Contents

Modelling and Forecasting Exchange Rate Volatility in Nigeria: Does One Model Fit All?

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Abstract

This study analyses the extent of volatility in exchange rate in Nigeria covering the sustainable democratic transitions between 1999 and 2011 using daily returns. The main innovation of this paper is that it evaluates the volatility under each democratic regime of four years namely 05/29/ 1999 – 05/28/2003; 05/29/2003 – 05/28/2007; and 05/29/2007 – 05/28/2011. The empirical evidence indicates that the behaviour of exchange rate tends to change over short periods of time with inconsistent leverage effects and persistence of shocks. Thus, applying a one-model-fits-all approach for exchange rate volatility in Nigeria will yield misleading and invalid policy prescriptions.

Key Words: Exchange rate, volatility modelling, volatility forecasting, monetary policy

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I. Introduction

The Central of Bank of Nigeria (CBN), just like any other Central Bank, is charged, among other functions, with the responsibility of ensuring and maintaining exchange rate stability. This is underscored by the fact that incessant exchange rate fluctuations may: (i) lead to huge losses or gains for traders in the foreign exchange market; (ii) deteriorate or improve balance of payments; (iii) cause significant losses or gains to both foreign and local investors; and (iv) distort international comparisons (see for example, Arize, 1995, 1997, 1998; Esquivel and Larraín, 2002; and Schnabl, 2007 for recent empirical evidence)[1]. Thus, both the government and profit-maximizing investors are keenly interested in the extent of volatility in exchange rate to make policy/investment decisions. Therefore, a measure of volatility in exchange rate provides useful information both to the investors in terms of how to make investment decisions and relevant monetary authorities in the formulation of appropriate liquidity supply policies to protect and strengthen the domestic currency. A more serious

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[1] *See for example, Clark (1973), Baron (1976a&b), Hooper and Kohlhagen (1978), Broll (1994) and Wolf (1995) for early contributions to the evidence.*

concern however, centres on how to model exchange rate when confronted with such volatility.

The concept of exchange rate volatility has been extensively dealt with in the literature.[2]However, different dimensions witnessed in the various analyses have continued to create vacuum for further studies. Summarily, two concerns can be raised on the modelling of exchange rate volatility: (i) Is exchange rate volatility regime neutral?[3] and (ii) Does a one-model-fits-all syndrome automatic in intra-regime analyses of exchange rate volatility? The former concern has been extensively dealt with in the literature (see Kočenda and Valachy, 2006 and Chipili, 2009 for a survey of literature). Majority of these studies find that exchange rate is more volatile in flexible exchange rate than in fixed exchange rate regime. Of course, a fixed exchange rate regime does not usually respond systematically to market forces and, therefore, one can easily pre-empt the results of these studies of larger variations in a flexible regime than in fixed.

The latter question, to the best of the knowledge of the author, does not seem to have received any notable attention in the literature.[4] This is the contribution of the present study. It can be argued that a flexible exchange rate regime under different democratic periods may give substantially different volatility trends depending upon the interest and effectiveness of monetary policy authorities in maintaining exchange rate stability. For example, different democratic periods in Nigeria (through the monetary policy institutions) have implemented several strategies to strengthen the value of the naira under a flexible exchange rateregime and, therefore, the extent of exchange rate volatility may differ significantly across different periods. Thus, if this was true, it becomes imperative to understand the peculiarities of the modelling framework for accounting for such significant differences. Generalizing the model of exchange rate volatility, notwithstanding the significant peculiarities, may lead to invalid and misleading policy prescriptions. Essentially, the study considers sub-samples determined by the different democratic periods in Nigeria which practiced flexible exchange rate regime to provide answers to the latter question. With these sub-samples, this study is able to evaluate the effectiveness of monetary policy authorities under each democratic period in maintaining exchange rate stability and assess the robustness of the empirical results.

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[2] *A brief review of some of these papers is provided in section 3.*

[3] *That is, can modeling of exchange rate be generalized for both fixed and flexible regimes?*

[4] *The only but unrelated paper is Narayan and Narayan (2007) that examined the modeling of oil price volatility. They considered various subsamples between 1991 and 2006 in order to judge the robustness of their results although the choice of the subsamples was not justified. In relation to exchange rate volatility however, studies in this regard are non-existent.*

In Nigeria, research in the area of modelling exchange rate is gradually emerging. The available studies are Olowe (2009) and Dallah (2011). These studies however, did not allow for probable significant variations in the modelling structure of exchange rate volatility in Nigeria. In addition, the use of high frequency daily returns on Nigeria'sexchange rate in the present study further provides reasonable basis for probable existence of autoregressive time varying heteroscedaticity in the series.

The full sample (FS) of the study is the period of sustainable democratic transitions in Nigeria- 05/29/1999 – 05/28/2011. Essentially, the period – 05/29/1999 marked the beginning of sustainable democratic era in Nigeria and subsequently followed by four successful democratic transitions each with four-year period. Thus, the sub-samples are 05/29/1999 – 05/28/2003 (SUB1); 05/29/2003 – 05/28/2007 (SUB2); and 05/29/2007 – 05/28/2011 (SUB3).[5] The current administration is barely five (5) months old and, therefore, is not included in the estimation sample.

In addition, in the course of empirical analysis, attention is paid to: (i) the use of appropriate model selection criteria including pre-tests as suggested by Engle (1982) to determine the choice of volatility model; and (ii) the application of appropriate forecast measures to evaluate the forecast performance of the preferred models

The findings from the empirical analysis appear mixed and in particular, there is evidence of inconsistent leverage effects and persistence of shocks.[6]Large depreciations were recorded during SUB1 and SUB3 compared to SUB2. Thus, monetary policy strategies seem more effective in the latter period than the two former periods. Comparatively, the TGARCH (1,1) model gives the best fit under SUB2 and SUB3 while the GARCH (1,1) is preferred under SUB1. The results obtained from the TGARCH (1,1) model reveals evidence of strong leverage effects. These effects indicate that positive shocks increased the volatility of exchange rate more than negative shocks of the same magnitude. Thus, good news in the foreign exchange market has the potential of increasing volatility in the exchange rate than bad news. In addition, the shocks leading to a change in volatility seem permanent during SUB3. This evidence further reinforces the need to restructure the current design of exchange rate management in Nigeria. The incessant reliance on monetary policy rate to influence the level of exchange

[5]FS and SUB1-3 denote full sample period-05/29/1999 – 05/28/2011 and sub-sample periods 05/29/1999 –05/28/2003; 05/29/2003 - 05/29/2007 and 05/29/2007 – 05/28/2011 respectively.
[6] This evidence is consistent with Narayan and Narayan (2007).

rate, among others, may not completely produce the desired results. Overall, applying one-model-fits-all approach for exchange rate volatility in Nigeria will yield misleading and invalid policy prescriptions.

Some stylized facts about the exchange rate management in Nigeria are provided in section 2. Relevant theoretical and applied research studies on volatility modelling of exchange rate are reviewed in section 3. While section 4 describes the structure of the volatility models considered in this paper, section 5 presents the empirical applications including forecasting. Section 6 concludes the paper.

II. Stylized Facts about Exchange Rate Management in Nigeria

Exchange rate management in Nigeria is motivated by the need to ensure and maintain exchange rate stability.[7] The actualization of this important objective is anchored on the ability of the monetary authorities to (i) prevent distortions in the foreign exchange (FOREX) market by at least narrowing the gap between the official and parallel markets; (ii) maintain a favourable external reserve position;(iii) promote healthy external balances; (Iv) diversify the export base and reduce incessant dependence on imports; and (v) curtail the incidence of capital flight. Table 1 presents some selected indicators of exchange rate management in Nigeria. The statistics provided cover the period 1999 to 2010 in line with the study period and structured along the democratic periods. The demand for FOREX has increased drastically during the three democratic transitions. The total FOREX utilization in Nigeria grew rapidly by 63.89% (from US$35,265.58 million to US$57,797.96 million) during 2003-2006 and subsequently by a significantly higher rate of 109.40% (from US$57,797.96 million to US$121,030.37) in 2007-2010.

The trends further reveal that the ever-increasing demand for FOREX in Nigeria was majorly driven by the need to settle high import bills. The ratio of FOREX utilization on imports to total shows that about 77.29% (equivalent to US$27,257.93 million) of the total FOREX utilization was used on imports during 1999-2002; a slightly higher magnitude of 81.71% (equivalent to US$47,224.08 million) during 2003-2006 and somewhat lower degree of 64.17% during 2007-2010 compared to the previous periods.The FOREX utilization on imports, just as the overall, grew rapidly by 73.24% (from US$27,257.93 million to US$47,224.08 million) during 2003-2006 period and subsequently by a somewhat lower rate of 64.46% (from US$47,224.08 million to US$ 77,664.05) in 2007-2010. The BOP values also support evidence of higher FOREX payments than receipts as huge deficits were

[7] The reasons for maintaining exchange rate stability have been discussed under section 1.

recorded for all the periods under consideration. Thus, the incessant high demands for FOREX may also account for the persistent depreciation in the domestic currency (naira) as presented in table 1.

Overall, the management of exchange rate in Nigeria has been rather challenging to the monetary authorities particularly on how to address the attendant consequences of increasing demands for huge FOREX in the country.

Table 1: Selected indicators of exchange rate management in Nigeria

Indicator	1999-2002	2003-2006	2007-2010
FOREX utilization on Imports (US$' Million)	27,257.93	47,224.08	77,664.05
Percentage change of Import FOREX	-	73.24	64.46
Total Utilization of FOREX(US$' Million)	35,265.58	57,797.96	121,030.37
Percentage change of Total FOREX	-	63.89	109.40
(a)Percentage of FOREX utilization on Imports to Total (%)	77.29	81.71	64.17
Balance of Payments (BOP) (US$' Million)	(4,624.85)	(28,250.40)	(68,909.52)
Official Exchange Rate (Naira/US$1.00): End-Period	126.8833	128.2919	150.4799
Average Official Exchange Rate (₦/US$1.00)	106.928	130.9139	135.8999

Source: Central Bank of Nigeria (CBN) Statistical Bulletin, 2010.

NB: Figures in (a) were computed by the author from the CBN Statistical Bulletin. The BOP values are cumulative and the parentheses imply deficits. Also, BOP values were provided in US$ million only for the period 2005 to 2010 and therefore, values for the preceding period 1999-2004 were computed by dividing the BOP in the local currency unit (Naira) by the official exchange rate (N/US$). Also note that BOP surpluses were recorded in between the periods.

III. Literature Review

The issue of volatility in financial time series including exchange rate has received considerable attention from both researchers and relevant practitioners and policy makers alike. Despite this phenomenal growth in research efforts, the choice of a modelling framework has remained inconclusive both theoretically and empirically. The Engle (1982) paper is the first notable work on volatility modelling of financial time series. The paper develops an Autoregressive Conditional Heteroscedasticity (ARCH) model to capture probable statistically significant correlations between observations that are large distance apart and time varying. After the seminal paper of Engle (1982), several extensions have emerged to improve on the latter. Among these extensions are the ARCH in Mean (ARCH-M) by Engle, et al (1987), the Generalized ARCH (GARCH) developed by Bollerslev (1986) and the GARCH family. The latter includes the integrated GARCH (IGARCH) model by Engle and Bollerslev (1986), the multivariate GARCH models (MGARCH) developed by Baba, et al (1990) and extended by Engle and Kroner (1995) and asymmetric GARCH models [exponential GARCH (EGARCH) proposed by Nelson (1991), GJR-GARCH by Glosten, et al(1993), and asymmetric power GARCH ((APGARCH) model by Ding, et al (1993)].[8]

Several extensive applications of these dimensions of volatility models in relation to modelling of exchange rate volatility exist in the literature. A survey of the existing literature can be found in Chipili (2009). A number of studies have evaluated exchange rate volatility under two prominent policy regimes namely fixed and floating regimes (see for example, Stockman, 1983; Mussa, 1986; Savvides, 1990; Papell, 1992; Lothian and Taylor,1996; Hasan and Wallace, 1996; Flood and Rose, 1998; Canales-Kriljenko and Habermeier, 2004; Kočenda and Valachy, 2006; and Stancik, 2006 and Olowe, 2009). The dominant consensus in the literature is that exchange rate volatility is greater under a flexible regime than under a fixed arrangement.

Some of these studies have also focused on country-specific analysis (see Singh, 2002, for India; Yoon and Lee, 2008, for South Korea; Chipili, 2009, for Zambia; Olowe, 2009, and Dalla, 2011, for Nigeria), while some others have evaluated comparatively for a panel of countries (e.g. Savvides, 1990, for developing countries; Papell, 1992, for European Monetary System; Bangake, 2006, for Africa; and Kočenda and Valachy, 2006, for Visegrad four countries); and the use of both asymmetric and symmetric volatility models has remained dominant. The significance of modelling exchange rate has also been reflected in a number of empirical studies capturing macroeconomic effects of exchange rate volatility (see Esquivel and Larrain, 2002, on linking exchange rate volatility with foreign direct investment and trade and Chowdhury, 1993; Arize, 1995, 1997, 1998; Dell'Ariccia, 1999; Arize, et al ,2000; Esquivel and Larraín, 2002; and Schnabl, 2007; examining exchange rate volatility on trade). The dominant empirical evidence

[8] See Engle (2002) for a comprehensive review of volatility models and recent extensions.

indicates that an increase in exchange rate volatility is associated with a decrease in the volume of international trade.

By and large, issues dwelling on exchange rate volatility have been extensively debated in the literature. As earlier emphasized, the issue of whether or not we can generalize the modelling of exchange rate volatility under different democratic transitions of the same policy regime (flexible regime) appears not to have received any attention in the literature. This is the contribution of this study. The section that follows describes the structure of the volatility models used.

IV. The Models

This paper begins with the following AR (*k*) process for financial time series $\left(z_t\right)$:

$$z_t = \eta + \sum_{i=1}^{k} \delta_i z_{t-i} + \varepsilon_t ; i = 1, \ldots, k ; t = 1, \ldots, T ; \varepsilon_t \sim \text{IID}\left(0, \sigma^2\right) ; \left|\delta_i\right| < 1 \quad (1)$$

z_t the return from holding the financial securities/assets, η is the risk premium for investing in the long-term securities/assets or for obtaining financial assets, z_{t-i} captures the autoregressive components of the financial series, δ_i represent the autoregressive parameters and ε_t is the error term and it measures the difference between the *ex-ante* and *ex-post* rate of returns. In equation (1), z_t is assumed conditional on immediate past information set $\left(\Omega_{t-1}\right)$ and, therefore, its conditional mean can be expressed as:

$$E\left(z_t \middle| \Omega_{t-1}\right) = \eta + \sum_{i=1}^{k} \delta_i z_{t-i} \quad (2)$$

Equation (2) shows that the conditional mean of z_t is time-varying which is a peculiar feature of financial time series. Assuming the error term $\left(\varepsilon_t\right)$ follows Engle (2002):

$$\varepsilon_t = \mu_t \left(\beta_0 + \sum_{j=1}^{q} \beta_j \varepsilon_{t-j}^2 \right)^{1/2} ; \quad j = 1, \ldots, q \quad (3)$$

where $\mu_t \sim \text{IID}(0,1)$ and it is also assumed that $\beta_0 > 0$ and $0 < \beta_1 < 1$.[9] Equation (3) defines ARCH (q) model as proposed by Engle (2002). Equivalently, equation (3) can be expressed as:

$$\varepsilon_t^2 = \mu_t^2 \left(\beta_0 + \sum_{j=1}^{q} \beta_j \varepsilon_{t-j}^2 \right) \tag{4}$$

Taking expectation of equation (4) given relevant information set (π_{t-1}) the conditional variance is derived as:

$$\text{var}(\varepsilon_t | \pi_{t-1}) = \beta_0 + \sum_{j=1}^{q} \beta_j \varepsilon_{t-j}^2 \text{ since } \text{E}\left(\mu_t^2 | \pi_{t-1}\right) = 1 \tag{5}$$

In the case of unconditional variance, however, using the lag operator (L), equation (5) becomes:

$$\sigma_t^2 = E\left(\varepsilon_t^2\right) = \frac{\beta_0}{1 - \beta(L)} \tag{6}$$

where $\sum_{j=1}^{q} \beta_j \varepsilon_{t-j}^2 = \beta(L) \varepsilon_t^2$ and $\beta(L)$ is the polynomial lag operator $\beta_1 L + \beta_2 L^2 + \ldots + \beta_q L^q$ Equation (4) defines ARCH (q) model where the value of the conditional variance $\left[\text{var}(\varepsilon_t | \pi_{t-1})\right]$ is a function of squared error term from past periods $\left(\varepsilon_{t-j}^2\right)$. The null hypothesis is given as: $H_0 : \beta_1 = \beta_2 = \cdots = \beta_J = 0$ and the hypothesis is tested using either the *F-test* or nR^2 that follows chi-square distribution proposed by Engle (1982). If the null hypothesis is (not) rejected, then there is (no) ARCH effect in the model. Equation (6) shows that the variance is larger when there is evidence of volatility in the time series.

Also considered is the model developed by Bollerslev (1986) which extends Engle (1982) ARCH model by incorporating lags of the conditional variance. Based on the latter, equation (5) becomes:

[9] This is a non-negativity constraint imposed on the ARCH model as proposed by Engle (1982) to ensure that the conditional variance is positive.

$$\sigma_t^2 = \beta_0 + \sum_{j=1}^{q} \beta_j \varepsilon_{t-j}^2 + \sum_{\gamma=1}^{p} \gamma_i \sigma_{t-i}^2 \qquad (7)$$

Where $p \geq 0$, $q > 0$, $\beta_0 > 0$, $\beta_j \geq 0$, $\gamma_i \geq 0$, $j = 1, \ldots, q$ and $i = 1, \ldots, p$.
Equation (7) is the GARCH (*p,q*) model where p and q denote the lagged terms of the conditional variance and the squared error term respectively. The ARCH effect is denoted by $\sum_{j=1}^{q} \beta_j \varepsilon_{t-j}^2$ and the GARCH effect $\sum_{\gamma=1}^{p} \gamma_i \sigma_{t-i}^2$. Using the lag operator, equation (7) is expressed equivalently as:

$$\sigma_t^2 = \beta_0 + \beta(L)\varepsilon_t^2 + \gamma(L)\sigma_t^2 \qquad (8)$$

Similarly, $\gamma(L)\sigma_t^2 = \sum_{\gamma=1}^{p} \gamma_i \sigma_{t-i}^2$ and $\gamma(L)$ is the polynomial lag operator $\gamma_1 L + \gamma_2 L^2 + \ldots + \gamma_p L^p$. By further simplification, equation (8) can be expressed as:

$$\sigma_t^2 = \beta_0 \left[1 - \gamma(L)\right]^{-1} + \beta(L)\left[1 - \gamma(L)\right]^{-1} \varepsilon_t^2 \qquad (9)$$

The unconditional variance, however, is smaller when there is no evidence of volatility:

$$\sigma_t^2 = \left[1 - \beta(L) - \gamma(L)\right]^{-1} \beta_0 \qquad (10)$$

Another important extensions also considered in the modelling of volatility in exchange rate are the ARCH in mean (ARCH-M) and the GARCH-M models that capture the effect of the conditional variance (or conditional standard deviation) in explaining the behaviour of stock returns. For example, when modelling the returns from investing in a risky asset, one might expect that the variance of those returns would add significantly to the explanation of the behaviour of the conditional mean, since risk-averse investors require higher returns to invest in riskier assets (see Harris and Sollis, 2005). For the ARCH-M, equation (1) is modified as:

$$z_t = \theta + \lambda \sigma_t^2 + \sum_{\gamma=1}^{p} \gamma_i \delta_i z_{t-i} + \varepsilon_t; \qquad i = 1, \ldots, k \qquad (11)$$

$$\text{Thus;} \quad \eta_t = \theta + \lambda \sigma_t^2 \tag{12}$$

Where σ_t^2 is as defined in equation (5). The standard deviation of the conditional variance can also be used in lieu. For the GARCH-M, the only difference is that conditional variance (σ_t^2) follows equation (7) instead.

