherent in the variables, we rewrite equation (3) as:

$$\log RGDP = \omega_0 + \omega_1 \log CAP + \omega_2 LAB + \omega_3 FDI + \omega_4 ECF + \omega_5 \log LE + \omega_6 OPN + \omega_7 \log FIV + \varepsilon \quad (5)$$

All the variables are as earlier defined while ε is an error term which is identically and independently distributed with mean zero and constant variance. Summarily, this can be compactly expressed as:. $\varpi_1, \varpi_2, \varpi_4, \varpi_5, \varpi_6, \varpi_7 \succ 0$ while $\varpi_3 \succ or \prec 0$

As earlier said, all variables are expressed in natural logarithmic forms because apart from helping to produce a better result as compared to linear functional form, it also helps to reduce problem of heteroscedasticity. Annual data spanning the period 1980-2010 was deployed in the study. These data were sourced from IMF's International Financial Statistics (IFS), World Development Indicators, 2012, Central Bank of Nigeria (CBN) Statistical Bulletin (2010) and various issues of the CBN annual reports.

A priori expectation posits a positive relationship between capital (CAP) and the real GDP. Growth theory has clearly delineated that growth occurs from the accumulation of physical capital accumulation. Labour (LAB) also bears a direct and positive relationship with real GDP, the extent of such relationship is believed to depend on the type and quality of labour involved. Skilled and educated labour is expected to contribute more than unskilled and illiterate labour. Traditional economic theory emphasizes the importance of labour to capital since the latter cannot on its own operate itself but to rely on efforts of the former to be functional.

5.2 Unit Root Test

Confirming the order of integration is a pre-requisite for almost all time series analysis. In this study, we applied the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwaitkowski-Phillips-Schmidt-Shin (KPSS) unit root tests to determine the order of integration for each series. Since the ADF test is low power in small sample Cheung and Lai, (1995), we also applied the PP and KPSS unit root tests to check the robustness of the estimation results.

5.3 Empirical Results and Discussion

Table.1 presents a descriptive statistics on all the variables of interest. The mean value of real GDP is N5237.87 billion with maximum and minimum being N11057.27 and 3038.04 respectively. In terms of the FDI ratio to GDP, the average value stands at 20.28 with a maximum of 85.55 and crashes to the negative minimum value of 7.40 while the dispersion from the mean value stands at 23.74. The mean value of economic freedom is 4.94 which is a reflection of the extent of economic freedom enjoyed in Nigeria. The maximum is as high as 6.51 and as low as 3.90 but with a wider dispersion from mean of 0.89.

Table. 1: Descriptive Statistics

	RGDP	CAP	LAB	FDI	ECF	LE	OPN	FIV
Mean	5237.87	22.4	106.75	20.28	4.94	46.74	65.17	26.44
Median	4033.42	22.24	103.85	11.4	4.56	46	70.6	24
Maximum	11057.27	30.48	156.05	85.55	6.51	51	97.32	49.9
Minimum	3038.04	13.82	68.45	-7.4	3.9	45	27.8	4.9
Std. Dev.	2340.59	3.9	26.47	23.74	0.89	1.9	18.68	12.32
Skewness	1.2	-0.01	0.27	1.58	0.54	1.12	-0.609	0.29
Kurtosis	3.06	2.89	1.88	4.4	1.7	2.94	2.39	2.2
Jarque-Bera	7.38	0.02	2	15.36	3.68	6.52	2.41	1.27
Probability	0.02	0.99	0.37	0	0.16	0.04	0.3	0.53
Sum	162374	694.33	3309.16	628.64	153.17	1449	2020.37	819.7
Sum Sq. Dev.	164000000	456.4	21022.7	16908.8	23.72	107.94	10465.6	4553.32
Observations	31	31	31	31	31	31	31	31

Source: Computed from the World Development Indicators, (WDI) 2012 and Frazer Institute Economic Freedom Datasets

Apart from the first moment statistics of the series, the results of other statistics are also evident from the table. For instance, Jarque-Bera which measures whether the series is normally distributed or not also rejects the null hypotheses of normal distribution for RGDP, FDI and LE while accepts for that of CAP, LAB, ECF and FIV. Kurtosis measures the peakedness or flatness of the distribution of the series. The statistics show RGDP as only variable that is normally distributed. However, only FDI is leptokurtic, since the distribution is peaked relative to the normal while other variables like CAP,LAB, ECF, LE, OPN and FIV are platykurtic, suggesting that the distribution are flat relative to the normal. Lastly, skewness is a measure of asymmetry of the distribution of the series around the mean. The statistic for skewness shows that all the variables except for CAP is positively skewed, implying that these distributions have long right tails.