Also of relevance to the study are the volatility models that capture the asymmetric effects or leverage effects not accounted for in the ARCH and GARCH models. Nelson (1991) proposed an exponential GARCH (EGARCH) model to capture the leverage effect. The EGARCH(p,q) is given as:

$$\text{Log}\left(\sigma_t^2\right) = \varnothing + \left[1-\gamma(L)\right]^{-1}\left[1+\beta(L)\right] f\left(\varepsilon_{t-1}/\sigma_{t-1}\right) \tag{13}$$

and

$$f\left(\varepsilon_{t-1}/\sigma_{t-1}\right) = \alpha\varepsilon_{t-1} + \vartheta\left(\left|\varepsilon_{t-1}/\sigma_{t-1}\right| - E\left|\varepsilon_{t-1}/\sigma_{t-1}\right|\right) \tag{14}$$

Unlike the ARCH and GARCH models, equation (13) shows that, in the EGARCH model, the log of the conditional variance is a function of the lagged error terms. The asymmetric effect is captured by the parameter α in equation (14) (i.e. the function $f\left(\varepsilon_{t-1}/\sigma_{t-1}\right)$). There is evidence of the asymmetric effect if $\alpha < 0$ and there is no asymmetric effect if $\alpha = 0$. Essentially, the null hypothesis is $\alpha = 0$ (i.e. there is no asymmetric effect and the testing is based on the t-statistic.[10] The conditional variance in the EGARCH model is always positive with taking the natural log of the former. Thus, the non-negativity constraint imposed in the case of ARCH and GARCH models is not necessary.

The asymmetric effect can also be captured using the GJR-GARCH[11] model which modifies equation (7) to include a dummy variable I_{t-j}.

$$\sigma_t^2 = \beta_0 + \sum_{j=1}^{q}\beta_j\varepsilon_{t-j}^2\varepsilon_{t-j}^2 + \sum_{\gamma=1}^{p}\gamma_i\sigma_{t-i}^2 + \sum_{j=1}^{q}\varphi_j\varepsilon_{t-j}^2 I_{t-j} \tag{15}$$

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[10] Conversely, a symmetric GARCH model can be estimated and consequently, the tests proposed by Engle and Ng (1993) namely the sign bias test (SBT), the negative sign bias test (NSBT) and the positive sign bias test (PSBT) can be used to see whether an asymmetric dummy variable is significant in predicting the squared residuals (see also Harris and Sollis, 2005).

[11] This was developed by Glosen, et al (1993)

where $I_{t-j} = 1$ if $\varepsilon_{t-j} > 0$ (positive shocks) and $I_{t-j} = 0$ otherwise. Therefore, there is evidence of asymmetric effect if $\varphi_j < 0$ which implies that positive shocks reduce the volatility of z_t more than negative shocks of the same magnitude. However, in some standard econometric packages like *G@RCH* programme and E-views, the reverse is the case for the definition of I_{t-j}. That is, $I_{t-j} = 1$ if $\varepsilon_{t-j} < 0$ (negative shocks) and $I_{t-j} = 0$ otherwise. Thus, there is evidence of asymmetric effect if $\varphi_j > 0$ which implies that negative shocks increase the volatility of z_t more than positive shocks of the same magnitude.[12]

V. Empirical Analysis

The empirical applications consider different plausible models for measuring volatility in the Nigerian exchange rate returns as previously discussed and consequently compare the forecasting strengths of these models for policy prescriptions. The analyses are carried out in four phases.[13] The first phase deals with some pre-tests to ascertain the existence of volatility in the Nigerian exchange rate returns. The ARCH Lagrangian Multiplier (LM) test proposed by Engle (1982) is used in this regard. The second phase proceeds to the estimation of different volatility models involving $\text{ARCH}\ (p)$ to $\text{GARCH}\ (p,q)$ type of models including their extensions. Model selection criteria such as Schwartz Information Criterion (SIC), Akaike Information Criterion (AIC) and Hannan-Quinn Information Criterion (HQC) are used to determine the model with the best fit. The third phase provides some post-estimation analyses using the same ARCH LM test to validate the selected volatility models. The fourth, which is the last phase, assesses the forecasting power of the model using forecasting measures such as Mean Absolute Error (MAE), Root Mean Square Error (RMSE), Theil's Inequality Coefficient (TIC) and Mean Absolute Percent Error (MAPE). Daily exchange rate (exr) data utilized in this study are collected from the Statistical bulletin of the Central Bank of Nigeria (CBN) over the period 05/29/1999 –05/28/2011.[14] All the analyses are carried out for the full sample and sub-samples as earlier emphasized. The exchange rate used in this paper is measured by the units of Nigerian domestic currency (*Naira*) to one unit of US dollar. The choice of exchange rate is underscored by the fact that the US dollar (USD) has remained dominant in the

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[12] *A comprehensive exposition of volatility models is provided by Harris and Sollis (2005)*
[13] *Engle (2001) and Kočenda and Valachy (2006) adopted a similar approach.*
[14] *Find the data at http://www.cenbank.org/rates/ExchRateByCurrency.asp. Accessible data for the period 05/29/1999 – 05/28/2003 from the official source- Central Bank of Nigeria (CBN) began on 12/10/2001.*

Nigerian foreign exchange market and, therefore, trading on USD may exert more impact on the *Naira* than all other foreign currencies combined.

V.1 Pre-Estimation Analysis

The pre-estimation analysis is done in two-folds: the first provides descriptive statistics for exchange rate and its returns and the second involves performing ARCH LM test on model (1) above which can now be re-specified as:

$$r_t = \eta + \sum_{i=1}^{k} \delta_i r_{t-i} + \varepsilon_t; \quad i = 1, \ldots, k; \quad t = 1, \ldots, T; \ \ \varepsilon_t \sim \mathrm{IID}\left(0, \sigma^2\right); \quad \left|\delta_i\right| < 1 \tag{16}$$

Where r_t denotes the exchange rate returns and is measured in this paper as:

$$r_t = 100 * [\Delta \log\left(asi_t\right)] \tag{17}$$

Essentially, Engle (1982) proposes three steps for the ARCH LM test to detect the existence of volatility in a series: (i) the first step is to estimate equation (16) by OLS and obtain the fitted residuals; (ii) the second step is to regress the square of the fitted residuals on a constant and lags of the squared residuals, i.e. estimate equation (18) below;

$$\varepsilon_t^2 = \rho_0 + \rho_1 \varepsilon_{t-1}^2 + \rho_2 \varepsilon_{t-2}^2 + \ldots + \rho_p \varepsilon_{t-p}^2 + u_t \tag{18}$$

(iii) the third step involves employing the LM test that tests for the joint null hypothesis that there is no ARCH effect in the model, i.e.: $H_0 : \rho_1 = \rho_2 = \ldots = \rho_P = 0$. In empirical analyses, the usual *F* test (or the statistic computed by multiplying the number of observations (n) by the coefficient of determination $\left(R^2\right)$ obtained from regression of equation (18)) is used. The latter statistic $\left(nR^2\right)$ is chi-squared distributed $\left(\chi_p\right)$ with p degrees of freedom which equal the number of autoregressive terms in equation (18).

Table 2 shows the descriptive statistics for exr_t and r_t covering both the full sample and sub-samples. The highest mean of exr_t was recorded during SUB3 followed by the mean values in SUB2 and SUB1, respectively. The exr_t reached its peak also during SUB3 while its least value was recorded during SUB1. Likewise, the highest standard deviation was recorded during SUB3 followed by SUB1, while the least standard deviation was recorded during SUB2.

There was evidence of negative skewness for exr_t during SUB1 and SUB3 implying the left tail was particularly extreme. However, positive skewness was evident during SUB2 suggesting that the right tail was particularly extreme in this instance. In relation to kurtosis, the exr_t was platykurtic for all the sub-samples indicating thinner tails than the normal distribution. Similarly, based on the Jarque Bera (JB) statistic that uses the information from skewness and kurtosis to test for normality, it was found that exr_t was not normally distributed.

Similarly in relation to exchange rate returns (r_t), the largest depreciation of exr_t (i.e. the largest positive r_t) as well as the highest standard deviation was recorded during SUB3. However, minimal appreciation of exr_t was experienced with the highest appreciation (i.e. highest negative r_t) recorded during SUB1. On the average, taking the full sample into consideration, the movements in exr_t have witnessed large depreciations. The r_t was positively skewed (i.e. the right tail is to the extreme) for SUB3 and negatively skewed over the periods SUB1 and SUB2. However, all the sub-samples were leptokurtic (i.e. evidence of fat tail). In addition, the JB test shows that r_t is not normally distributed for all the sub samples and, therefore, the alternative inferential statistics that follow non-normal distributions are appropriate in this case (see for example, Wilhelmsson, 2006). The available alternatives include the Student-*t* distribution, the generalized error distribution (GED), Student-*t* distribution with fixed degrees of freedom and GED with fixed parameter. All these alternatives are considered in the estimation of each volatility model and the Schwartz Information Criterion (SIC), Akaike Information Criterion (AIC) and Hannan-Quinn Information Criterion (HQC) are used to determine the one with the best fit. Based on the empirical analysis, the skewed Student-*t* distribution performed well than any other skewed and leptokurtic error distribution and are consequently reported.

Table 2: Descriptive Statistics

Statistics	Full sample		Sub-samples					
			SUB1		SUB2		SUB3	
	exr_t	r_t	exr_t	r_t	exr_t	r_t	exr_t	r_t
Mean	131.50	0.01	121.97	0.02	129.92	-0.00	136.57	0.01
Median	128.50	0.00	125.51	0.00	129.03	0.00	146.10	0.00
Maximum	153.09	6.39	130.51	2.01	137.70	2.03	153.09	6.39
Minimum	112.35	-3.91	112.35	-3.91	125.73	-2.65	116.05	-3.10
Std. Dev.	11.14	0.25	5.54	0.28	3.13	0.11	14.53	0.32
Skewness	0.37	9.29	-0.50	-3.63	0.37	-4.14	-0.47	11.01
Kurtosis	2.09	295.80	1.46	92.58	1.93	306.79	1.37	220.79
Jarque Bera	196.15	$1.24*10^7$	75.12	$1.78*10^5$	103.16	$5.62*10^5$	241.87	$2.92*10^6$
Obs	3457	3456	535	534	1462	1461	1462	1461

Source: Computed by the Author

Figure 1 below shows the trend in exr_t over the full sample (FS). The exr_t relatively increased incessantly over SUB1. During SUB2, it hovered around 125 and 135 before it declined persistently at the later part of the period. The FS period witnessed unprecedented sharp movements in exr_t as it rose significantly at the early part of the period before it eventually maintained a fairly steady pattern for the rest of the period. Overall, the pattern depicted in the graph adjudges the unsteady behaviour of exr_t over the period under consideration, although the variability seems to differ over the sub-sample periods.

Figure 1: Trends in Nigerian exchange rate- exr_t (Naira/USD),12/10/2001-05/28/2011

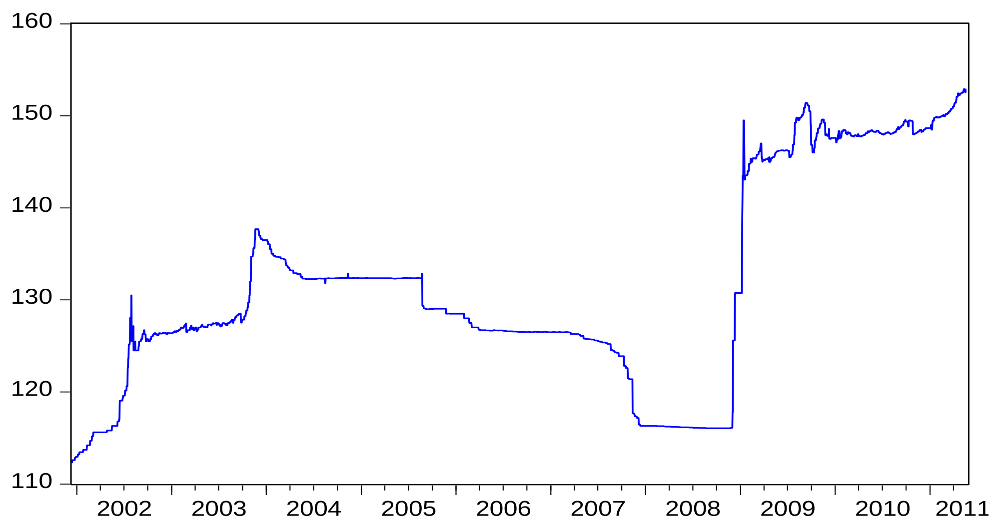

Figure 2: Trends in Nigerian exchange rate returns – r_t (%), 1999:06-2011:05

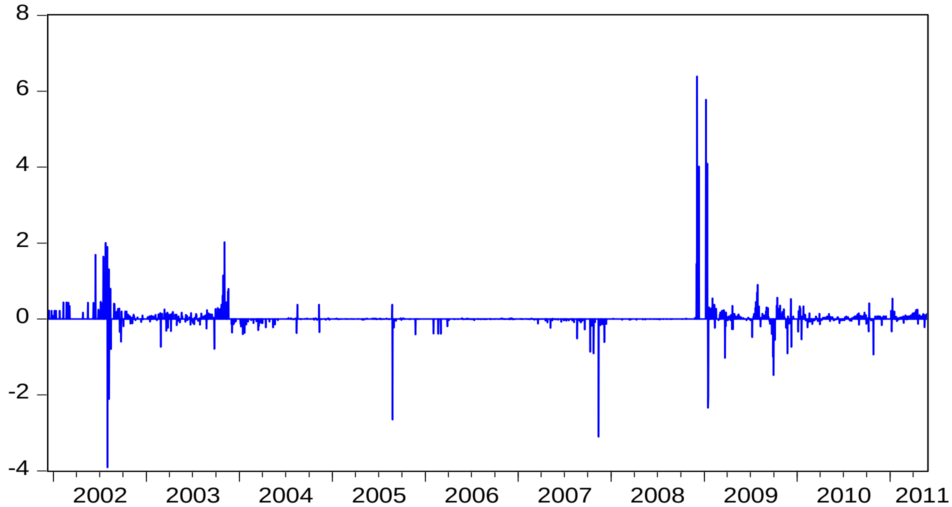

Figure 2 depicts the behaviour of r_t over FS. The notable spikes are evidences of significant unsteady patterns of exchange rate returns and the highest spike is recorded during SUB3 which also coincided with the period of global financial crisis. This observation also confirms the evidence in table 2, indicating that the period, SUB3 suggests the highest points of volatility in exr_t followed by SUB1. Thus, large depreciations in exr_t were observed during these periods. The exr_t was however, relatively steady over the period, SUB2. The graph also clearly shows evidence of volatility clustering where periods of high volatility are followed by periods of tranquillity. Overall, very few points in the graph hover around zero and, therefore, there are frequent instances of depreciation and appreciation although the former appears dominant.

Figure 3 shows a combined graph for exr_t and r_t over the same period. It further reinforces the observations in table 2 and figures 1 and 2 with the trends in r_t showing some evidences of variability in exr_t. It is easier to trace these spikes in r_t to the periods they represent.

Table 3 shows the test statistics for the existence of ARCH effects in the variables. The r_t shows evidence of ARCH effects as judged by the results of the *F-test* and nR^2 up to 10 lags for FS sample as well as SUB1-3. The test statistics at all the chosen lags are statistically significant at 1 percent and thus resoundingly rejecting the "no ARCH" hypothesis. However, the result is mixed for SUB2 as it shows evidence of ARCH effects only for first order autoregressive process with conditional variance of lag 5. This is consistent with the results described under the summary statistics in table 2 and figures 1 – 3 depicting the existence of large movements in exchange rate during SUB1 and SUB3, while fairly stable movements characterized SUB2.

Figure 3: A combined graph for exr_t and r_t , 1999:06-2011:05

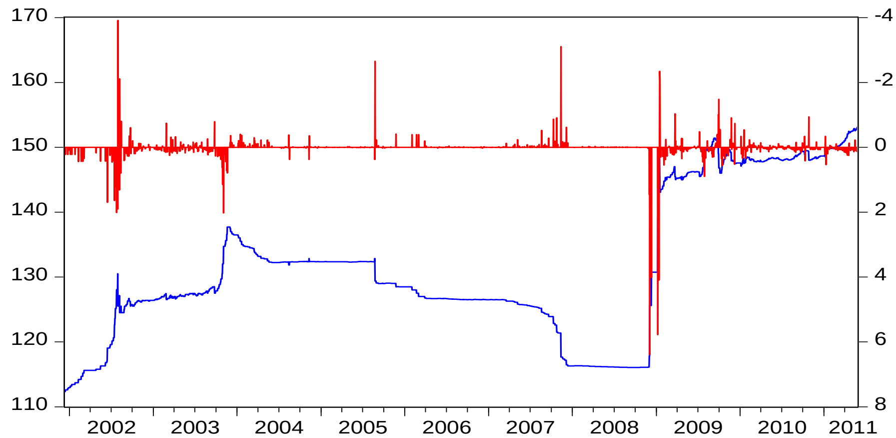

Table 3: ARCH TEST							
Dependent Variable: Exchange rate returns (r_t)							
Sample Period: 12/10/2001-05/28/2011							
Model	**Period**	$p=1$		$p=5$		$p=10$	
		F-test	nR^2	*F-test*	nR^2	*F-test*	nR^2
$k=1$	FS	4.352**	4.249**	18.00*	87.86*	24.97*	233.49*
	SUB1	46.173*	42.633*	9.74*	45.09*	22.85*	161.38*
	SUB2	0.348	0.348	2.25**	11.21**	1.27	12.72
	SUB3	0.356	0.356	8.51*	41.50*	9.66*	91.19*
$k=2$	FS	4.943**	4.939**	19.99*	97.30*	26.81*	249.45*
	SUB1	45.591*	42.132*	9.61*	44.49*	22.78*	160.94*
	SUB2	0.377	0.377	1.96	9.76	1.11	11.11
	SUB3	0.433	0.433	9.96*	48.33*	10.73*	100.65*
$k=3$	FS	4.733**	4.730**	20.44*	99.44*	26.88*	250.11*
	SUB1	45.462*	42.017*	9.58*	44.37*	22.73*	160.61*
	SUB2	0.378	0.378	1.96	9.76	1.11	11.11
	SUB3	0.342	0.342	10.71*	51.85*	10.95*	102.53*

Source: Computed by the Author

Note: Model follows the autoregressive process in equation (16) of order $k=1,2,3$ respectively and p is the lag length for the test statistics based on equation (18). *= 1% level of significance; **= 5% level of significance.