Having described the characteristics of the data, we begin by testing the order of integration using the ADF, PP and KPSS unit root tests. The results of the three unit root tests are reported in Table 1. At the 1 per cent significant level, the results of ADF unit root test suggest that all variables are integrated of order one, *I*(1) process. However, the PP and KPSS unit root tests exhibit that all variables are stationary at the first difference. As noted in the earlier section, the ADF test often has weak power when the sample size of a study is small, so we preferred to use the results provided by PP and KPSS unit root tests. For this reason, we surmised that the variables can be well characterized as *I*(1) process.

Table 2: Unit Root Test

Variables	ADF	PP	KPSS
$\ln RGDP$	-1.341	-1.446	0.650 ***
$\Delta \ln RGDP$	–4.327 ***	–4.369 ***	0.086
lnCAP	–1.343	–1.052	0.394 ***
$\Delta \ln CAP$	–5.268***	–9.486***	0.043
$\ln LAB$	-0.587	–1.399	0.232 ***
$\Delta \ln LAB$	–4.410 ***	–4.455 ***	0.099
FDI	–0.816	–1.437	0.551***
ΔFDI	–5.398***	–5.380***	0.085
$\ln ECF$	–0.448	–0.358	0.624***
$\Delta \ln ECF$	–6.196***	–6.196***	0.029
$\ln LLE$	-1.123	-1.345	0.732***
$\Delta \ln LLE$	-4.324***	-4.141***	0.022
$\ln OPN$	-1.228	-1.1412	0.897***
ΔOPN	-4.421***	-4.532***	0.037
$\ln FIV$	-0.563	-0.768	0.685***
$\Delta \ln FIV$	-2.768**	-4.987***	0.039

Note: ***, ** and * denote the significant at the 1, 5 and 10 per cent level, respectively. The optimal lag order for ADF test is determined by AIC, while the bandwidths for PP and KPSS tests are determined by using the Newey-West Bartlett kernel.

5.4 Estimation of Growth-Augmented Model

Having presented the time series properties of the data, attempts are therefore made to present multivariate regression results for FDI-Economic freedom and Economic growth. The results of the estimation are presented in Table 3.

From the results all the variables have the expected signs except for degree of openness variable which carries a negative sign. Also, the magnitude of the level of their significances varies from one variable to another. For instance, capital denoted by LCAP has the expected positive sign. By implication, it shows that a 1% increase in investment proxied by gross fixed capital formation raises output by 0.08% but statistically insignificant. This is not unexpected as most of capital infrastructural facilities in Nigeria have deteriorated and outdated. Special references are made to erratic electricity supply and bad road networks across the country.

Table: 3 Estimates of Economic Growth and Foreign Direct Investment in Nigeria (1980-2010)

Independent variables	Model I: Coefficients (Without Correction for Autocorrelation)	Model II: Coefficients (With Correction for Autocorrelation)
Constant	-12.612 (0.125)***	-16.259 (0.146)***
LCAP	0.078 -0.517	0.029 -0.049
LLAB	0.982 (1.2126)***	1.11 (0.321)**
FDI	0.012 -1.23	0.053 -0.078
ECF	0.501 (1.019)*	0.574 (0.184)*
LLE	3.333 (0.109)**	2.127 (0.432)*
OPN	-0.015 (0.035)**	-0.019 (0.114)**
LFIV	0.044 -0.076	0.048 -1.016
AR(1)	-	0.885 (0.039)***
R-squared	0.762	0.78
Adjusted R-squared	0.708	0.708
Durbin-Watson stat	1.064	1.894
F-statistic	129.09	128.82
Prob(F-statistic)	0	0
Diagnostic Statistics		
χ^2_{NORMAL}	1.8841[0.3091]	0.5082[0.6376]
χ^2_{WHITE}	0.0325 [0.8113]	1.0115[0.5733]
χ^2_{ARCH}	2.1216[0.1292]	0.3990[0.6821]
χ^2_{RESET}	4.2582[0.0058]	1.6220[0.5505]
χ^2_{SERIAL}	6.1718[0.0294]	0.2074[0.8374]

Note: ***(**)* represent 1%, 5% and 10% level of significance. Standard Errors are in parentheses.