V.2 Estimation and Interpretation of Results

Given the evidence of ARCH effects in r_t, the paper begins the volatility modelling by first estimating equation (16) with GARCH(p,q) effects where $p,q=1$, followed by the various extensions. The ARCH(q) is not estimated based on the theoretical assumption that GARCH(p,q) model with lower values of p and q provide a better fit than an ARCH(q) with a high value of q (see Harris and Sollis, 2005). The model selection criteria – SIC, AIC and HQC are used to choose the model with the best fit among the competing models. Other model selection criteria such as R^2 and $\bar{R}^2$ (adjusted R^2) are not used due to their inherent limitations. For example, R^2, given as $\left(1-\hat{\varepsilon}'\hat{\varepsilon}/r'r-n\bar{r}^2\right)$, is non-decreasing of the number of regressors and, therefore, there is a built-in tendency to over-fit the model. Although the $\bar{R}^2$ is an improvement on R^2 as it penalizes the loss of degrees of freedom that occurs when a model is expanded, it is, however, difficult to ascertain whether the penalty is sufficiently large to guarantee that the criterion will necessarily produce the best fit among the competing alternatives. Hence, the AIC, SIC and HQC have been suggested as alternative fit measures. These criteria are given as:[15]

$$\text{AIC}(g)=\text{Log}\left(\hat{\varepsilon}'\hat{\varepsilon}/n\right)+2g/n \tag{19}$$

$$\text{SIC}(g)=\text{Log}\left(\hat{\varepsilon}'\hat{\varepsilon}/n\right)+g\log n/n \tag{20}$$

$$\text{HQC}(g)=\text{Log}\left(\hat{\varepsilon}'\hat{\varepsilon}/n\right)+2g\log\log n/n \tag{21}$$

Among these criteria shown by equations (19), (20) and (21), the SIC is often preferred as it gives the heaviest penalties for loss of degrees of freedom. Thus, the model with the least value of SIC is assumed to give the best fit among the competing alternatives.

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[15] Equations (19), (20) and (21) are derived from taking the natural logarithm of $\text{AIC}(g)=s_r^2\left(1-R^2\right)e^{2g/n}$ $\text{SIC}(g)=s_r^2\left(1-R^2\right)n^{g/n}$ and $\text{HQC}(g)=s_{(r)}^2(1-R^2)n^{e^{2g/n}}$. g denotes the number of parameters in the model. For example, if only the AR model (equation 16) is estimated, $g=k+1$ However, if equation (16) is estimated with ARCH (*q*) effects (i.e. a combination of equations (16) and (5)), $g=k+q+2$ On the other hand, if equation (16) is estimated with GARCH (*p*,*q*) effects (i.e. a combination of equations (16) and (7)), $g=k+p+q+2$.

Table 4: AR(1)-GARCH(1,1) model estimation				
Dependent Variable: Exchange rate returns (r_t)				
Variable	**Coefficient**			
	FS	**SUB1**	**SUB2**	**SUB3**
constant (M)	$-1.07*10^{-4}$ (-0.820)	0.004 (1.474)	$-9.02*10^{-5}$ (-0.545)	$-8.20*10^{-5}$ (-0.285)
AR(1) (M)	-0.002 (-0.037)	-0.016 (-0.133)	-0.006 (-0.069)	0.030 (0.507)
constant (V)	$4.76*10^{-7}$ (22.205)*	$3.13*10^{-5}$ (7.271)*	$1.31*10^{-6}$ (23.545)*	$7.63*10^{-8}$ (7.661)*
ARCH1 (V)	0.059 (37.392)*	0.016 (10.637)*	0.021 (19.899)*	0.060 (26.540)*
GARCH 1 (V)	0.827 (437.54)*	0.920 (202.51)*	0.809 (210.85)*	0.847 (347.73)*
AIC	-4.189	-2.174	-5.660	-3.622
SIC	-4.181	-2.135	-5.642	-3.604
HQC	-4.186	-2.159	-5.654	-3.616
OBS	3455	533	1461	1461

Source: Computed by the Author

Note:: *, **, *** → 1%, 5%, 10% levels of significance respectively. In addition, the variables are identified as either (M) indicating that the variable features in the conditional mean equation or (V) which implies that the variable is in the conditional variance equation. These notations apply to all the estimations in this paper.

Table 4 shows the results of the estimated GARCH (1,1) model for all the considered periods. Both the ARCH and GARCH effects are statistically significant for all the periods and, therefore, the evidence of volatility initially reported in table 3 appears to have been captured. Also, the sums of the coefficients for the ARCH and GARCH effects are less than one, which is required to have a mean reverting variance process. However, all the sums are close to one indicating that the variance process only mean for each period reverts slowly to the mean. The sums are 0.89, 0.94, 0.83, and 0.91 for FS, SUB1, SUB2 and SUB3 respectively. Thus, among the three sub-samples, SUB1 has the lowest variance reverting process and followed closely by SUB3 while SUB2 has the highest. This trend further authenticates the evidence obtained in tables 2 and 3 and also suggests high level of persistence in the exchange rate volatility over SUB1 and SUB3.

Similarly, the GARCH(1,1) model is compared with the GARCH-M(1,1) model. The results of the latter are presented in table 5. Based on the results obtained under FS, the GARCH-M (1,1) does not seem to improve the GARCH (1, 1) model for

exchange rate as the coefficients on $\left(\sqrt{(\text{GARCH1})}\right)$ included in the conditional mean equation is statistically insignificant and, therefore, does not add any useful information to the volatility of exchange rate in Nigeria. Similar results are evident under SUB1 and SUB2. However, the coefficient on $\left(\sqrt{(\text{GARCH1})}\right)$ is statistically significant and negative under SUB3. This implies that when there was a high volatility in the exchange rate during SUB3, investors shifted to less risky assets and this consequently lowered the exchange rate returns. Apparently, this was the case during the period of the global financial crisis which falls within SUB3.
Nonetheless, there is still evidence of long memory volatility in exchange rate returns. The ranking of the degree of persistence in volatility in exchange rate is the same as the GARCH(1,1) model. In terms of the comparative performance of the two models, the GARCH(1,1) model gives a better fit for all the samples using the SIC.

Table 5: AR(1)-GARCH-M(1,1) model estimation

Dependent Variable: Exchange rate returns (r_t)

Variable	**Coefficient**			
	FS	**SUB1**	**SUB2**	**SUB3**
constant (M)	$-2.03*10^{-4}$ (-1.231)	$-9.16*10^{-4}$ (-0.175)	$5.76*10^{-5}$ (0.173)	$-7.20*10^{-5}$ (-0.238)
AR(1) (M)	-0.003 (-0.070)	-0.022 (-0.194)	-0.007 (-0.092)	0.014 (0.229)
$\left(\sqrt{(\text{GARCH1})}\right)$ (M)	0.036 (1.083)	0.150 (1.177)	-0.045 (-0.486)	-0.010 (-3.188)*
constant (V)	$4.84*10^{-7}$ (22.198)*	$3.04*10^{-5}$ (7.300)*	$1.31*10^{-6}$ (23.489)*	$8.91*10^{-8}$ (7.321)*
ARCH1 (V)	0.058 (37.362)*	0.016 (10.700)*	0.021 (19.870)*	0.056 (27.091)*
GARCH 1 (V)	0.828 (436.43)*	0.920 (206.36)*	0.809 (210.34)*	0.857 (379.59)*
AIC	-4.190	-2.177	-5.660	-3.621
SIC	-4.180	-2.129	-5.638	-3.599
HQC	-4.186	-2.158	-5.651	-3.613
OBS	3455	533	1461	1461

Source: Computed by the Author

The asymmetric GARCH models are also estimated to examine the probable existence of leverage effects. Evidently, the Threshold GARCH (TGARCH) model and the Exponential GARCH (EGARCH) model have become prominent in this regard. Tables 6 and 7 show the results obtained from estimating the two mentioned asymmetric models.

The results obtained from the TGARCH (1,1) model reveals evidence of strong leverage effects for all the samples. These effects indicate that positive shocks increased the volatility of exchange rate more than negative shocks of the same magnitude during the samples under consideration. Notably, the leverage effects were dominant in SUB2 followed by SUB3 with SUB1 having the least. Thus, good news in the foreign exchange market has the potentiality of increasing volatility in the exchange rate than bad news. In addition to the leverage effects, there is evidence of long memory volatility in exchange rate returns using the TGARCH (1,1) model. Unlike the GARCH(1,1) and GARCH-M(1,1) models, the variance process is not mean reverting under SUB3 as the coefficients on ARCH and GARCH effects sum to one indicating that the shocks leading to a change in volatility appear permanent. Although, the variance processes under SUB1 and SUB3 are mean reverting, the movements also seem very sluggish as the sums of coefficients are very close to one.

In terms of the performance of TGARCH(1,1) compared with GARCH(1,1) model, the former gives a better fit under FS, SUB2 and SUB3 while the latter model is preferred under SUB1.

Source: Computed by the Author

Table 6: AR(1)-TGARCH(1,1) model estimation

Dependent Variable: Exchange rate returns (r_t)

Variable	**Coefficient**			
	FS	**SUB1**	**SUB2**	**SUB3**
constant (M)	$-8.31*10^{-5}$ (-0.709)	0.004 (1.514	$-5.21*10^{-5}$ (-0.337)	$-2.14*10^{-5}$ (-0.075)
AR(1) (M)	-0.007 (-0.246)	-0.016 (-0.131)	$-4.02*10^{-7}$ (-0.004)	0.001 (0.016)
constant (V)	$2.53*10^{-7}$ (23.217)*	$3.21*10^{-5}$ (6.874)*	$1.07*10^{-6}$ (23.479)*	$4.13*10^{-8}$ (9.756)*
ARCH1 (V)	0.105 (34.373)*	0.018 (10.489)*	0.173 (16.888)*	0.123 (21.691)*
GARCH 1 (V)	0.871 (611.83)*	0.921 (190.24)*	0.792 (202.37)*	0.878 (380.13)*
ASYMMETRY (V)	-0.103 (-34.199)*	-0.005 (-2.168)**	-0.171 (-16.841)*	-0.121 (-21.536)*
AIC	-4.393	-2.172	-5.862	-3.863
SIC	-4.382	-2.123	-5.840	-3.841
HQC	-4.389	-2.153	-5.854	-3.855
OBS	3455	533	1461	1461

Interestingly, the intuition behind the results of the EGARCH (1, 1) model is not different from the TGARCH model. Similarly, for all the samples, the coefficients on $\sqrt{ARCH1/GARCH1}$ (V) are positive which is the equivalent interpretation for the negative sign of the coefficient on asymmetry in the TGARCH(1,1) model. This further validates the conclusion that positive shocks have the tendency of aggravating the volatility in Nigeria's foreign exchange market. However, based on the SIC values, the EGARCH(1,1) does not seem to alter the modelling preference for the samples. On the basis of the magnitude of impact, the largest asymmetric effects were obtained during SUB2, while the least were recorded during SUB3.

In summary, the estimation results show that different volatility models with different peculiarities fit different democratic regimes in Nigeria.

Table 7: AR(1)-EGARCH(1,1) model estimation

Dependent Variable: Exchange rate returns (r_t)

Variable	**Coefficient**			
	FS	**SUB1**	**SUB2**	**SUB3**
constant (M)	$2.67*10^{-6}$ (0.005)	0.005 (1.680)***	$-1.13*10^{-6}$ (-0.006)	$7.41*10^{-7}$ (0.001)
AR(1) (M)	0.013 (0.426)	-0.014 (-0.166)	0.003 (0.070)	-0.019 (-0.997)
constant (V)	-1.211 (-70.420)*	-0.182 (-12.690)*	-1.176 (-36.135)*	-0.238 (37.677)*
$\left\|\sqrt{ARCH1/GARCH1}\right\|$ (V)	0.125 (60.949)*	0.089 (11.825)*	0.074 (27.365)*	0.053 (39.532)*
$\sqrt{ARCH1/GARCH1}$ (V)	0.035 (21.083)*	0.039 (6.303)*	0.051 (19.994)*	0.026 (21.454)*
LOG(GARCH 1) (V)	0.859 (401.37)*	0.983 (418.06)*	0.896 (298.81)*	0.975 (1331.05)*
AIC	-3.554	-2.150	-5.591	-3.424
SIC	-3.544	-2.101	-5.570	-3.402
HQC	-3.551	-2.130	-5.583	-3.416
OBS	3455	533	1461	1461

Source: Computed by the Author

Note: EGARCH (1,1) Model is given as : $\ln(\sigma_t^2) = \emptyset + \vartheta\left|\sqrt{\varepsilon_{t-1}^2/\sigma_{t-1}^2}\right| + \propto\sqrt{\varepsilon_{t-1}^2/\sigma_{t-1}^2} + \gamma\ln(\sigma_{t-1}^2)$. If the asymmetry effect is present, $\propto < (>) 0$ implying that negative (positive) shocks increase volatility more than positive(negative) shocks of the same magnitude while if $\propto = 0$, there is no asymmetry effect.

V.3 Post-Estimation Analysis

Recall that the pre-estimation test confirms the existence of ARCH effects in Nigeria's exchange rate necessitating the estimation of different volatility models as presented above. As a follow up on this, the paper also provides some post-estimation analyses to ascertain if the volatility models have captured these effects. The post-estimation ARCH test is carried out using both the *F*-test and chi-square distributed nR^2 test. The results obtained for all the samples as presented in table 8 do not reject the null hypothesis of no ARCH effects. All the values are statistically insignificant at all the conventional levels of significance. Thus, this study further authenticates the theoretical literature that ARCH/GARCH models are the most suitable for dealing with volatility in financial time series. Thus, ignoring the volatility in the Nigeria's foreign exchange market when in fact it exists yields inefficient results and policy prescriptions offered from such analyses will be invalid.

Table 8: ARCH TEST

Dependent Variable: Exchange rate returns (r_t)

Model	Period	P =1		P = 5		P = 10	
		F-test	nR^2	*F-test*	nR^2	*F-test*	nR^2
GARCH(1,1)	FS	0.001	0.001	0.007	0.034	0.010	0.104
	SUB1	0.113	0.114	0.090	0.455	0.622	6.276
	SUB2	0.478	0.480	0.127	0.636	0.081	0.820
	SUB3	0.003	0.003	0.014	0.068	0.008	0.083
GARCH-M(1,1)	FS	0.001	0.001	0.007	0.034	0.010	0.104
	SUB1	0.111	0.112	0.090	0.454	0.613	6.185
	SUB2	0.471	0.471	0.125	0.626	0.080	0.809
	SUB3	0.003	0.003	0.013	0.068	0.008	0.083
TGARCH(1,1)	FS	0.019	0.019	0.026	0.129	0.025	0.252
	SUB1	0.130	0.130	0.100	0.506	0.615	6.208
	SUB2	0.061	0.061	0.078	0.392	0.275	2.767
	SUB3	0.020	0.020	0.017	0.090	0.018	0.180
EGARCH(1,1)	FS	0.002	0.002	0.002	0.009	0.002	0.016
	SUB1	0.150	0.150	0.128	0.647	0.612	6.174
	SUB2	0.244	0.244	0.120	0.603	0.503	5.052
	SUB3	0.015	0.015	0.011	0.058	0.012	0.125

Source: Computed by the Author

Note: p is the lag length for the test statistics. The mean equations for all the models follow first order autoregressive process as previously estimated.

V.4 Forecast Evaluation of the Volatility Models

This section evaluates the forecast performance of the volatility models using standard forecast measures. Essentially, the forecast allows the projection of *s*-step ahead of *T* (the sample size) for r_t. Thus, the forecast function can be obtained by taking the conditional expectation of r_{T+s} In the case of the estimated mean equation in this paper, the forecast function for *s*-steps ahead can be expressed as:

$$E\left(r_{T+s}|\Omega_T\right)=\eta+\delta_1 r_{T+s-1};\quad \varepsilon_t\sim \text{IID}\left(0,\sigma^2\right) \tag{22}$$

where Ω_T denotes the available information set. Given equation (22), one-step ahead forecast of r_t will be $\eta + \delta_1 r_T$; two-step ahead will be $\eta + \delta_1 r_{T+1}$ and so on. The corresponding *s*-step ahead forecast for the conditional variance in a GARCH(1,1) model for example, can be expressed as:

$$E\left(\sigma^2_{T+s}|\Omega_T\right)=\beta_0+\beta_1\varepsilon^2_{T+s-1}+\gamma_1\sigma^2_{T+s-1} \tag{23}$$

Thus, one-step ahead forecast of σ_t^2 will be $\beta_0+\beta_1\varepsilon^2_T+\gamma 1\sigma^2_T$; two-step ahead will be $\beta_0+\beta_1\varepsilon^2_{T+1}+\gamma 1\sigma^2_{T+1}$; and so on. Forecasts of σ^2_T for some of the extensions can also be obtained in a similar way. Measures of forecast performance employed in this paper are the Mean Absolute Error (MAE), the Root Mean Square Error (RMSE), the Theil's Inequality Coefficient (TIC) and the Mean Absolute Percent Error (MAPE). These measures are given as:

$$\text{RMSE}=\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\hat{r}_t-r_t\right)} \tag{24}$$

$$\text{MAE}=\frac{1}{T}\sum_{t=1}^{T}\left|\hat{r}_t-r_t\right| \tag{25}$$

$$\text{MAPE}=\frac{1}{T}\sum_{t=1}^{T}\hat{r}_t-r_t/r_t \tag{26}$$

$$\text{TIC}=\frac{\sqrt{\frac{1}{\text{T}}\sum_{t=1}^{T}\left(\hat{r}_t-r_t\right)^2}}{\sqrt{\frac{1}{\text{T}}\sum_{t=1}^{T}\left(\hat{r}_t\right)^2}-\sqrt{\frac{1}{\text{T}}\sum_{t=1}^{T}\left(r_t\right)^2}} \tag{27}$$

Where r_t and $\hat{r}_t$ denote actual and forecasted volatility of exchange rate returns, respectively. These measures are used to evaluate the performance of the models in forecasting daily volatility for 2 weeks ahead of each period considered. Both the actual and relative statistics are computed to provide a comprehensive picture of the forecasts. The former are obtained for each model from the computation of RMSE, MAE, MAPE and TIC for all the samples. However, the relative statistics are obtained by dividing the actual statistics by that of the worst performing model under each measure. Based on the evidence obtained from the estimation, the EGARCH (1,1) model appears to be the worst model for all the subsamples based on the SIC values and was consequently used as the base category for computing the relative statistics. Two things are achieved with this division: (i) the ranking of the models by their forecast performance is ascertained; and (ii) the magnitude of forecasting accuracy of each model relative to the worst performing model is quantified. The volatility model with the least RMSE, MAE, and MAPE and highest TIC for both actual statistics and relative statistics is the best forecasting model. To achieve (ii), under each measure, the difference between the relative statistics of each model and that of the worst performing model is computed. The results are presented in tables 9 and 10. Table 9 shows the actual and relative statistics for all the models, while table 10 provides the magnitude of forecasting accuracy relative to the worst performing model.

Table 9: Forecast Evaluation Measures for the Volatility Models

Dependent Variable: Exchange rate returns (r_t)

Model	**Period**	**MAE**		**RMSE**		**MAPE**		**TIC**	
		Actual	Rel (%)	Actual	Rel (%)	Actual	Rel (%)	Actual	Rel (%)
GARCH(1,1)	FS	0.04	100.00	0.25	100.00	16.58	99.97	1.00	100.00
	SUB1	0.06	98.46	0.28	100.00	17.17	100.23	0.99	98.90
	SUB2	0.02	10.37	0.11	100.90	13.89	99.96	1.00	99.90
	SUB3	0.05	100.00	0.32	100.00	19.02	99.97	1.00	100.00
GARCH-M(1,1)	FS	0.04	100.00	0.25	100.00	16.58	99.96	1.00	99.90
	SUB1	0.06	96.92	0.28	100.00	17.22	100.56	0.99	99.30
	SUB2	0.17	100.61	0.11	100.00	13.89	99.97	1.00	99.90
	SUB3	0.05	100.00	0.32	99.69	19.02	99.97	1.00	100.00
TGARCH(1,1)	FS	0.04	100.00	0.25	100.00	16.58	99.98	1.00	100.00
	SUB1	0.07	100.00	0.28	100.00	17.16	100.18	0.99	98.90
	SUB2	0.02	10.37	0.11	100.00	13.90	99.98	1.00	100.00
	SUB3	0.05	100.00	0.32	100.00	19.03	99.99	1.00	100.00
EGARCH(1,1)	FS	0.04	100.00	0.25	100.00	16.59	100.00	1.00	100.00
	SUB1	0.07	100.00	0.28	100.00	17.13	100.00	1.00	100.00
	SUB2	0.16	100.00	0.11	100.00	13.90	100.00	1.00	100.00
	SUB3	0.05	100.00	0.32	100.00	19.03	100.00	1.00	100.00

Source: Computed by the Author

Based on the actual statistics for all the measures of forecast accuracy, with the exception of MAE values for SUB2, the forecast performance of the EGARCH (1,1) model is not significantly different from other volatility models. However, particularly in relation to the MAE values under SUB2, the EGARCH model is resoundingly less accurate than GARCH (1,1) and TGARCH (1,1) models and the latter two models relatively have the same level of forecast performance. In quantitative terms, the relative statistics for MAE obtained from the GARCH (1,1) and TGARCH (1,1) models during SUB2 relative to EGARCH are 10.37% which was the least recorded and substantially lower than the second least value of 96.92% for GARCH-M (1,1) model during SUB1. Except for these trends, the relative statistics are essentially approximately 100% showing that the forecast performance of the EGARCH (1,1) model is more or less as accurate as other competing volatility models.