The situations have particularly led to closure of most businesses in Nigeria occasioning their opting to other neighbouring Africa countries where investment climate are relatively conducive for businesses to flourish. Examples can be cited of Dunlop Tyres and Paterson Zochonis (PZ) that has opted to Ghana because of high cost of doing in Nigeria. Labour variable denoted as (LAB) also has a positive sign and also statistically significant at a conventional level of one percent. This can be attributed to industrious nature of an average Nigerian even in the face of unemployment problem confronting the country most especially in government occupations. Available statistics have shown that over 70% of the Nigerian economy is dominated by informal sector activities. The inference that can be drawn from this is that, the informal sectors provide job employments to a large number of people in the country. Instances abound to support this assertion. The organized informal sectors had largely contributed to the country's gross domestic product unlike unorganized informal sector whose activities are mostly not recorded.

The coefficient on Foreign direct investment (FDI) variable theoretically complies with apriori expectation of positive sign but not significant at any conventional levels. This can be attributed to the fact that most of the inflows are concentrated on petroleum sector whose impact in terms of employment generation is negligible. This finding has equally been confirmed by several studies for Nigeria. Examples include: Konings (2001); Zukowska-Gagelmann (2002) and Ajide and Adeniyi (2010). Economic freedom denoted by ECF is positively associated with economic growth and statistically significant only at a 10% conventional level. The implications of the results are that there might have been considerable improvements in some of the components of economic freedom like the size of government, legal structure and security of property rights, access to sound money, freedom to trade internationally and regulation of credit, labour and business. Such improvements in the components can be explained in part by the enthronement of democratic structures in the country since 1999 till date.

Also, the life expectancy (a surrogate for human capital development) has the expected positive sign. A 1 % increase in life expectancy tends to increase the country's economic growth by multiple of 3. Not only that the coefficient on life expectancy variable is positively related to the level of economic growth but it is also statistically significant at a 5% level. This can plausibly be explained by improved healthcare service delivery and continued health enlightens programs by the government. OPN which measures the degree of openness of the economy is also significant in both model I and II at 5% levels but has contradictory signs of negative. This may be attributed to devastating impacts that may be associated with openness of economy to the host country. For instance, many indigenous industries have been shut down as well as most businesses due to the low level of patronage for their products in preference for imported products. Further, financial sector development (FIV) proxied by credit extended by banking system is in consonance with apriori expectation. More importantly, it shows that banking credit has not been channeled towards productive real sectors thereby failing to drive the desired changes expected in the economy.

The R^2 which is a measure of model goodness of fit stand at 71% even when adjusted for. By implication, the explanatory prowess of the model is undoubtedly substantial to have explained growth to the tune of about 71% while the error term can be held liable for the remaining percent. However, the model is seriously fraught with serial autocorrelation problem as Durbin-Watson (DW) statistic remains unacceptably low with a value of 1.064. Unlike DW statistics, F-statistics falls within the acceptance region with a value of 129.09 showing the level of joint significance of the explanatory variables.

Model II presents the corrected estimates of the model having adjusted for autocorrelation problems. This is achieved having conducted First Order Autoregressive, AR (1). With such estimation, the value of Durbin-Watson statistics eventually falls within an acceptable region. It is quite interesting however to note that there was no marked differences in results when compared with Model I except for variations in the level of significances.

In addition, the Model II passes all diagnostic tests for non-normality of error term, white heteroskedasticity, autoregressive conditional heteroskedasticity, model specification and serial correlation, whereas Model I fails to accept the null hypothesis of no serial autocorrelation and model specification.

Table 4: Augmented Dickey Fuller Test for Residuals (Null Hypothesis: Has a Unit Root)

Exogenous: None

Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.023824	0.0095
Test critical values:	1% level	-2.604746	
	5% level	-1.946447	
	10% level	-1.613238	

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

A cointegration test using the Augmented Dicken Fuller test procedure was conducted on the residuals from the estimated static long run equation in Table 3. In Table 4 the table statistics of -3.0238 is less than the critical value of -2.6047, -1.9464 and -1.6132 percent levels of significance. Thus, the null hypothesis that the least squares residuals contain a unit root is rejected. This means there is a long run cointegrating relationship among the variables namely: economic growth and all the regressors, and this occurs at 1%, 5% and 10% levels of significance.

When non-stationary variables are found to be cointegrated, the conventional wisdom is to estimate an error correction model (Engle and Granger, 1987). This shows the short run response of the economic growth to changes in the explanatory variables. It includes the speed of adjustment to equilibrium when the short run position of the economic growth deviates from the long run position. Table 4 shows the results of the error correction model of economic growth.