Table 10: Magnitude of Forecasting Accuracy Relative to EGARCH(1,1) Model

Dependent Variable: Exchange rate returns (r_t)

Model	Period	MAE (%)	RMSE (%)	MAPE (%)	TIC (%)
GARCH(1,1)	FS	0	0	0.03	0
	SUB1	1.54	0	-0.23	1.1
	SUB2	89.63	-0.9	0.04	0.1
	SUB3	0	0	0.03	0
GARCH-M(1,1)	FS	0	0	0.04	0.1
	SUB1	3.08	0	-0.56	0.7
	SUB2	-0.61	0	0.03	0.1
	SUB3	0	0.31	0.03	0
TGARCH(1,1)	FS	0	0	0.02	0
	SUB1	0	0	-0.18	1.1
	SUB2	89.63	0	0.02	0
	SUB3	0	0	0.01	0

Source: Computed by the Author

As presented in table 10, the magnitudes of forecasting also confirm the results in table 9. With the exception of MAE values for SUB2, the magnitudes of forecasting accuracy of the volatility models relative to EGARCH(1,1) reveal infinitesimal differences and in fact, in most cases were not different from zero, therefore, indicating that the forecasting performance of the EGARCH (1,1) model is not different from other models. However, under SUB2 and in relation to MAE, GARCH(1,1) and TGARCH (1,1) models were substantially more accurate than EGARCH(1,1) by 89.63%, while minimal differences were recorded for the other forecasting measures.

V5. Implications of Findings and Concluding Remarks

The paper provides empirical support for the arguments that flexible exchange rate regime under different democratic transitions may give substantially different volatility trends and may affect the choice of the modelling framework for such volatility. The domestic currency (*Naira*) relative to the US dollar has suffered large depreciations over the years, hence, the evidence of volatility in the exchange rate for all the samples studied. Three implications can be drawn from these findings:

(i) The behaviour of exchange rate tends to change over short periods of time with inconsistent leverage effects and permanent shocks. The TGARCH (1,1) model gives the best fit under SUB1 and SUB3, while the GARCH (1,1) is preferred under SUB2. While the variance processes under SUB1 and SUB2 were mean reverting, the shocks under SUB3 (the most recent period) seem permanent;

(ii) Applying one-model-fits-all approach for exchange rate volatility in Nigeria will yield misleading and invalid policy prescriptions.

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Structural Breaks in Some Selected WAMZ Macroeconomic Time Series

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Abstract

Anecdotal evidence shows that country-specific inflation has remained largely persistent and heterogeneous across the West African Monetary Zone (WAMZ). Uncertainty about the nature of inflation persistence often undermines regional convergence due to the asymmetric responses from monetary authorities. Consequently, the objective of this paper is to identify whether or not structural breaks exist in the price level of member countries. The paper uses the method of Lee and Strazicich (2003) with multiple breaks to identify if there were spurious rejections in the ADF tests of selected macroeconomic variables of WAMZ countries. The result fails to reject the existence of the null hypothesis of unit root for fifteen (15) variables and a second root for twenty (20) variables. With the exception of Ghana, the CPI for other member countries has a second root, indicating that inflation is explosive with hysteresis effect. This feature of inflation is associated with a similar structural dysfunction in other macroeconomic indicators, including the exchange rate, nominal gross domestic product, money supply and the lending rate. In other words, breaks in these fundamentals are important sources of persistence and hysteresis in the price level.

JEL Classification: C12, C22

Keywords: Structural breaks, unit root test, selected WAMZ macroeconomic data

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I. Introduction

Sequel to the creation of the West African Monetary Zone (WAMZ), the West African Monetary Institute was established in 2001 to carry out the necessary technical and preparatory work towards the realization of a monetary union, in particular, for the Anglophone countries. Eventually, the WAMZ article of agreement was acceded to by The Gambia, Ghana, Guinea, Nigeria and Sierra Leone. This was against the backdrop that the French speaking Francophone countries - the West African Economic and Monetary Union (UEMOA) already operates a single currency – the CFA. The WAMZ project was a direct result of the Fast Track initiative of ECOWAS to allow any 2 or more countries outside the UEMOA – largely Anglophone - to implement the region's economic and monetary integration programmes. It was envisaged that with these countries

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adopting the second currency in the sub-region, the two zones, i.e. WAMZ and UMEOA will merge into a single ECOWAS monetary zone. The four primary convergence criteria established for the WAMZ were: a single digit inflation; fiscal deficit to GDP ratio not exceeding 3 per cent; external reserves enough to cover at least three months of imports; and central bank financing of fiscal deficit should not exceed 10 per cent of previous year's tax revenue. In addition, other structural harmonization programmes have been put in place to enhance trade integration, financial integration and statistical harmonization, among others.

Over a decade of preparatory work, price levels in the zone are still characterized by significant volatility and persistence. There is enough evidence in the literature to suggest that persistence in the price level can result in negative implications in the efforts towards achieving low and stable inflation in the long run. Johansen (1992, pp. 313-334) stated that "Some time series such as the log of prices (P), have the property that even the inflation rate ΔP is nonstationary, whereas the second difference $\Delta^2 P$ is stationarity." Clements and Hendry (2003, p305) noted that 'shifts in deterministic terms (intercepts and linear trends) are the major source of forecast failure.' The works of Dornbusch (1976), Taylor (1979) and Ball (1993) clearly provides insight on the plausibility of dynamic inconsistency if the central bank operates on a path of loss function not fitted for example, with a stationary inflation.

The corollary is that if the price level is mean-reverting, very useful information can be obtained from the historical inflation path to generate forecasts. A random walk in the inflation data would therefore, imply that a shock to prices will be permanent. These concerns provide the intuition to investigate fundamental gaps yet to be articulated relating to structural breaks in the data which pose risks to monetary policy in the West African Monetary Zone (WAMZ) and nominal inflation convergence.

Recent studies on inflation dynamics in the WAMZ such as Essien, et al. (2007a, 2007b), Onwioduokit, et al. (2007), Kitcher, et al. (2007) and Abradu-Otoo and Doyina-Ameyaw (2007) have largely focused on country specific determinants and policy mix that will deliver single digit inflation. These analyses largely ignored issues of unit root with endogenous breaks.

This paper will draw lessons from the correlation between the breaks in the price level and those of the other variables in order to provide insights on the sources of structural change and persistence in the inflation rates. This paper is yet to find any recent contributions to the unit root debate with structural breaks determined endogenously in the price level data and other selected macroeconomic time series originating from the West African Monetary Zone.

An examination of the nature of structural breaks provides a clear understanding of the nature and extent of the long-run adjustment path of price levels for convergence and predictability of not only the loss function but also the forecast of inflation. An examination of the unit root with breaks properties of WAMZ price level and selected macroeconomic data deserves investigation as convincing evidence suggests that the non-stationarity of macroeconomic time series poses important implications for inflation convergence. Cochrane (1994) notes that the absence of mean reversion in real output 'challenges a broad spectrum of macroeconomic theories designed to produce and understand transitory fluctuations'.

The main aim of this paper, therefore, is to employ the method of Lee and Strazicich (2003a & b) test to examine the existence and significance of structural breaks in some selected macroeconomic series of some WAMZ member countries using quarterly data. In particular, the paper re-examines the validity of trend stationarity in the inflation rates of five (5) WAMZ countries using quarterly data. Identification of structural breaks within this time series produces a new evidence of the impact of integration arrangements, institutional and regulatory reforms since the commencement of the zone.

The paper is structured in five sections. Section 2 reviews some empirical literature on unit root analysis of WAMZ macroeconomic data. Section 3 presents the theoretical basis of the Lee and Strazicich (2003a & b) approach to unit root testing and data. Section 4 discusses the findings from the unit root testing, while section 5 concludes the paper.

II. Some Empirical Literature

Although several studies have shown that macroeconomic time series display some degree of stochastic non-stationarity, linear-based approaches to unit root testing have been shown to have a low power and considerable size distortions. Thus, linear tests such as the ADF, Phillip-Perron may fail to differentiate unit root processes from stationary processes that exhibit large persistence (Arize, 2011; Froot and Rogoff, 1995) and non-linearities (Arize, 2011). In studies on the WAMZ, the ADF and Phillips – Perron have become popular toolkits in unit root analysis, while the empirical literature on unit root testing with structural breaks on macroeconomic time series is sparse. Some of the recent literature point to potential weakness in the power of the test of linear framework to unit root testing. It will suffice to highlight a few of the studies that have characterized the recent unit root debate on macroeconomic time series.

Arize, et al. (2005) in a study of inflation and structural shift in fifty developing countries (including five African countries, namely Gabon, Ghana, Kenya, Mauritius and Morocco) using the fractional integration test of Geweke and Porter-Hudak (1983, GPH hereafter), the authors find that inflation can be modeled as a nonstationary variable.

Kumar, et al. (2011) in a study to evaluate the stability of the money demand function in Nigeria applied the ADF and Elliot-Rothenberg-Stock (ERS) tests on real money, real income, nominal rate of interest, real exchange rate and inflation rate over the period 1960-2008. This study finds for the ADF test that the unit root test under the null of no unit root in these variables cannot be rejected at the 5 per cent level (except for the inflation rate). However, the ERS test suggests that all the levels of the variables are non-stationary. Unlike the ADF test, the ERS test finds that the inflation rate is a non-stationary series.

In a related study, Chukwu, et al. (2010) investigated the presence of cointegration and structural breaks in the Nigerian long-run money demand function and finds that the Ng – Perron test for unit root suggests that the null hypothesis of a unit root in real money demand, real income, inflation and the spread between the lending and deposit rates in their levels cannot be rejected. However, the Ng – Perron test rejects the null that their first differences have unit roots.

In a recent study, Arize (2011) investigated whether the inflation rate is non-stationary or stationary using quarterly inflation rate data from thirty-four African countries. Using linear and non-linear techniques, the null hypothesis of a unit root in inflation rate in Africa could not be rejected. In particular, the non-linear KSS test validates the non-stationarity of inflation in more countries than the linear tests. For the DF-GLS, the null hypothesis of non-stationarity of inflation could not be rejected at the 5 percent level of significance in seventeen countries implying that inflation is non-stationarity in seventeen out of thirty-four cases (Angola, Cape Verde, Chad, Cote d' Ivoire, Egypt, Gambia, Ghana, Guinea-Bissau, Mauritius, Mozambique, Niger, Nigeria, South Africa, Sudan, Swaziland, Tanzania and Togo). Also, in four additional countries the results indicate inability to reject the null hypothesis of non-stationarity of inflation using the ADF test statistic but not by DF-GLS test statistic (Botswana, Kenya, Morocco and Rwanda). Applying non-linear tests, the null hypothesis of nonstationarity of inflation rate could not be rejected in seven more countries, using the AKSS test statistics but not the DF-GLS or ADF tests (Benin, Burkina Faso, Cameroon, Ethiopia, Gabon, Senegal and Seychelles).

III. Data and Methodology

WAMZ member countries are characterized by various forms of structural change including structural adjustments and financial liberalization reforms since attaining independence. If such structural changes are present in the data generating process, but not captured in the empirical estimation, a researcher may incorrectly conclude that the series under investigation has a stochastic trend. As a consequence of this, any shock —whether demand, supply, or policy-induced — to the variable will persist. Piehl, et al. (1999) notes that knowledge of breakpoint is centripetal to the accurate evaluation of any program intended to bring about structural changes; such as the tax reforms, banking sector reforms and regime shift.

In this paper, the method of Lee and Strazicich (2003a & b) would be applied to test for unit root hysteresis and persistence in the price level. The single and two-break LM unit root tests are robust as it is mildly affected by breaks under the null. The choice of Lee and Strazicich (see Strazicich, et al. (2004)) is imperative for allowing for structural changes under the unit root null hypothesis, as stochastic non-stationarity may lead to size distortions. The test also has the flexibility of identifying the number of breaks given the information asymmetry about specific breakpoints. The Lagrange Multiplier (LM) unit root test takes the following form:

$$y_t = \alpha^t M_t + e_t, \qquad e_t = \rho e_{t-1} + \varepsilon_t \tag{1}$$

where M_t consists of exogenous variables and ε_t is an error term that follows the classical properties. The LM unit root test allows for structural breaks in the spirit of Perron (1989). In the case of the model with one-break test, $M_t = [1, t, D1_t, DT1_t]$, and in the case of the model with two-break test, $M_t = [1, t, D1t, D2t, DT1t, DT2t]$, where $Djt = 1$ for $t \geq TBj + 1$, $j = 1, 2$, and $Djt = 0$ otherwise, where TBj represents the break date. Lee and Strazicich (2003a, b) use the following regression to obtain the LM unit root test statistic:

$$\Delta y_t = \alpha' \Delta M_t + \varphi \overline{s}_{t-1} + \mu_t \tag{2}$$

where $\overline{S}_t = y_t - \hat{\psi}_q - M_t \hat{\alpha}_t$, $t = 2,\ldots,T$; $\hat{\alpha}$ are coefficients in the regression of Δy_t on ΔM_t; $\hat{\psi}_q$ is given by $y_t - M_t \alpha$; and y_1 and M_1 represent the first observations of y_t

and M_t, respectively. The LM test statistic is given by $\bar{\tau}$ = *t*-statistic for testing the unit root null hypothesis that $\varphi = 0$. The location of the structural break (*TB*) is determined by selecting all possible break points for the minimum *t*-statistic as follows:

$$\text{In}f\,\tilde{\tau}\left(\tilde{\theta}_i\right) = \ln\ f_\theta \tilde{\tau}\left(\theta\right) \tag{3}$$

where $\theta = T_B / T$. The search is carried out over the trimming region (0.15*T*, 0.85*T*), where *T* is the sample size. Critical values for the one-break case are tabulated in Lee and Strazicich (2003a), while critical values for the two-break case are tabulated in Lee and Strazicich (2003b).

The sources of data are the statistical bulletin (various issues) of member countries and WAMZ Macroeconomic and Convergence Report (various issues) and the International Financial Statistics (IFS) of the International Monetary Fund (IMF). The key variables used in this paper on quarterly basis for the period 1980:1 to 2008:4 include the consumer price index (CPI), consumer price index excluding energy (CPIE), nominal gross domestic product (NGDP), real gross domestic product (RGDP),nominal exchange rate (NER), interest rate (LR) and money supply (BM). The quadratic linear sum was used to interpolate annual GDP into quarterly series given the paucity of quarterly data.

IV. Analysis of Results

With some degree of anticipation, given several economic crises, changes in institutional arrangements, policy changes and regime shifts in these countries, these macroeconomic variables are subject to structural breaks and probably, the ADF test is considered biased towards not rejecting the unit root at the first difference.

The time series properties of selected macroeconomic data for The Gambia, Ghana, Guinea, Nigeria and Sierra Leone are examined first by using the ADF test during the period 1980Q1-2008Q4. As expected, the null hypothesis of a unit root in all variables under investigation cannot be rejected at the 5 per cent significance level. The ADF test results are reported in tables 2, 4, 6, 8 and 10, while those with structural breaks are reported in tables 3, 5, 7, 9 and 11 for The Gambia, Ghana, Guinea, Nigeria and Sierra Leone, respectively.

Allowing for two structural breaks in the data, *k* is the optimal number of lagged first-difference terms included in the unit root test to correct for serial correlation. *TB1* and *TB2* denote the break dates. Critical values at different breakpoints for a sample size T = 100 are reported in Strazicich *et al.* (2003). Table 1 provides a summary result for the nature of the roots in the time series data with the test suggesting a unit root for fifteen (15) variables and a second root for twenty variables (20)[1].

A second root in the consumer price index confirms explosive path and hysteresis effect for inflation in the WAMZ which could lead to a complex challenge for monetary authority restoring inflation to its steady state level. This is evident for the inflation in all the member countries, except Ghana. In table 1, it can be discerned that the consumer price index is not a stationary series, and hence, inflation has a unit root. As a corollary to this, other plausible determinants of the price level, the BM, NGDP, RGDP and LR, also have a second root in inflation. It is intuitive to reason that any development that will introduce a shift or change in these variables, there will be an underlying hysteresis effect on the price level making inflation to be explosive.

Table 1: Roots in the Time Series Data for Five WAMZ Member Countries

Country	Second Root Null	Unit Root Null
The Gambia	NGDP, CPI, CPIE	ER, BM, RGDP, LR
Ghana	BM, LR	ER, NGDP, RGDP, CPI, CPIE
Guinea	BM, NGDP, RGDP, CPI, CPIE, LR	ER
Nigeria	RGDP, CPI, CPIE, BM, LR	ER, NGDP
Sierra Leone	ER, RGDP, CPI, LR	BM, NGDP,CPIE

Table 2: Results of unit root tests without structural breaks - The Gambia

Variables	ADF [k]
1 Nominal GDP	-3.21622[2]
2 Real GDP	-6.00504[2]*
3 Broad Money (M2)	-5.05208[2]*
4 Exchange Rate	-3.62462[2]**
5 Consumer Price Index (CPI)	-3.05300 [2]
6 Consumer Price Index (CPI) - Core	-3.10999 [2]
7 Maximum Lending Rate	-5.21362 [2]*

Linear trend included. For ADF test, critical values at 1%, 5% and 10% significance level are -4.04366, -3.45079 and -3.15051, respectively. * denotes statistical significance at 1% level. ** denotes statistical significance at 5% level. *** denotes statistical significance at 10% level.

[1] 7 variables for each of the 5 cross-sections – The Gambia, Ghana, Guinea, Nigeria and Sierra Leone

Table 3: Result of Lee and Strazicich with Multiple Break Test: The Gambia

Variables	a (t-statistics)	[k]	TB1 / TB2	t-statistics
Nominal GDP	-0.3837 (-4.6106)	[2]	1987:03	-3.6894
			2001:01	3.2933
Real GDP	-0.6219 (-6.7137)***	[2]	1984:01	-3.7979
			1986:03	-2.2337
Broad Money (M2)	-0.7491 (-7.4624)***	[2]	1993:03	-3.4498
			2002:01	1.8412
Exchange Rate	-0.5145 (-5.7092)**	[2]	1983:03	-5.3573
			2003:01	2.5025
Consumer Price Index	-0.4486 (-5.0700)	[2]	1985:03	2.8308
			1988:01	-3.6546
Consumer Price Index - Core	-0.3868 (-4.6745)	[2]	1987:02	-4.1755
			2001:04	1.2503
Maximum Lending Rate	-0.5755 (-6.2223)**	[2]	2002:03	3.5399
			2005:03	-0.4297

The critical values for Lee-Strazicich two break test are -6.32, -5.73 and -5.32 at 1 %, 5 % and 10% levels of significance, respectively. * (**) *** denote statistical significance at 10%, 5% and 1% levels, respectively.

The break dates characterising The Gambia's' time series data (Table 3) highlighted the control regime of the early 80s, while in 1993 there was significant weakness in the banking system and expansionary fiscal policy. The coup of 1994 led to a massive reduction in donor funds. The period 2002 – 2005 witnessed the depreciation of the exchange rate of The Gambian dallasi, high inflation and deceleration in economic output. This followed the economic structural adjustment under the IMF-ESAF that spanned 1998 to 2001.

Table 4: Results of unit root tests without structural break - Ghana

Variables	ADF [k]
1 Nominal GDP	-5.32493[2]*
2 Real GDP	-3.13500[2]
3 Broad Money (M2)	-3.99782[2]**
4 Exchange Rate	-3.91179[2]**
5 Consumer Price Index (CPI)	-5.27483 [2]*
6 Consumer Price Index (CPI) - Core	-5.89951 [2]*
7 Maximum Lending Rate	-5.08639 [2]*

Linear trend included. For ADF test, critical value at 1%, 5% and 10% significance level are -4.04366, -3.45079 and -3.15051, respectively.

Table 5: Result of Lee and Strazicich with Multiple Break Test - Ghana

Variables	a (t-statistics)	[k]	TB1 / TB2	t-statistics
Nominal GDP	-0.6149	[2]	1995:01	3.5740
	(-5.7106)**		1999:04	0.6978
Real GDP	-0.5243	[2]	1984:01	2.4050
	(-5.4779)*		1991:01	2.011
Broad Money (M2)	-0.4357	[2]	1989:01	-1.5280
	(-4.5207)		1992:01	2.7155
Exchange Rate	-0.7390	[2]	1984:01	-2.4894
	(-5.6368)*		1986:03	3.8018
Consumer Price Index	-0.5154	[2]	1986:03	-0.4188
	(-5.3825)*		1997:01	-1.5540
Consumer Price Index_ Core	-0.6520	[2]	1986:01	-0.4210
	(-6.3838)***		1993:04	-0.0932
Maximum Lending Rate	-0.5164	[2]	1995:03	-2.9179
	(-5.9270)**		2000:03	2.1361

The critical values for Lee-Strazicich two break test are -6.32, -5.73 and -5.32 at 1 %, 5 % and 10% levels of significance, respectively. * (**) *** denote statistical significance at 10%, 5% and 1% levels, respectively.

In the case of Ghana (Table 5), the economic downturn witnessed in the early 80s led to the collapse of the exchange rate following extensive liberalization and adoption of structural adjustment programmes. The economic crisis that characterized the economy between 1999 and 2001 resulted in substantial drop in donor funds leading to the subsequent adoption of the ESAF. The breaks in the early 1990s were mainly occasioned by economic reforms.

Table 6: Results of unit root tests without structural break - Guinea

Variables	**ADF [k]**
1 Nominal GDP	-3.15264[2]
2 Real GDP	-3.56392[2]**
3 Broad Money (M2)	-3.85998[2]**
4 Exchange Rate	-4.08453[2]*
5 Consumer Price Index (CPI)	-2.12184 [2]
6 Consumer Price Index (CPI) - Core	-2.28122 [2]
7 Maximum Lending Rate	-3.59782 [2]**

Linear trend included. For ADF test, critical value at 1%, 5% and 10% significance level are -4.04366, -3.45079 and -3.15051, respectively.

Table 7: Result of Lee and Strazicich with Multiple Break test: Guinea

Variables	a (t-statistics)	[k]	TB1 / TB2	t-statistics
Nominal GDP	-0.4617 (-5.0042)	[2]	1985:03	-1.1869
			1993:01	-3.1757
Real GDP	-0.4191 (-5.0988)	[2]	1989:02	-2.0646
			2002:03	-3.0796
Broad Money (M2)	-0.4568 (-5.0758)	[2]	1985:03	-1.0756
			1994:01	-2.3110
Exchange Rate	-0.4599 (-5.4129)*	[2]	1987:03	-3.5648
			2004:04	-3.4966
Consumer Price Index	-0.3346 (-4.1032)	[2]	1992:03	-2.5734
			2004:01	-0.6506
Consumer Price Index – Core	-0.2755 (-3.7751)	[2]	1990:03	-2.4633
			2003:04	2.1613
Maximum Lending Rate	-0.4392 (-5.2579)	[2]	1992:03	-4.5094
			2005:01	1.6244

The critical values for Lee-Strazicich two break test are -6.32, -5.73 and -5.32 at 1 %, 5 % and 10% levels of significance, respectively. * (**) *** denote statistical significance at 10%, 5% and 1% levels, respectively.

In Table 7, it can be discerned that structural and institutional issues were some of the challenges causing structural breaks in the time series data. Economic liberalization of the 80s, weak banking sector, political instability and declining donor funds are some of the major factors causing .structural breaks in the macroeconomic variables.

Table 8: Results of unit root tests without structural break - Nigeria

Variables	**ADF [k]**
1 Nominal GDP	-3.87141[2]**
2 Real GDP	-4.89358[2]*
3 Broad Money (M2)	-3.10460[2]
4 Exchange Rate	-4.04601[2]*
5 Consumer Price Index (CPI)	-2.67828[2]
6 Consumer Price Index (CPI) - Core	-2.78606[2]
7 Maximum Lending Rate	-5.54866[2]*

Linear trend included. For ADF test, critical value at 1%, 5% and 10% significance level are -4.04366, -3.45079 and -3.15051, respectively.

Table 9: Result of Lee and Strazicich Unit Root Test with Multiple Breaks - Nigeria

Variables	a (t-statistics)	[k]	TB1 / TB2	t-statistics
Nominal GDP	-0.6138	[2]	1995:04	-0.8551
	(-5.7098)*		1998:04	2.5386
Real GDP	-0.4276	[2]	1998:02	-0.5993
	(-5.1934)		2000:04	0.6329
Broad Money (M2)	-0.4422	[2]	1986:03	-1.0239
	(-4.6380)		1994:03	-4.0811
Exchange Rate	-0.5317	[2]	1990:03	-2.0900
	(-5.5771)*		1994:01	-4.7089
Consumer Price Index	-0.3976	[2]	1992:03	-0.9799
	(-4.4626)		1996:04	-2.0684
Consumer Price Index – Core	-0.4431	[2]	1991:03	-1.5331
	(-4.9270)		1996:01	-3.7719
Maximum Lending Rate	-0.5613	[2]	1993:03	-3.9006
	(-6.3476)***		1996:01	-0.1987

The critical values for Lee-Strazicich two break test are -6.32, -5.73 and -5.32 at 1 %, 5 % and 10% levels of significance, respectively. * (**) *** denote statistical significance at 10%, 5% and 1% levels, respectively.

Breaks in Nigeria's time series data (Table 9) were associated with economic adjustment in the mid-1980s and regime shift from control to indirect monetary policy implementation technique, 1991-1993, and thereafter. The exchange rate which was hitherto fixed was devalued and the banking crisis of the late 80s, 1994-1998 caused a break in the money supply and interest rate.

Table 10: Results of unit root tests without structural break - Sierra Leone

Variables	ADF [k]
1 Nominal GDP	-3.36494[2]
2 Real GDP	-2.45437[2]
3 Broad Money (M2)	-4.13408[2]*
4 Exchange Rate	-3.49463[2]**
5 Consumer Price Index (CPI)	-3.54935 [2]**
6 Consumer Price Index (CPI) - Core	-4.16223 [2]*
7 Maximum Lending Rate	-3.96257 [2]**

Linear trend included. For ADF test, critical value at 1%, 5% and 10% significance level are -4.04366, -3.45079 and -3.15051, respectively.

Table 11: Result of Lee and Strazicich Multiple Break Test - Sierra Leone

Variables	a (t-statistics)	[k]	TB1 / TB2	t-statistics
Nominal GDP	-0.7019 (-5.7842)**	[2]	1985:02	-1.5990
			1993:01	-3.7966
Real GDP	-0.4105 (-4.9023)	[2]	1995:03	-3.0223
			2001:01	-0.3795
Broad Money (M2)	-0.6538 (-5.8187)**	[2]	1989:04	-5.3079
			1994:04	0.6840
Exchange Rate	-0.4531 (-5.0025)	[2]	1985:04	-4.5831
			1989.02	-0.7528
Consumer Price Index	-0.5777 (-5.0794)	[2]	1986:02	-1.1122
			1992:03	-3.4061
Consumer Price Index – Core	-0.6996 (-6.0308)**	[2]	1985:03	-1.3517
			1992:01	-4.5546
Maximum Lending Rate	-0.5417 (-6.1282)**	[2]	1992:03	-4.4134
			1995:02	-1.0850

The critical values for Lee-Strazicich two break test are -6.32, -5.73 and -5.32 at 1 %, 5 % and 10% levels of significance, respectively. * (**) *** denote statistical significance at 10%, 5% and 1% levels, respectively.

Table 11 shows the break results for Sierra Leone. The country was hit by economic crisis in the early 80s and plunged into conflict in 1991 lasting up to January 2002. Within this period, the exchange rate and trade was liberalized. The impact of the conflict was worsened by the economic sanctions which trailed the 1997 coup following an initial restoration of peace. The exchange rate depreciated significantly and in the post-crisis era the country attained a Heavily Indebted Poor countries (HIPC) status by the end of 2006.

V. Conclusion

The paper offers prognostic insight on the presence of persistence and unit root hysteresis under structural breaks. The unit root testing with multiple breaks using the method of Lee and Stracizich (2003) is used to identify if there were spurious rejections in the ADF tests of the selected macroeconomic variables of WAMZ countries. The unit root test results with breaks fails to reject the existence of the null hypothesis of unit root for fifteen (15) variables and a second root for twenty (20) variables. With the exception of Ghana, the CPI for other member countries has a second root, indicating that inflation is explosive with hysteresis effect. This feature of inflation is associated with a similar structural dysfunction in other macroeconomic indicators, including the exchange rate, nominal gross domestic product, money supply and the lending rate.

Specifically, the results indicate that breaks in the consumer price level are associated with breakpoints in output, exchange rate, interest rate and money supply. In other words breaks in these fundamentals are important sources of persistence and hysteresis in the price level. Confirmatory results from a reverse hysteresis equation shows hysteresis to be a real inflation phenomenon in Ghana and Guinea. It is concluded that assuming away inflation persistence and breaks in the data can lead to sub-optimal outcomes for monetary policy as a means of achieving stable and low inflation.

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Social Determinants and Dynamics of Health Inequality in Nigeria

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Abstract

This paper sheds light on the social determinants of health inequality in Nigeria by quantifying the dynamic relationship between socioeconomic indicators and child anthropomorphic outcomes. Applying multivariate regression analysis and the Blinder-Oaxaca decompositions on recent demographic and health survey [DHS] data the study shows that bad health is disproportionately concentrated on the poor and some geopolitical zones of the country. Differences in wealth account for about 58.0 per cent and 33.0 per cent of differences in child nutritional and underweight status between the poor and nonpoor. Although improving over time, these differences suggest better targeted social policy reforms in the country.

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JEL Classification:I14, I15, J11,
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I. Introduction

This study analyses socioeconomic determinants of health inequality and how they account for changes in health inequality, focusing on child health in the six geopolitical zones in Nigeria. Health problem is one of the major challenges faced by many developing countries especially in the Sub-Saharan Africa. Unfortunately, Nigeria is ranked low in terms of health achievement especially in the area of child health. The observed inequality in mean child health across the six geopolitical zones of the country is quite substantial. Even though Nigeria has made progress in reducing child mortality and child malnutrition over the years, available statistics show that the country is still lagging behind compared to her peers. The patterns of health status in Nigeria mirror many other Sub-Saharan African (SSA) nations but are worse than would be expected given Nigeria's GDP per capita (Gustafsson-Wright, , et.al, 2008**)**. Figure1 shows the trend of Nigeria's under-5 mortality rate and those of other countries with data compiled from the United Nations database.

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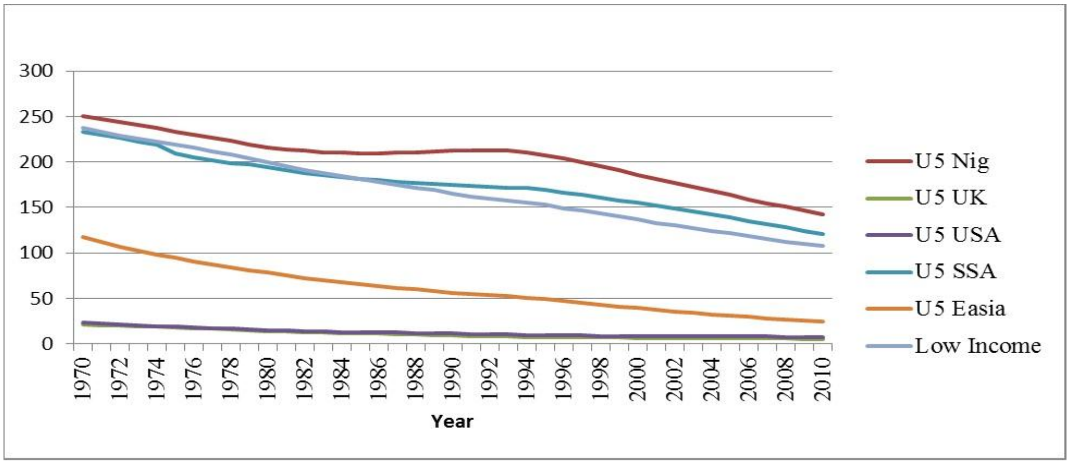
Figure 1: Dynamics of Under-5 Mortality Rate in Nigeria and Other Countries

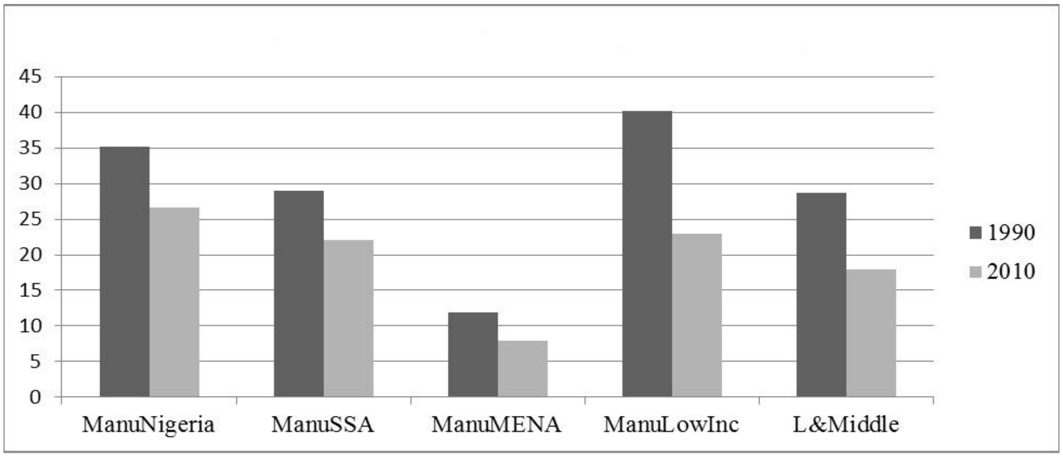


Source: United Nations Common Database and authors' computations

The figure1 above shows that under-5 mortality rate in Nigeria has been consistently higher than both the Sub-Saharan African (SSA) and low income country average since the 1970s, despite the downward trend. Again, compared to East Asian developing countries, the country is a worst performer. The East Asian countries are converging to the developed country average (for example, the United Kingdom (UK) and United States of America (USA)) under five mortality rate. Nigeria' mortality gap from the developed world is still as high as 147 deaths per 1000 as at 2010.

Figure 2 shows the rate of malnutrition for children between 0 and 5 years of age for the period 1990 and 2010. It can be seen from the figure that in 1990, Nigeria's under malnutrition rate was better than only the average of low income (ManuLowInc) countries. By 2010, the Nigerian under-5 malnutrition rate was worse than the average of low income countries. Compared to the Sub-Saharan (ManuSSA) and Low and Middle Income countries (L&Middle) average child malnutrition, Nigeria is still an under performer.

Figure 2: Malnutrition Rate for Children 0 – 5 Years in Nigeria and Country Groupings



Source: United Nations Common Database and authors' computations

However, Nigeria is a very large country with a population of over 150 million, in six geopolitical zones, 36 states, and 774 local government areas. It has over 200 ethnic nationalities with wide variations in geographical, cultural, socioeconomic compositions and historical tendencies which were amalgamated into one nation through colonial policy. It is hypothesized that these different compositions would lead to different health outcomes among the populations. Surprisingly, very little is known empirically about the extent these differences relate to health inequalities both within and across the six geopolitical zones in the country. Furthermore, urbanization in Nigeria is occurring rapidly but at different rates in different parts of the country. On average the percentage of the population living in urban areas is expected to rise from 42.0 per cent to 55.4 per cent by 2015. The country's population is largely young: the median age is 18.7 years and about 45.0 per cent of the population is under the age of 15 (Population Reference Bureau, 2007). The implication is that large differences in health status of the component populations if not addressed properly and early enough, could adversely affect the quality of human capital potential of the country and, hence, economic growth.

International literature has found large cross-country variations in health outcomes but cross-country results are unlikely to explain much about the determinants of health inequality in Nigeria given the different institutional and macroeconomic environments across countries. Moreover, existing literature differ on the determinants of health and health inequality. One strand of literature finds that health inequality is strongly and positively associated with income inequality and social stratification (Hill and Yazbeck, 1994; Galobardes, et al., 2006; Marmot et al., 1984; Marmot and Brunner 2005; Marmot, et al 1997; Kagamimori, et al, 2009; Chandola et al 2006; Wilkinson, 1999; Kim and Ruger, 2006; Wagstaff, 2002; Epstein, 2007; Cutler, et al 2008; Thomas, 2009, among others). Another strand of literature finds however, that there are controversial results about the hypothesis that an individual`s health depends not only on the individual's income but on the distribution of income (that is relative income) within where he resides (Judge, *et al* 1998; Smith, 2004; Wilkinson and Pickett, 2006; Seeman, *et al* 2008, among others). Yet another strand argues that it is health that determines social status which in turn affects health (for example Wagstaff, 2002; Chandola, *et. al*, 2005; Thomas, 2009, among others).

On the other hand, previous research in Nigeria has been focused on issues such as inequality in the provision of healthcare (Ibiwoye and Adeleke, 2008), the distributive effect of healthcare financing (Ichoku and Fonta, 2006; Ichoku , Fonta, and Onwujekwe, 2009), the demand for healthcare (Onwujekwe and Uzochukwu, 2005; Amaghionyeodiwe, 2008), inequalities in self-rated health (Ichoku et al, 2011), as well as on the macroeconomic analysis of population health (Omotor, 2009; Anyanwu and Erhijakpor, 2009). This study therefore provides a new insight into the empirical literature on the determinants of health in Nigeria by focusing on inequality in child health. In broad terms, the study ascertains if inequality in health outcomes in Nigeria can be explained by disparities in socioeconomic status (SES) of individuals. The study also ascertains if regional differences in health outcome are due to regional differences in SES and other factors and if such differences vary overtime. Hence, our study is unique in the sense that it focuses on zonal variations in health and conducted under a similar set of institutions and macroeconomic conditions using a recent demographic and health surveys dataset for Nigeria.

This paper is, therefore, structured into four sections. Section I is the introduction; section II deals with the methodology and data; section III deals with the presentation of results and discussions on findings; while the policy recommendations and conclusion are treated in section IV.