Table5: Results from the Error Correction Model

Regressor	Coefficient	Probability
Constant	0.2153(7.6255)***	0.0000
ΔLRGDP	0.1851(1.0512)	0.2157
Δ LCAP	0.2718(1.2126)	0.3613
ΔLCAP(-1)	0.1972(1.1001)	0.5189
Δ LLAB	0.0511(3.6219)***	0.0000
ΔLLAB(-1)	0.0477(2.8219)**	0.0005
ΔFDI	0.2271(1.3347)	0.3199
ΔFDI(-1)	0.3881(1.2663)	0.2781
ΔECF	0.0026(2.4091)**	0.0071
Δ ECF(-1)	0.0518(2.7117)**	0.0006
Δ LLE	0.0177(1.8791)*	0.0517
ΔLLE(-1)	0.0117(1.5718)	0.2115
ΔOPN	-0.0255(1.9912)*	0.0008
ΔOPN(-1)	-0.0239(2.1818)**	0.0071
ΔLFIV	0.1776(1.3133)	0.1771
ΔLFIV(-1)	0.2149(1.5178)	0.2191
ECM(-1)	-0.2105(-2.5155)**	0.0001
Adjusted R-Square	0.839	
Durbin-Watson	2.099	
F-Statistic	31.98	
Standard Error	0.075	

Note: ***(**)* represent 1%, 5% and 10% level of significance. T-Statistics are in parentheses

From Table 5, it can be observed that all the explanatory variables comply with the theoretical apriori signs with the exception of degree of openness variable. The results of the error correction model are not significantly different from that static long run regression model. It is interesting to note that the lagged values of economic freedom also impact positively on economic growth as indicated on the table. Contrariwise, FDI is insignificant at any levels.

Table 6: Regression Results of Components of Economic Freedom Index on Economic Growth

Variables	Effect of Size of Government	Effect of Legal System and Property Rights	Effect of Sound Money	Effect of Freedom to Trade Internationally	Effect of Regulation
Constant	-6.0389 (0.0087)***	-4.9419 (0.0097)***	-6.7191 (0.0065)***	-7.0476 (0.0119)***	-8.1726 (0.0092)***
LCAP	0.0251 -0.1041	0.0194 -0.0924	-0.0079 -0.0907	0.0399 -0.0724	0.0178 -0.0992
LLAB	1.7012 (0.1331)*	1.7996 (0.0432)**	1.3498 (0.2212)***	0.9005 (0.1009)**	1.5606 (0.0707)**
FDI	0.0092 -0.7218	0.0063 -0.9859	0.0022 -0.6922	-0.0012 -0.9029	0.0093 -0.7971
LLE	1.7772 (0.0132)**	1.7944 (0.1170)*	2.6511 (0.1773)*	2.6908 (0.0166)**	2.3402 (0.4331)*
OPN	-1.2314 (0.1002)**	-1.0919 (0.0899)*	-1.0918 (0.1534)*	-1.7871 (0.2211)**	-1.5416 (0.0991)*
LFIV	0.0147 -1.2761	0.0191 -0.8765	0.0393 -0.8133	0.0399 -0.8765	0.0331 -0.9679
SG	-0.0194 (0.0134)*				
LS		0.1663 -0.4332			
MA			0.09 -0.1876		
FT				0.9675 (0.3145)*	
RG					0.0909 -0.6578
AR(1)	0.8812 (0.0119)***	0.8643 (0.1876)***	0.7726 (0.0178)***	0.7404 (0.0312)***	0.8297 (0.1101)***

Note: ***(**)* represent 1%, 5% and 10% level of significance. Standard Errors are in parentheses.

The error correction term has the right sign, it is at the 5%, and lies in the relevant range. The speed of adjustment of the ECM term shows that 21% of the deviation of the short run economic growth from the long run is recovered within a year. The coefficient of determination (R-square) shows that 83.9 % of the variation in growth is explained by the explanatory variables in the model.

Table 6 shows the importance of decomposing the components of economic freedom variable on economic growth. The rationale for this is to show which of the components specifically represents a driving force in the aggregate composite index of economic freedom for Nigeria. The use of aggregative composite index tends to mask some salient factors relating to causal impact of economic freedom-growth relationships. It is on the basis of this, the study presents the decomposition analysis in what follows.