II. Methodology and Data

II.1 Theoretical Framework

This paper derives its theoretical framework from the social causation perspective theory of health inequality (Marmot, et. al, 1991, among others). This hypothesis suggests that the stress associated with low social position, such as exposure to social adversity and lack of resources to cope with difficulty, might contribute to the development of mood disorder which causes poor health. The theory argues that a positive relationship exists between socio-economic status and vulnerability to mood disorder, with high rates of vulnerability found among individuals with lower educational and social achievements. According to this theory, this causal effect of socio-economic status on health is likely to be mainly indirect, through a number of more specific health determinants which are differently distributed across socio-economic groups. One aspect of this theory emphasizes the effect of material factors (Link, Stueve, and Phelan, 1998) and posits that people who have more resources in terms of knowledge, money, prestige, and social connections are better able to avoid risk and to adopt protective strategies that are available at a given time in a given place. As a result, they have better health. This framework therefore, provides a useful guide for specifying our empirical model of health outcome as shown in equation (1), which includes individual's socioeconomic variables-education and income (or asset index which is the proxy for income), after controlling for other health variables.

II.2 Model Specification

Following from the framework described above we specify the empirical health outcome model as:

$$H_i = \alpha_o + \alpha_1 \text{VitmA} + \alpha_2 \text{safewater} + \alpha_3 \text{sanitation} + \alpha_4 \text{electricity} + \alpha_5 \text{child\_demo} + \alpha_6 \text{hhdemo} + \alpha_7 \text{region} + \alpha_8 \text{educ} + \alpha_9 \text{sector} + \alpha_{10} \text{asset\_index} + \alpha_{11} \text{year\_dum} + \mu \quad (1)$$

where :

H_i	=indicator for child nutritional status which in this study are negative of height-for-age (haz) and weight-for-age (waz) z-scores. The z-scores are multiplied by -1 so that positive coefficients increase child malnutrition while negative coefficients reduce it.
VitmA	= vitamin A available to the child at least two months after delivery
Safewater	= availability of safe drinking water
Sanitation	= availability of sanitary toilet
Electricity	= household has electricity
Child_demo	= child demographics-age, and sex
Hhdemo	= household demographics-age of head, gender of head
Region	=indicator variable for the six geopolitical zones in Nigeria
Educ	= maternal education level
Asset_index	= asset index (used as a proxy for household income or welfare)

We conducted our analyses with two widely used socioeconomic variables in the literature namely, education level of mother and household income (asset index).

Mothers with higher level of education are likely to have healthier children since they are better able to understand and apply health knowledge on the upbringing of their children. Also, education is likely to influence health knowledge and hence, drives health behaviour and thus, generates inequality in health outcome. Such mothers are more likely to adopt better diet for the family as well as avoid seeking health care among nonqualified practitioners. Better educated women know more about health and how to produce health efficiently through good habits (Grossman, 1972; Kenkel, 1991; among others). Income is also another variable in the SES vector which is likely to drive health knowledge and health behavior and hence, create disparity in SES and health.

II.3 Estimation Issues and Econometric Methodologies

We are aware of potential endogeneity problem between Health and SES. Poor health can lead to low SES, low SES can lead to adverse health outcomes, or a third variable determines both health and SES. The existence of a reverse causal relationship between health and income is well explained in an empirical work by Case (2002). In spite of the wide literature on the positive relationship between income and health, the reverse causality is subject to controversy (Salardi, 2007). The application of two-stage procedure helps in overcoming this problem although it seems difficult to find the right instruments where the residuals are not correlated to the health variable. Following Martin and Haddad (2006), we constructed a long-run indicator of wealth, using principal components analysis, to substitute the income variable because according to them, a long-run wealth or asset index is less exposed to reverse causality with health conditions.

II.4 Oaxaca-type Decompositions

In order to relate inequality in health outcomes to socioeconomic status variables, we applied the Oaxaca decomposition on equation (1). The Oaxaca decomposition (Oaxaca, 1973), explains the gap in the mean of an outcome variable between two groups. The gap is decomposed into that part that is due to group differences in the magnitudes of the determinants of the outcome in question, on the one hand, and group differences in the effects of these determinants, on the other.

The Oaxaca decomposition for any two groups say A and B (poor and non-poor, urban and rural, north and south), and an outcome variable Hi (height-for-age and weight-for-age z-scores), and a vector of predictors (including the constant), X (which are the regressors in equation (1) is described in the following equations. Following Jann (2008), the question Oaxaca decomposition tries to answer is how much of the outcome difference:

$$R = E(H_A) - E(H_B) \tag{2}$$

is accounted for by group differences in the predictors, where E(H) denotes the expected value of the outcome variable. Based on the linear model:

$$Y_\ell = X'_\ell \beta_\ell + \varepsilon_\ell, \quad E(\varepsilon_\ell) = 0, \quad \ell \in \{A, B\} \tag{3}$$

where β contains the slope parameters and the intercept, and ε is the error. Hence, the mean outcome difference can be expressed as the difference in the linear prediction at the group-specific means of the regressors. That is

$$R = E(H_A) - E(H_B) = E(X_A)'\beta_A - E(X_B)'\beta_B \tag{4}$$

since

$$E(Y_\ell) = E(X'_\ell \beta_\ell + \varepsilon_\ell) = \quad E(X'_\ell \beta_\ell) + E(\varepsilon_\ell) = \quad E(X'_\ell)'\beta_\ell$$

With $E(\beta_l) = \beta_l$ and $E(\varepsilon_l) = 0$ by assumption.

To identify the contribution of group differences in predictors to the overall outcome difference, equation 4 can be rearranged as follows:

$$\mathrm{R} = [\mathrm{E}(\mathrm{X_A}) - \mathrm{E}(\mathrm{X_B})]'\beta_\mathrm{B} + \mathrm{E}(\mathrm{X_B})'(\beta_\mathrm{A} - \beta_\mathrm{B}) + [\mathrm{E}(\mathrm{X_A}) - \mathrm{E}(\mathrm{X_B})]'(\beta_\mathrm{A} - \beta_\mathrm{B}) \tag{5}$$

This is a "three-fold" decomposition. That is, the outcome difference is divided into three parts:

$$R=E+C+I$$

The first component of equation (5) $E = [E(X_A) - E(X_B)]' \beta_B$, amounts to that part of the differential that is due to group differences in the predictors (the "endowment effect"). The second component $C = E(X_B)'(\beta_A - \beta_B)$, measures the contribution of differences in the coefficients (including differences in the intercept). The third component $I = [E(X_A) - E(X_B)]'(\beta_A - \beta_B)$, is an interaction term accounting for the fact that differences in endowments and coefficients exist simultaneously between the two groups.

The decomposition in equation (5) is formulated from the view point of Group B. That is, the group differences in the predictors are weighted by the coefficients of Group B to determine the endowment effect (E). In other words, the E component measures the expected change in Group B's mean outcome, if

Group B had Group A's predictor levels. Similarly, for the second component (C), the differences in coefficients are weighted by Group B's predictor levels. That is, the second component measures the expected change in Group B's mean outcome, if Group B had Group A's coefficients (Jann, 2008). Since the z-scores were multiplied by -1, negative coefficient in the Oaxaca decomposition results suggests that the variable reduces the gap in child nutritional status while a positive coefficient suggests the variable is widening child nutritional gap for the group of interest.

II.5 Decomposition of the Concentration Index

The Oaxaca decomposition can be used to explain socioeconomic related health inequality in the mean of health variable of interest between two groups such as the poor and the non-poor. On the other hand, decomposition of concentration index can help to measure and explain inequality in health across the entire distribution of some measure of SES. This is very useful for policy purposes. Wagstaff, et al (2003) demonstrate that the health concentration index can be decomposed into the contributions of individual factors to income-related health inequality, in which each contribution is the product of the sensitivity of heath with respect to that factor and the degree of income-related inequality in that factor. For any linear additive regression model of health (*y*), such as:

$$y = \alpha + \sum_k \beta_k x_k + \varepsilon \tag{6}$$

The concentration index for y, C, can be written as:

$$C = \sum_k \left(\frac{\beta_k \bar{x}_k}{\mu} \right) C_k + \frac{GC_\varepsilon}{\mu} \tag{7}$$

where μ is the mean of *y*, $\bar{x}_k$ is the mean of x_k, C_k is the concentration index for x_k (defined analogously to C), and $GC\varepsilon$ is the generalized concentration index for the error term (ε). Equation (7) shows that *C* is equal to a weighted sum of the concentration indices of the *k* regressors, where the weight for x_k is the elasticity of *y* with respect to x_k

$$n_k = \beta_k \frac{\bar{x}_k}{\mu} \tag{8}$$

The residual component of equation (6) reflects the inequality in health that cannot be explained by systematic variation across income groups in the x_k. Thus equation (6) shows, that by coupling regression analysis with distributional data, the causes of inequality can be partitioned into inequalities in each of the x_k. The decomposition also shows how each determinant's separate contribution to total income-related health inequality can be decomposed into three parts: (i) its effect on health (βk), (ii) its mean in the population (k_x) and (iii) its association with income rank (C_k). As such, the method therefore not only allows us to separate the contributions of the various determinants, but also to identify the importance of each of these three components within each factor's contribution.

II.6 The Data

The data used in the study were secondary data from the Nigeria Demographic and Health Surveys (DHS) for 2003 and 2008 which were designed to provide estimates of population and health indicators for Nigeria as whole, urban and rural areas, and the six geo-political zones. Representative probability samples of 7,864 and 36,000 households were selected for the 2003 and 2008 NDHS surveys, respectively. The sample was selected using a stratified two-stage cluster design consisting of 365 clusters for 2003 and 888 clusters for 2008 and enumeration areas were developed from 1991 and 2006 population census frame, respectively. In the second stage, a complete listing of households was carried out in each selected cluster. An average of 21 and 41 households was respectively selected in every cluster in 2003 and 2008 by equal probability systematic sampling. All women aged 15-49 and all men aged 15-59 who were residents of the households were interviewed. From the DHS data, we constructed the indicators of child health used in this study which are: nutritional status measured by height-for-age and weight-for-age z-scores, calculated for children less than 10 years according WHO (2006) methodology.

III. Results and Discussions

The results are presented in the appendix. Tables 1, 2 and 3 are the summary statistics, while tables 4 and 5 show the Oaxaca decompositions of determinants of health inequality. Tables 6 and 7, respectively, show the decomposition of health concentration index and variations in nutritional status by geopolitical zones.

III.1 Summary Statistics by Socioeconomic Status and Zones

Tables 1, 2 and 3 show the summary statistics of health-related variables (standard deviations in parenthesis) by wealth index, education level of mother and geopolitical zones respectively. Table 1 shows that households at the tail end of wealth distribution on the average have lower access to safe drinking water, have poor sanitary toilet, and have low level of completed education of mother. Also, the poorer the household, the worse the average health of children less than 10 years measured by stunting and underweight and the less likely would the household have access to health infrastructure measured by average intake of vitamin A up to two months after delivery. Table 2 shows that on the average, households with better educated mothers have higher access to safe-drinking water, are less exposed to unsafe toilet, and have higher average income measured by the wealth index. With better educated mothers, average child health is higher, that is the likelihood of stunting and underweight is lower and access to health infrastructure increases. Table 3 shows that the northern geopolitical zones on the average have lower average health-related inputs such as safe drinking water, sanitary toilet and access to vitamin A compared to the southern geopolitical zones. The tables also indicate that the northern zones as a group have poor socioeconomic status and have poor average child health measured by the prevalence of malnutrition in the area. This is shown clearly in table 7.

III.2 Oaxaca Decomposition Results

Tables 4 and 5 show Oaxaca decompositions of Height-for-age (HAZ) and Weigh-for-age (WAZ) z-scores, respectively, for the poor and nonpoor in the first four columns and for the north and south in the last four columns of each table. For the poor and nonpoor Oaxaca decompositions, wealth index, regional factors, and access to safe drinking water as well as child demographics have significant endowment effects on child health inequality as shown in column 3 of table 4. Education level of mother has no significant endowment effect on child nutritional gap between the poor and nonpoor but has significant coefficient effect as shown in column 4 of table 4. However, maternal education has significant effect in the prevalence of child underweight between the poor and nonpoor households as shown in column 3 of table 5. Wealth differential accounts for about 58 per cent of nutritional gap between the poor and nonpoor children measured by HAZ and also accounts for about 33 per cent of why the poor children have disproportionately higher share of underweight in the population measured by WAZ as shown in column 3 of tables 4 and 5, respectively. Hence, differences in asset ownership between the poor and nonpoor households act to widen child health inequality in favour of the nonpoor. Again, table 5 shows that differences in educational levels account for about 12.6 per cent of the observed differences in higher prevalence of underweight among children of the poor compared to nonpoor children. Table 4, column 4 shows that effective utilization of education of mother to obtain maximum health benefit explains about 23.0 per cent of child nutritional gap between the poor and nonpoor.

Regional characteristics explain about 9.4 per cent of the nutritional gap and 18.9 per cent of underweight gap as shown in column 3 of tables 4 and 5 respectively. Child demographics account for -2.0 to -3.0 per cent of outcome difference. This means that being a female child reduces inequality in child health outcome between the poor and nonpoor by between 2.0 and 3.0 per cent (see column 3 of table 4 and 5). The year dummy contributes 1.5 per cent and this is statistically significant, implying that, inequality in nutritional status (HAZ) between children born in poor households and those born in nonpoor households increased by 1.5 per cent between 2003 and 2008 while inequality in the prevalence of underweight (WAZ) among children of the poor over the same period decreased by 0.7 per cent as shown in column 3 of tables 4 and 5 repectively. Access to safe drinking water has significant endowment and coefficient effects which act to reduce child nutritional inequality (measured by HAZ) between the poor and nonpoor. Living in rural area increases nutritional inequality due to knowledge gap between the poor and nonpoor by about 59.8 per cent while the effect of rural residence on WAZ as shown in table 5 is not significant.

For the North and South, health gap difference shown in column 6 of table 4 and 5 is statistically significant and the decompositions into the various contributing factors are shown in columns 6,7,8,and 9 of tables 4 and 5,.Table 4 shows that access to safe drinking water, wealth index, availability of vitamin A at least up to two months after delivery, child and household demographics as well as place of residence have significant endowment and coefficient effects as shown in colums 7 and 8. Income gap (difference in asset index) between the northern and southern geopolitical zones increases inequality in child nutritional status by about 16.2 per cent (column 7 of table 4) and increases inequality in child underweight by about 9.30 per cent (column 7 table 5). Income has significant coefficient effect which reduces inequality due to differences in characteristics of north and south by about 39.0 per cent. Availability of vitamin A reduces child nutritional gap by 5.83 per cent between the north and south. Access to safe drinking water reduces the nutritional gap between the north and south by about 3.81 per cent and effective utilisation of safe drinking water to obtain maximum health benefits reduces child nutritional gap between the North and South by about 20.8 per cent as shown in columns 7 and 8 of table 4. Effect of education on child health inequality between the north and south is not significant.

III.3 Decomposition of Concentration Index

Table 6 shows the concentration index of height-for-age z-score for children less than 10 years for 2003 and 2008 and its decomposition into various contributing factors. Overall, the negative values of the concentration index indicate that poor health (in this case malnutrition) is disproportionately concentrated on the poor in both time periods. However, the results show that health inequality between the poor and nonpoor reduced in 2008 (the value of the index in absolute terms is smaller in 2008). For example the concentration index was -0.0726 in 2003 and became -0.0414 in 2008. We further decomposed the concentration index into various contributing factors as reported in the table.

Negative values of concentration index imply more concentration of bad health on the poor. Positive contribution of a variable to concentration index means the variable reduces the concentration of bad health on the poor whereas negative contributions imply the variable increases concentration of bad health on the poor. Elasticities measure the extent of sensitive of the concentration index on a particular variable. The results show that the concentration index was very sensitive to child demographic characteristics such as the age and gender, household characteristics such as the gender of the household head, education, access to electricity and place of residence because of their high elasticity coefficients. The results show that in 2003 there was high inequality in the asset index to the advantage of the rich. Access to safe drinking water, electricity, good toilet facilities and availability of vitamin A to a child at least two months after delivery are tilted to the advantage of the nonpoor. Inequality in education is also disproportionately concentrated on the rich. In 2008, wealth related inequality was still very high and again disproportionately concentrated on the rich. Inequality in education and sanitary toilet declined sharply in 2008, while there were slight declines in inequality in access to electricity, safe drinking water, availability of vitamin A, and residence as well as in child demographics. These declines contributed to the decline in the overall concentration index for child malnutrition in 2008.

The percentage contribution of each variable to the overall concentration index is shown in the last column for each year. We see that child age, asset index, place of residence, and access to electricity contributed more positively to the concentration index. In essence, their impacts widened the observed health inequality in 2003. On the other hand, access to safe drinking water, sanitary toilet, education level, and zonal factors contributed more negatively to concentration index. In 2008, the percentage contribution to the concentration index by the wealth variable increased to about 32.8 per cent while the percentage contribution of access to electricity became negative implying access to more electricity is very likely to reduce health inequality between the poor and nonpoor. The percentage contribution of zonal factors to concentration index was highly negative in 2003 but became highly positive in 2008. This implies that the reduction in inequality in the malnutrition we observed between 2003 and 2008 may partly be attributed to the reduction in the gaps in zonal characteristics or returns to those characteristics.

The concentration curves as depicted in figure 3 and figure 4 in the appendix show the pattern of distribution of the prevalence of malnutrition over time and within each geopolitical zone. Looking at the curves we could not see dominance of one curve over another but the concentration indices in figure 5 indicate that in 2003 the degree of health inequality was higher than in 2008 but this was largest in the South East. This means that malnutrition was more disproportionately concentrated on the poor in 2003 than in 2008 and that this disproportionate degree of concentration was more in the south east in 2003 and 2008 compared to any other zone. However, the south east does appear to have on the average better population nourishment compared to other zones but the distribution of health in the zone was highly unequal. However in 2008 we saw an overall improvement in the distribution of health across all zones. However, the South East still has more disproportionate concentration of health on the poor compared to the other zones. This again has important implication for policies that target both improvement in mean health and its distribution in the population.

Table 7 shows the distribution of the prevalence of malnutrition across the six geopolitical zones and across socioeconomic groups. Based on the World Health Organisation (WHO) classification of population degree of malnutrition we are able to rank the degree of malnutrition across all groups. As the table shows there is strong evidence of high to very high degree of malnutrition among the population and very limited degree of medium degree of malnutrition and this varies across the zones. For example, the percentage of children under 10 years that were malnourished 2003 in the North East and North West was respectively 47.0 per cent and 61.0 per cent; and 26.8 per cent and 43.3 per cent of those children being severely exposed to malnutrition, respectively, in the same year. In the North Central, 34.3 per cent of children less than 10 years were moderately malnourished, while the 15.6 per cent were severely malnourished. Thus, there were very high cases of both moderate and severe malnutrition in all the zones but the figures show it was worst in the North than in the South in both 2003 and

2008. However, in 2008, we observed that the degree of malnutrition of less than 10 year olds began to worsen in both the North and South.

IV. Recommendations and Conclusion

One policy recommendation from our findings is that specific interventions are needed to improve the welfare level of individuals especially the poorest groups most of whom are found in the north-east and north-west. One of such interventions is the provision of basic education for women and making it affordable. Women education is vital for effective utilization of health information and healthcare to raise a healthy family. Hence, giving women greater opportunities to be formally educated would improve health outcome and also reduce health inequality across all groups. Another key recommendation from our findings is that income generating activities in the private and public sectors should be created. The government could achieve this by supporting the private sector with soft loans and providing the basic infrastructure such as electricity so that small scale enterprises could be run at sustainable costs. This is important because policies that improve income or welfare conditions of the population especially the poorest group will be effective in improving the mean health of this group. In other words, more inclusive growth is needed to ensure that income plays dual role in household and individual health namely, improving mean health and reducing health inequality across all groups. Interventions are needed to improve health and other basic infrastructure and educating people on the utilization. Providing basic amenities such as safe drinking water and sewage systems by the government will be very effective in reducing health inequality between the rich and the poor in all the six zones of the country. However, it is also important that extensive education of the people on the utilization of these amenities for better health should be carried out through mass literacy campaigns and public enlightenment not by using the mass media alone but by sending community health workers to educate the people from time to time. This is necessary because it is not uncommon to see people that have access to good drinking water but drink rain water or from well.