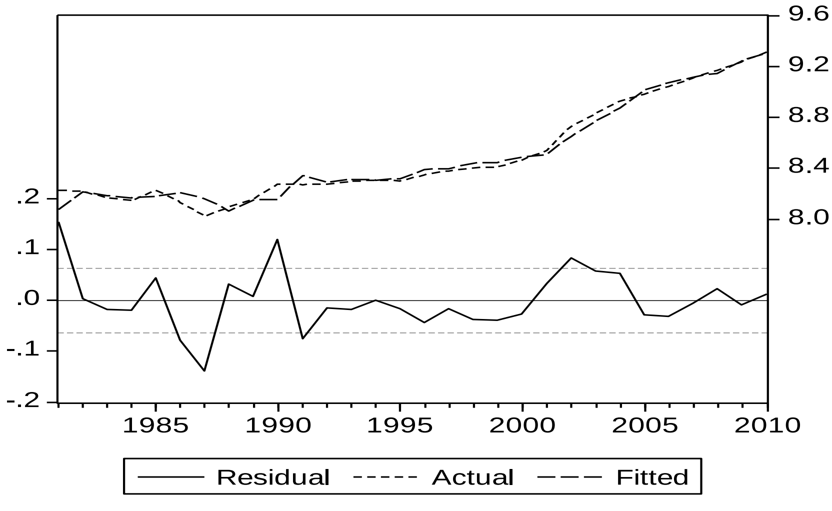

Figure 5: Actual and Fitted Values of Economic growth in Nigeria

Just like what was obtained in Table 3, all the variables theoretically comply with apriori expectation except degree of openness variable whose signs are negative for the entire models estimated. Labour and degree of openness appear as the most important variables influencing economic growth as their level of significances vary from 1%, 5% and 10% respectively across the models. Similar to what was obtained in Table 3, coefficients on capital variable are not statistically significant in all the estimated models but carry the expected signs. Life expectancy is also very important factor significantly affecting economic growth but just in two models, specifically when access to sound money and regulation of credit, labor, and business are controlled for in models 3 and 4 respectively. Financial sector development is also not statistically significant in any of the models. More importantly, of all components of economic freedom, size of government (SG) and freedom to trade internationally (FT) are the only variables whose coefficients are statistically significant at a conventional level of 10%. These results further confirm what was displayed in figure 1 of the diagram. It is interesting to note that the value of both R-squared and the adjusted are the same for all the models. The Durbin-watson statistics also lies within the range of 1.7797 and 1.9216 which to a large extent reveals a fairly absence of autocorrelations in the models. The joint significances of the models are also satisfactory.

Figure 5 further lends credence to our estimated results in Model II. The fit is quite impressive and since fitted value is able to track the actual date. Notably, the ability of the model to capture turning points is remarkable.

6.0 Conclusion and Policy Recommendations

Research on the causes of growth has generated and received a wide attention in the economic literature to date but a particular strand that crafts a role for economic freedom in growth-FDI space is still at its infancy. This study contributes to the debate by further our understanding on the tripartite relationship among the trio using a multivariate regression approach in a growth-augmented framework over the period covering 1980 through 2010. It was discovered that labour, economic freedom and life expectancy have significant associations with economic growth in Nigeria albeit, at different conventional levels. Similar results were obtained when first-order autogressive was made to correct for autocorrelation problem in the estimated model. Intriguingly, at a disaggregated level, we found only size of government and freedom to trade internationally variables as key economic freedom components whose impacts on economic freedom appear to be more profound since their coefficients are statistically significant at a conventional level of 10%. This therefore suggests the import of using disaggregative rather than aggregative composite index which tend to mask the consequences of certain policy variables, thereby encouraging wrong policy diagnosis and thus assist in formulating bad policy prescriptions.

Some key implications which can be drawn from this study include: first, improving and strengthening the components of economic freedom will certainly create a more friendly investment climate conducive for businesses to flourish. Since a business environment consistent with economic freedom can foster economic growth in order to attract inflows of FDI. Second, Openness is another important predictor for driving growth but must be cautiously allowed in order not to discourage indigenous manufacturers or shut them out of business. Third, excessive intervention by government in the economy should be drastically reduced so as to allow freedom to be enjoyed and exercised by private individuals who might want to operate freely. Fourth, working labour force should be more engaged and allowed to participate more in the country since their contributions to economic growth is felt. This can be achieved through provision of enabling working environment. Lastly, more budgetary allocations should be channeled towards health delivery schemes and education promoting activities since the likelihood of elongating life expectancy is tandem with such exercises.

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