Socioeconomic variables are important determinants of both the mean health and the distribution of health in the population. Furthermore, to the socioeconomic factors, child demographics and regional endowments also play significant roles in explaining health discrepancies observed in the population. These findings are consistent with some empirical works done in many countries but one key finding of the study that is different from other studies is that much of the zonal gap in child mean health outcome in Nigeria are accounted for not by socioeconomic endowments but by knowledge gap in the utilisation of those endowments to produce better health. For Nigeria to move closer to the health related MDG targets, specific actions, as we have recommended, should be taken to influence child health outcome positively.

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Appendix

Table 1: Summary Statistics of the Health Variables by Wealth Index

Variable	poorest	poorer	middle	richer	richest	Total
safe dri_water	0.128	0.236	0.303	0.500	0.724	0.339
	(0.334)	(0.425)	(0.460)	(0.500)	(0.447)	(0.473)
safe toilet	0.217	0.357	0.359	0.444	0.786	0.400
	(0.412)	(0.479)	(0.480)	(0.497)	(0.410)	(0.490)
educlevel Mother	0.300	0.477	0.809	1.280	1.955	0.854
	(0.583)	(0.698)	(0.850)	(0.898)	(0.830)	(0.950)
stunting	0.536	0.515	0.472	0.390	0.313	0.461
	(0.499)	(0.500)	(0.499)	(0.488)	(0.464)	(0.498)
underweight	0.397	0.338	0.263	0.202	0.131	0.285
	(0.489)	(0.473)	(0.440)	(0.402)	(0.337)	(0.451)
received vitamin A	0.0847	0.132	0.234	0.346	0.545	0.238
	(0.278)	(0.339)	(0.423)	(0.476)	(0.498)	(0.426)

Table 2: Summary Statistics of the Health Variables by Education Level of Mother

	no education	primary	secondary	higher	Total
safe drinking water	0.259	0.311	0.467	0.637	0.339
	(0.438)	(0.463)	(0.499)	(0.481)	(0.473)
safe toilet	0.381	0.318	0.442	0.757	0.400
	(0.486)	(0.466)	(0.497)	(0.429)	(0.490)
wealth index	2.013	2.795	3.716	4.620	2.726
	(1.063)	(1.264)	(1.222)	(0.703)	(1.397)
stunting	0.538	0.440	0.362	0.271	0.461
	(0.499)	(0.496)	(0.480)	(0.445)	(0.498)
underweight	0.394	0.224	0.159	0.105	0.285
	(0.489)	(0.417)	(0.365)	(0.307)	(0.451)
received vitamin A	0.101	0.264	0.422	0.565	0.238
	(0.302)	(0.441)	(0.494)	(0.496)	(0.426)

Table 3: Summary Statistics of the Health Variables by Geopolitical Zones

	north central	north east	north west	south east	south west	south south
safe dri_water	0.248	0.260	0.338	0.491	0.379	0.484
	(0.432)	(0.439)	(0.473)	(0.500)	(0.485)	(0.500)
safe toilet	0.353	0.327	0.521	0.416	0.314	0.413
	(0.478)	(0.469)	(0.500)	(0.493)	(0.464)	(0.492)
Educlevel Mother	0.928	0.447	0.326	1.502	1.552	1.531
	(0.940)	(0.761)	(0.691)	(0.830)	(0.750)	(0.889)
wealth index	2.783	2.039	2.280	3.325	3.365	3.829
	(1.353)	(1.165)	(1.225)	(1.265)	(1.247)	(1.273)
stunting	0.481	0.483	0.567	0.292	0.378	0.348
	(0.500)	(0.500)	(0.496)	(0.455)	(0.485)	(0.477)
underweight	0.229	0.359	0.432	0.138	0.149	0.144
	(0.420)	(0.480)	(0.495)	(0.345)	(0.356)	(0.351)
received vitamin a	0.266	0.133	0.0856	0.359	0.381	0.492
	(0.442)	(0.339)	(0.280)	(0.480)	(0.486)	(0.500)

Table 4: Blinder-Oaxaca Decompositions of Child Nutritional Status (Malnutrition) using Height-for-Age Z-score for Children<10

	Poor and Nonpoor				North and South			
	Differential	Endowments	Coefficients	Interaction	Differential	Endowments	Coefficients	Interaction
Prediction_1	2.283***				2.113***			
	(0.000)				(0.000)			
Prediction_2	1.753***				1.279***			
	(0.000)				(0.000)			
Difference	0.530***				0.834***			
	(0.000)				(0.000)			
vitamin A		0.0144	-0.0497	0.0350		-0.0583**	-0.253***	0.162***
		(0.530)	(0.411)	(0.411)		(0.049)	(0.000)	(0.000)
safe dr_water		-0.0453*	-0.236***	0.150***		-0.0381**	-0.208***	0.0752***
		(0.100)	(0.001)	(0.001)		(0.046)	(0.001)	(0.002)
good_sanitation		0.00370	0.0899	-0.0401		-0.00312	0.0851	0.00674
		(0.862)	(0.201)	(0.201)		(0.434)	(0.139)	(0.170)
has electricity		-0.0950	0.115	-0.104		-0.0135	0.133	-0.0635
		(0.191)	(0.435)	(0.435)		(0.761)	(0.246)	(0.246)
child_demo		-0.0267**	0.547**	-0.020***		-0.00378	0.726***	-0.0033
		(0.012)	(0.012)	(0.008)		(0.664)	(0.002)	(0.722)
hhold_demo		0.00649	-0.361	0.000508		-0.0209	-1.227***	0.0936***
		(0.172)	(0.257)	(0.947)		(0.216)	(0.000)	(0.000)
region		0.0940**	-0.269**	0.0752				
		(0.016)	(0.028)	(0.221)				
education		0.0528	0.230**	-0.164**		0.0957	-0.0779	0.0518
		(0.234)	(0.029)	(0.046)		(0.301)	(0.136)	(0.622)
Rural Resid		0.00553	0.598**	0.171**		-0.0142	0.754***	0.0786***
		(0.892)	(0.041)	(0.041)		(0.489)	(0.004)	(0.004)

wealth index		0.582***	0.618	-0.386		0.162*	0.0195	-0.00663
		(0.001)	(0.173)	(0.173)		(0.054)	(0.948)	(0.948)
Y=2008		0.0154***	10.02	0.000948		-0.00285	27.04	-0.000501
		(0.004)	(0.903)	(0.903)		(0.222)	(0.756)	(0.761)
Total		0.607***	0.203	-0.280		0.103	0.337***	0.394***
		(0.000)	(0.397)	(0.292)		(0.297)	(0.000)	(0.000)
Constant			-11.10				-26.66	
			(0.892)				(0.760)	
Observations	16660				16660			

p-values in parentheses $^{*}p< 0.10$, $^{**}p< 0.05$, $^{***}p< 0.01$

Table 5: Blinder-Oaxaca Decompositions of Child Nutritional Status (Malnutrition) using Weight-for-Age Z-score for Children<10

	Poor and Nonpoor				North and South			
	Differential	Endowments	Coefficients	Interaction	Differential	Endowments	Coefficients	Interaction
Prediction_1	1.420***				1.309***			
	(0.000)				(0.000)			
Prediction_2	0.729***				0.400***			
	(0.000)				(0.000)			
Difference	0.691***				0.909***			
	(0.000)				(0.000)			
vitamin A		0.0369***	0.0586	-0.0412		0.0393**	0.0173	-0.0111
		(0.007)	(0.117)	(0.117)		(0.039)	(0.663)	(0.663)
safe dri_water		-0.0143	0.0368	-0.0234		0.00314	0.0907**	-0.033**
		(0.379)	(0.392)	(0.393)		(0.797)	(0.026)	(0.027)
good_sanitation		-0.000567	-0.0333	0.0149		-0.00202	0.0525	0.00416
		(0.964)	(0.439)	(0.439)		(0.430)	(0.148)	(0.178)
has electricity		-0.0110	-0.0126	0.0114		-0.0150	0.0445	-0.0212
		(0.798)	(0.890)	(0.890)		(0.600)	(0.538)	(0.538)
child_demo		-0.0201***	0.591***	-0.00548		-0.00392	0.183	0.00384
		(0.003)	(0.000)	(0.264)		(0.521)	(0.213)	(0.481)
hhold_demo		-0.000404	-0.211	0.00135		0.00211	-0.269	0.00916
		(0.885)	(0.279)	(0.770)		(0.845)	(0.191)	(0.550)
region		0.189***	0.0406	0.0561				
		(0.000)	(0.595)	(0.137)				
education		0.126***	-0.0618	0.0547		0.0737	-0.0439	0.244***
		(0.000)	(0.338)	(0.281)		(0.215)	(0.175)	(0.000)
Rural resid		0.0324	0.0137	0.00391		0.0124	0.0593	0.00618
		(0.180)	(0.940)	(0.940)		(0.349)	(0.713)	(0.713)
wealth index		0.328***	-0.130	0.0809		0.0930*	-0.390**	0.132**
		(0.002)	(0.643)	(0.643)		(0.085)	(0.037)	(0.037)
Year=2008		-0.00659**	78.40	0.00742		0.00138	58.02	-0.00107
		(0.032)	(0.119)	(0.126)		(0.275)	(0.289)	(0.387)
Total		0.659***	-0.129	0.160		0.204***	0.371***	0.333***
		(0.000)	(0.389)	(0.330)		(0.001)	(0.000)	(0.000)
Constant			-78.82				-57.39	
			(0.117)				(0.295)	
Observations	16660				16660			

p-values in parentheses $^{*}p< 0.10$, $^{**}p< 0.05$, $^{***}p< 0.01$

Table 6: Table Decomposition of Concentration Index for Height-for-Age Z-scores of Children<10 Years, Nigeria, 2003 and 2008

Variable	2003				2008			
	Elasticities	Concindex	Contrib	%Contrib	Elasticities	Concindex	Contrib	%Contrib
Child age	0.858	-.0315	-.0271	0.373	.3857	.025	.01	-.231
Agesq	-.3291	-.0562	.0185	-.255	-.223	.043	-.01	.231
Male Child	-.1366	.0013	-.0002	.0024	-0.275	.002	-.001	.012
Asset Index	-.0305	.6108	-.0186	.257	-.0228	.594	-.0136	.328
Vitamin A	-.0133	.1783	-.0024	.0326	-.0086	.197	-.0017	.0413
male HH Head	-.1256	-.0060	.0008	-.0104	.0274	-.023	-.0006	.0153
Age HHH	.0460	-.0227	-.001	.0144	-.005	-.013	.0001	-0.002
Urban Residence	.262	-.094	-.0247	.3400	.0189	-.087	-.0016	.0395
Electricity	-.1833	.2785	-.0511	.704	.0294	.273	.0080	-.1941
Safe water	.0053	.2620	.0014	-.019	-.0062	.227	-.0014	.0342
toilet	.0029	.1108	.0003	-.005	-.0238	.284	-.0068	.1631
Education	.1999	.0125	.0025	-.035	.0175	.005	.0001	-.002
Zones			.0445	-.6133			-.0129	.3113
Residual			-.0155	.2135			-.0105	.2536
Total			-.0726				-.0414	

Table 7: Prevalence of Malnutrition (Stunting and Underweight) by Zones and Year

Groups	Year and Heath Indicator							
	2003				2008			
	Mean	SD	% below -2SD	% below -3SD	Mean	SD	% below -2SD	% below -3SD
Zones								
North Central	-1.238	2.3158	34.33	15.61	-2.2156	3.7319	48.58	32.7
North East	-1.739	2.3937	47.01	26.77	-2.0499	3.2829	50.76	35.07
North West	-2.4814	3.2529	61.16	43.32	-2.4019	3.8233	56.83	40.7
South East	-1.0741	2.771	26.98	16.55	-1.0518	3.6867	29.02	16.63
South West	-0.8694	2.7342	26.76	11.34	-1.8085	3.8572	38.18	23.83
South South	-1.0045	2.7447	31.03	12.9	-1.3051	3.1289	35.17	18.74

Figure 3: Concentration Curves of Negative of WAZ Z-scores for Children < 10 Years by Zones

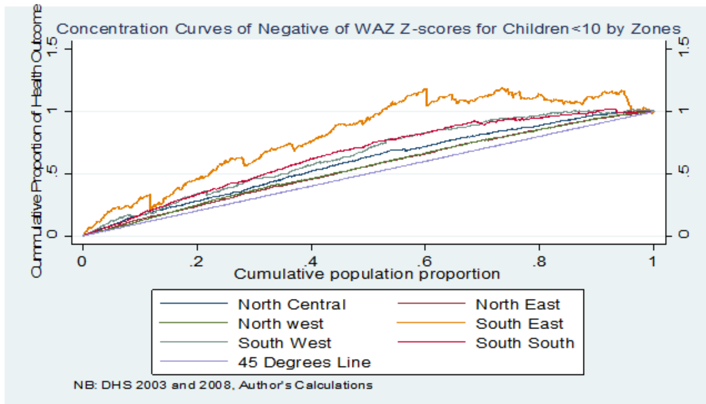


Figure 4: Concentration Curves for HAZ for Children < 10 Years by Zones

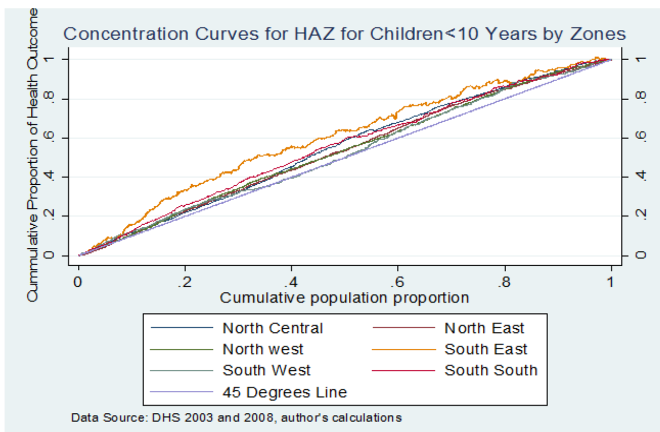
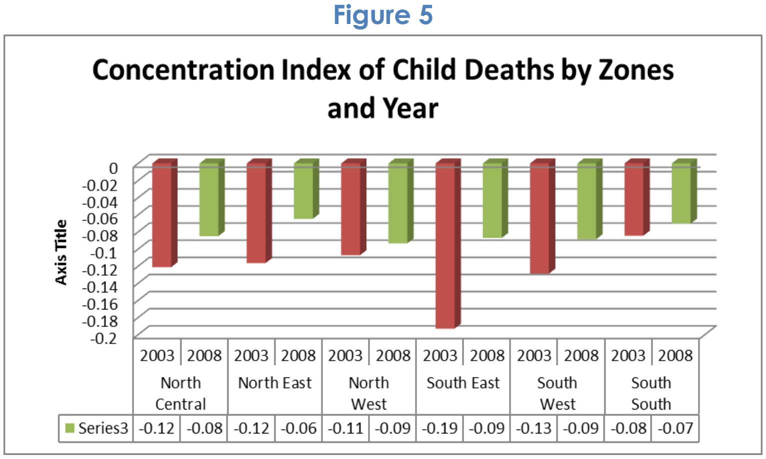


Figure 5



Demand For International Reserves: A Case For Reserves Accumulation In Nigeria

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Abstract

This paper examined the determinants of international reserves holding in Nigeria, where a huge amount of foreign reserves is necessary to ensure good macroeconomic policy and international credit worthiness. Adopting a dynamic modeling approach combined with the Mizon-Richard encompassing test, both precautionary and mercantilist motives explain holding of foreign reserves in Nigeria. Specifically, the current account variability and past levels of external reserves drive reserve holding in the short run. In the long run, the former and the money supply are significant determinants. Therefore, enhancement of exports through support for quality and competitiveness of non-oil exports are key to reserves management.

Keywords: *External reserves, Cointegration, Buffer stock model, Mercantilist motive, Error correction (ECM),*

JEL Classification: F31.

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I. Introduction

The need to finance current account deficits makes the stability and stockpiling of external reserves imperative. In the absence of foreign reserves, balance of payment deficits would have to be corrected through a reduction in aggregate expenditure, imposing macroeconomic adjustment costs manifested in sharp contractions of investment and consumption, thereby inducing recessionary pressures. According to the Guidotti-Greenspan rule of thumb of the 1990s, countries should hold liquid external reserves equal to their foreign liabilities due within a year. Foreign reserves accumulation has high economic and social costs, including a high opportunity cost of low returns on reserve assets, losses due to domestic currency depreciation, and forgone gains from investment and social expenditure that could be financed by external reserves. Therefore, there is a need for monetary authorities to have a better understanding of the determinants and economic costs of external reserve accumulation and de-accumulation in order to design optimal external reserves management strategies to minimize these costs.

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Nigeria, since 2004, experienced phenomenal growth in foreign exchange reserves partly due to rising crude oil prices in the international market occasioned by instability and regional conflicts and increasing global demand for oil, especially from China[1]. With macroeconomic stabilization at the forefront of national economic policymaking, the need for Nigeria to hold adequate level of foreign reserves is perceptively imperative; at least to retain the flexibility to borrow from abroad and also hedge against the volatility in external capital flows.

This paper seeks to analyze the determinants of international reserves in Nigeria. External sector vulnerability and the need for external and internal balance in a developing economy like Nigeria provoke the need for adequate predictions of foreign reserves behaviour.[2] Adequate knowledge and understanding of the determinants and dynamics of external reserves in a country-specific manner not only ensures sustainable stability and confidence in the economy, it is also essential for more informed successful and efficient macroeconomic policy design and implementation. Most studies on international reserves were focused on panel or cross-country analyses (Ball and Reyes (2006); Cheung and Ito (2007); Elhiriaka and Ndikumana (2007); Parent and Gosselin (2005); Aizenman and Lee (2005); Sehgal and Sharma (2008); Frenkel and Jovanovic (1981); Lane and Burke (2001); Aizenman and Marion (2002); Kenen and Yudin (1965); Kelly (1970); Iyoha (1970)).

Of these, only few accounted for the time series properties of the response of the determinants of international reserves (Sehgal and Sharma (2008); Khan and Ahmed (2005); Ford and Huang (1994); Badinger (2004)). Generally, the models adopted in these studies focused on either the monetary, buffer stock or mercantilist approaches. Also, none of these studies focused on Nigeria and data used for most of the cross-country studies did not include Nigeria's data. This paper modestly attempts to bridge these gaps by specifying a model that incorporates behavioural characteristics embedded in the precautionary, mercantilist and monetary approaches as well as examining the time series characteristics of the data with a view to minimizing spurious regression that

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[1] Over-reliance on crude oil for over 90 per cent of Nigeria's foreign exchange earnings makes its capital account susceptible to international crude oil price fluctuations. This has been further exacerbated by high import bills that have contributed to the level of fluctuations in reserves over the years.

[2] Overall, greater exposures of developing countries like Nigeria to sudden stops and reversals of capital flows, growing trade openness, and the desire to improve competitiveness and to reduce real exchange rate volatility go a long way towards accounting for the observed increase in the rapid and massive stockpiling of international reserves (Aizenman, 2007)

characterize less rigorous econometric techniques. The rest of the paper is organized as follows. Section 2 reviews related theoretical, methodological and empirical literature on factors influencing the demand for international reserves while section 3 presents a brief trend analysis of external reserves and some general causal factors. Modeling issues are addressed in section 4, while in section 5, the results of the time series characteristics of the data, the encompassing tests, and long and short run econometric estimates are presented and discussed. The paper is concluded in section 6.

II. Review of Literature

The determinants of international reserves are implicitly explored in the literature on adequacy of reserves, cost of reserves, optimality of reserves, and demand for international reserves, among others. Theoretically, the Keynesians argue that individuals demand cash to transact daily for purchases of goods and services and as a contingency against unforeseen circumstances/expenditures as well as a store of wealth. In contrast, classical monetary theory in the Cambridge cash balance approach had argued that individuals will need money for transaction purpose only, but modern monetarism is of the view that the demand for money is no longer a function solely of interest and income but also that of the rate of return on a much wider spectrum of physical and financial assets. The basic analytical approach of most studies on international reserves is the equivalence of the transaction, precautionary and speculative motive for holding cash balances either by individuals or countries holding foreign reserves (see Keran (1971) and Landell-Mills (1989)). Moreover, the transaction and speculative motives are important for an individual economic unit but plays no role in the decision of monetary authorities regarding the optimal portfolio. The precautionary motive dominates the latter's decision to hold certain stocks of liquid assets (Heller, 1966). Keran (1971) indeed argued forcefully for the equivalence of the precautionary motive for holding international reserves. In the same vein, the motives for holding reserves appear identical to those of holding money domestically, though there are important distinctions. Whatever the motive for holding reserves, the central bank ultimately wants to earn income from placement of the reserves (Obaseki, 2007).

Over 90 per cent of Nigeria's foreign exchange inflows and outflows are denominated in the United States (US) dollar (Usman, (2005), Tella (2007), Obaseki (2007)) as its crude oil receipts and other non-oil exports are invoiced in the US dollar while most of its obligations such as external debt service and foreign exchange market intervention are carried out with the US dollar and require some level of reserves depletion. This suggests that Nigeria's external reserves act as a buffer against unforeseen exigencies (See Nda, 2006). This is contrary to another popular explanation for the high level of reserves, that is, export competitiveness, and which draws strongly from the mercantile perspective, as a development strategy. Moreover, Dooley et al(2004) have argued that reserve accumulation reflects the intervention of Asian central banks who want to prevent their currency from appreciating against the U.S. dollar in order to promote export-led growth.

Sehgal and Sharma (2008) suggested that the cost of holding excess reserves in India was quite high and stood at about 4.75 and 3.50 per cent of GDP in 2004-05 and 2005-06, respectively. They analyse a demand function for India reserves holding and in the function include the sensitive part of the capital account and monetary disequilibrium with the traditional determinants of reserves. They made use of cointegration and VECM approach on Indian quarterly data and find evidences for both precautionary as well as mercantile motives behind holding reserves in India.

Frenkel and Jovanovic (1981) applied the inventory theoretic framework which follows from the precautionary motive for holding reserves to model external reserves holding behaviour. Heller (1966) on the other hand theorizes that external reserves demand is essentially an inventory control problem, in which case reserves serve as buffer stocks accumulated in times of abundance and depleted in times of scarcity. Thus, a country's holding of international reserves is negatively related to its marginal propensity to import (MPI). Many theoretical works on international reserves rely on the buffer stock model to guide their specification, Frenkel and Jovanovic (1981), Lizondo and Mathieson (1987), Parent and Gosselin (2005) and Flood and Marion (2002) while the precautionary framework links reserves accumulation directly to exposure to sudden shocks, capital flight, and volatility; the mercantilist approach views foreign reserves accumulation as a residual of an industrial policy, a policy that may impose negative externalities on other trading partners (Aizenman and Lee, 2005). The thrust of the mercantilist motive is to save foreign reserves in a bid to reduce or prevent appreciation of the domestic currency, with the ultimate goal of increasing export-led growth.

An alternative perspective relies on the monetary approach to balance of payments and relates changes in international reserves to changes in money demand. Edward (1984), Elbadawi (1990) and Elhairaika and Ndikumana (2007) used this framework. Aizenman and Lee (2005), compare the importance of precautionary and mercantilist motives in the hoarding of foreign reserves in developing countries. They provide empirical evidence that shows the superiority of the precautionary motive over the mercantilist motive and argue that theoretically, large precautionary demand for international reserves arises as self-insurance to avoid costly liquidation of long term projects when the economy is vulnerable to sudden shocks.

Empirically, using a cross country regression for 29 less developed countries (LDCs) in 1970, Iyoha (1976) examined the determinants of international reserves holding by the monetary authorities of less developed countries and found that the opportunity cost variable[3] is a vital determinant of foreign reserves holding. Landell-Mills (1989) in an empirical study of the relationship between international reserves and their opportunity cost showed that a country's reserves holding is sensitive to the rates at which they can borrow at the international financial markets. The author also found that international borrowing cost were highly significant determinants of reserves holding particularly before 1982 for the group of countries that were to face debt difficulties. Ben-Bassat and Gottlieb (1992) in an empirical study of the effects of opportunity cost on international reserves holding on Israel during the period 1968–1988 found that if measured correctly, opportunity cost played a pivot role in determining reserves.

A review of Nigeria's foreign reserves management showed that the country's reserves have been managed over the years by correspondent banks abroad as well as reputable international investment companies (Obaseki, 2007). He goes further to conclude that apart from the exchange rate mechanism, other factors influence the design of a framework for reserves management in Nigeria such as the state of the money market and balance of payments. Lane and Burke (2001) examined the cross-country variations in the level of international reserves over the period 1981 – 95 and found that trade openness is the most important of all the variables they considered. The authors also provided evidence that financial deepening is correlated with an increase in reserves ratio and indebted developing economies tended to have small reserves ratios.

Flood and Marion (2002) estimated optimal reserves holdings for countries under various monetary regimes and found that in a world with high capital mobility, interest rates were weakly significant and not robust in explaining reserves holdings. However, Ball and Reyes (2006) argued strongly against such findings, and thus carried out a two stage least square analysis due to the endogeneity of interest rates and international reserves under fixed exchange rate regimes to

[3] The opportunity cost variable is a measure of the other benefits which could have been accrued if external reserves were not saved and/or used for other purposes.

buttress the importance of interest rates. They showed that interest rate was statistically significant in their specification.
Badinger (2004) estimated Austria's demand for international reserves over the period 1985:1-1997:4, tested for short-run effects of the disequilibrium on the national money market and found that Austria's long-run reserves demand exhibited a stable function of imports, uncertainty and the opportunity cost of holding reserves with strong economies of scale. Aizenman and Marion (2003, 2004) investigated the interpretation of relatively high demand for international reserves in the Far East (emerging Asia) and the relatively low demand by some other developing economies (e.g. Africa and Latin America). They found that reserves holding over the period 1980 – 1996 was a function of some key factors such as the size and volatility of international transactions, exchange rate arrangement, political corruption, and external borrowing. Their model specification showed that sovereign risk, costly tax collection to cover fiscal liabilities and loss aversion led to relatively large build-up of reserves.

Abdullateef and Waheed (2010) examine the implication of investment, inflation and exchange rate for Nigeria's external reserves holding using ordinary least squares (OLS) and vector error correction (VEC) and found that changes in reserves influence foreign direct investments and exchange rates but found no influence on reserves over domestic investments and inflation rates. Choi, et al (2007) examined the interaction between capital flows and international reserves holding within the context of increasing financial integration and found that capital flows had a negative relationship with external reserves for advanced economies while the responsiveness of reserves to capital flows was fuelled by the rapid spate of globalisation for emerging market economies.

Using panel data from 21 African countries, Elhiraika and Ndikumana (2007) examined the causes and economic implications of reserves accumulation with emphasis on the impact of exchange rate, inflation, public and private investment. They empirically showed that accumulation was not just driven by portfolio choice or stabilisation objective, but African countries, especially those endowed with natural resources, needed to adopt a more pro-growth approach to external reserves management. Similarly, Parent and Gosselin (2005) estimated a long-run reserves demand function in a panel of eight Asian emerging-market economies and provided evidence of a positive structural break in the demand for international reserves by Asian central banks in the aftermath of the financial crisis of 1997–98. Their result also showed that the actual level of reserves accumulated in 2003–04 was still in excess relative to that predicted by the model. According to the author, empirical research on international reserves establishes a relatively stable long-run demand for reserves based on a limited set of explanatory variables. However, the authors opined that the determinants of reserves holdings reported in the literature can be grouped into five categories: economic size, current account vulnerability, capital account vulnerability, exchange rate flexibility, and opportunity cost which form the basis for their empirical specification.

Sehgal and Sharma (2008) analysed the demand function for India's reserves holdings with a large number of variables using time series analysis (co-integration and vector error correction mechanism) on Indian quarterly data and found that most of the variables used in the study had significant impact on reserves demand in India. Similarly using time series techniques, Khan and Ahmed (2005) with quarterly data of Pakistan over the period 1982:1 – 2003:2 sought to determine the long and short run determinants of external reserves holding in Pakistan and found that there existed a stable long run reserves demand. In the short run, reserves responded positively to the variations in the balance of payments and negatively to its own lagged changes and, thus, concluded that variations in balance of payments played an important role both in the short and long run.

Obstfeld, et al (2008) attempted to provide reasons for the rapid accumulation of reserves in emerging market economies in recent times by investigating the empirical determinants of reserves growth in a broad panel of developing, emerging and advanced economies. Their analysis showed that there had been a statistically robust and economically significant correlation of reserve levels (reserve/GDP) with financial openness (a measure of cross-border capital mobility), financial development (proxied by M2/GDP), and exchange rate policy. Trade was statistically significant but foreign debt was not. In all, the explanatory variables in the foreign reserves behaviour/movement models were somewhat similar but differ markedly in the adopted proxies to measure some of the variables, whether cross-sectional or country-specific.

The major methodological techniques used in estimating the reserves equations were ordinary least square (OLS) adopted by Iyoha (1976) with distributed lag; Landell-Mills (1989) with pooled cross-section; Ben-Bassat and Gottlieb (1992) with autoregressive processes; Burke and Lane (2001) with heteroscedastic consistent standard errors. Two stage least square (2SLS) employed by Ball and Reyes (2006), panel data were used by Elhiraika and Ndikumana (2007) and time series analysis using ARIMA were employed by Heller and Khan (1978); Ford and Huang (1994) with ECM; Badinger (2004) with vector error correction method; Jo (2007) with co-integration and error correction model; Sehgal and Sharma (2008) with co-integration and vector error correction mechanism; and Khan and Ahmed (2005) with vector error correction.

III. Trend of Nigeria's External Reserves and its Determinants

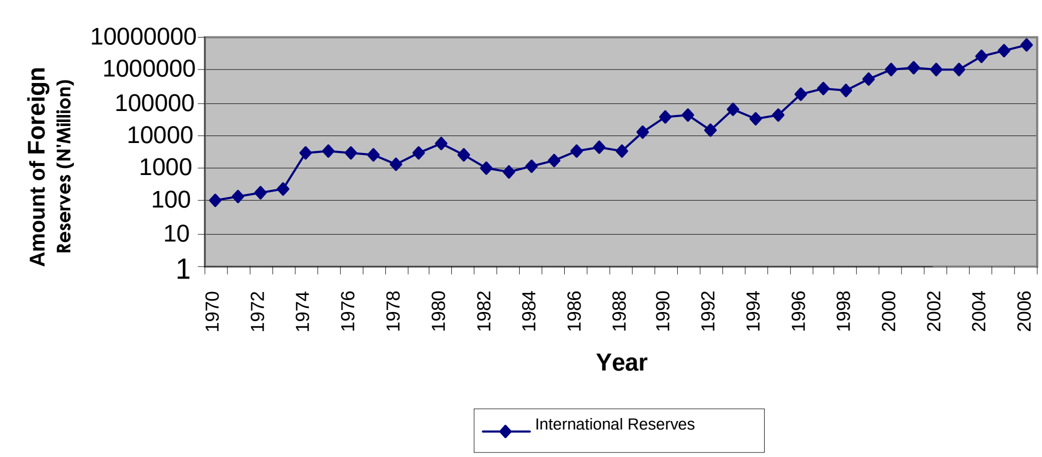
The global economic meltdown of 2008/2009 affected Nigeria's external sector. This was reflected in the substantial depletion of reserves, sudden withdrawal of portfolio capital by investors and a dwindling trade balance induced by the global crude oil price shock. As at the end of 2009, external reserves stood at USD42.4billion which was equivalent to about 18 months of import cover. This was in excess of the stipulated target of 6 months of import cover under the West African Monetary Zone (WAMZ) convergence criteria.

Following weak demand for Nigeria's export, external trade slowed, with the oil sector particularly affected during the period as crude oil exports fell by 32.9 per cent, as the price of Nigeria's reference crude (Bonny Light) fell precipitously from an average of USD101.15 per barrel to USD62.08 per barrel (CBN, 2009). In addition to this, reserves decumulation during the period was also induced by capital outflows even as direct investment remained stagnant between 2008 and 2009. Crude oil export earnings have persistently dominated the revenue-expenditure profile of Nigeria. In addition to increased oil revenue earnings occasioned by rising global crude oil price, higher degree of openness to capital inflows have resulted in the gradual accretion of international reserves. However, prolonged oil glut added to the growing current account deficits and subsequent economic turbulence experienced in the 1980s. There was a dramatic change from 1999 as external reserves took an upward trend occasioned by sustained current account surpluses which continued to subdue the deficit in the capital accounts; positive terms of trade shocks as a result of higher global crude oil prices; fiscal discipline; and resilience of monetary policy actions (CBN, 2009).

The number of months of import equivalent used to assess the adequacy of external reserves holding increased from about 8 months in 1999 to an all-time high of about 23 months in 2006 before moderating to approximately 22 months in 2007. By 2008 and 2009, Nigeria's reserves chest could only finance about 17 months of import mainly due to the global financial crisis which affected exports and disrupted capital inflows. It is pertinent to note that accumulation of reserves also accelerated as foreign debt service obligations fell. For instance, external debt stock which stood at over US$20 billion as at 2005 fell sharply to about US$3 billion in 2005. This period coincides with the period during which reserves holding rose by over 80 per cent from US$28 billion in 2005 to US$42 billion in 2006.

Two phases alternately marked by reserves accumulation and depletion that have occurred contemporaneously with the major oil price shocks and other domestic imbalances over the period of 1970-2007. During 1970 – 71, 1973 – 75, 1979 – 80, the net performance of the external sector resulted in the accumulation of foreign reserves; on the other hand, during the periods 1972, 1976 – 78, and 1981 – 82, Nigeria experienced severe balance of payments crisis culminating in a rapid depletion of external reserves. As a result of the boom-bust cycle, Nigeria's earnings from petroleum exports fell from over US$25.0 billion in 1980 to US$6.4 billion in 1986. In recent times Nigeria is envisaged to produce approximately 2,000,000 barrels per day but barely meets its OPEC quota due to the instability and persistent crisis in the Niger-Delta which disrupt crude oil extraction. Also, persistent and unprecedented rise of international crude oil prices in addition to robust domestic indicators like downward trending and/or single digit inflation, stable exchange rate, low fiscal deficits and debt stock, sustained growth in domestic output, positive current account balance due to macroeconomic fundamentals like internal reforms have led to phenomenal growth in external reserves position from a meager US$0.15 billion in 1970 (equivalent of 1.7 months of import cover) to US$4.99 billion in May 1999. By 2002, the foreign reserves stood at US$7.7 billion. The external reserves level rose to US$43.5 billion in 2006 (equivalent to 28.4 months of import cover). The gross reserve as at end December 2007 stood at over US$51billion and increased to over US$63 billion as at August 2008.

Figure 1: Trend of External Reserves in Nigeria



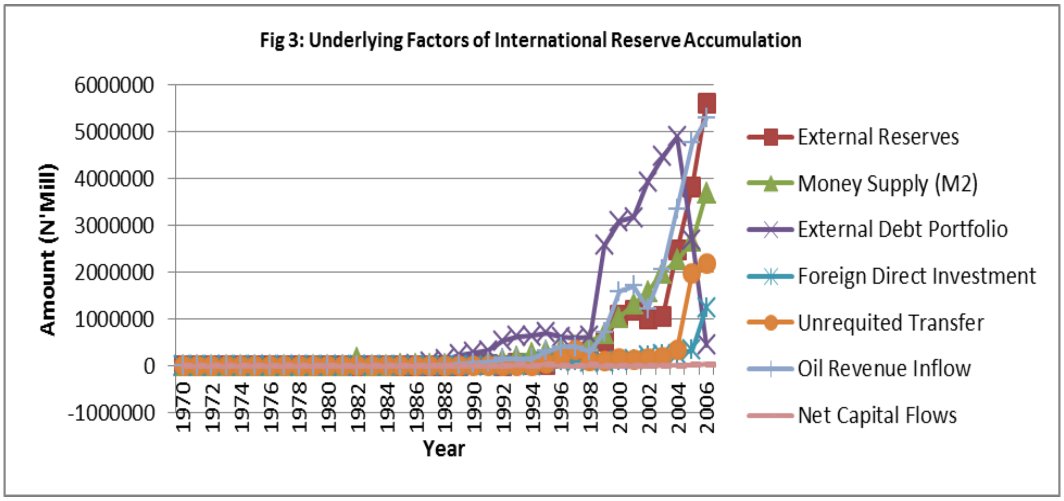
Source: CBN Statistical Bulletin (2006)

Figure 2 shows the months of import cover which is a veritable indicator of measuring reserves adequacy. The trend mirrors that of reserves shown in figure 1. Between 1980 and 1994, only 5 of the 15 year sample met the conventional (and WAMZ minimum requirement) measure of reserves adequacy with respect to its ability to finance 4 to 6 months of import. However, from 1996 to 2006, the government has surpassed the West African Monetary Zone (WAMZ) minimum requirement of six months.

External reserves assumed a sharp rise in the 1973-1974 periods due to the first oil price shock influenced by the oil embargo in October 1973. The 1980s and particularly 1983 represent the period of the oil glut which reduced oil export earnings and thus reserves. The period was also characterized by external indebtedness. Increase in oil exports in the 1990s raised external reserves holdings to levels higher than in the 1970s and 1980s. The trend of external reserves in the 1990s was relatively stable except for 1992 which saw a sharp decline from N44.25 billion in 1991 to a mere N13.99 billion and there from rose sharply to N67.25 billion. Since 1999, external reserves witnessed a relatively stable and gradual pile up attributable to the tight fiscal stance of government and the reduced debt service burden induced by the debt relief.

Figure 3 depicts the trend of oil revenue, global remittances, growing foreign direct and portfolio investments capital inflows, guarantees and grantas sources of international reserves accumulation. Oil revenue earnings assumed an upward trend in 2002, debt portfolio dropped from over US$35bn in 2004 to about US$3.5 in 2007 while foreign direct investments and portfolio capital inflows induce an increase in foreign reserve accumulation, remittances inwards have also added significantly to external reserves holding especially since year 2004.

Capital inflows into Nigeria have a tremendous effect on reserves accumulation even as foreign direct investment (FDI) dominates the mix. FDI inflows increased from N624.5 billion in 2006 to N759.4 billion and N460.2 billion respectively, in 2007 and 2008 but it rose by 24.4 per cent to N572.5 billion in 2009. As from 2000, the Nigerian economy witnessed a remarkable increase in portfolio investments to an all-time high of N360.3 billion in 2006 but fell by 7.7 per cent to N332.5 billion in 2007. The consolidation of the banking sector in 2004 led to a surge in foreign portfolio investment in the form of bonds and equity as a result of the initial public offerings by the deposit money banks and liberalization of the money markets which permitted foreign investors to invest in treasury bills for at least a year. As at 2009, the banking sector still had the dominant share of imported capital with about 49.5 per cent of the total.



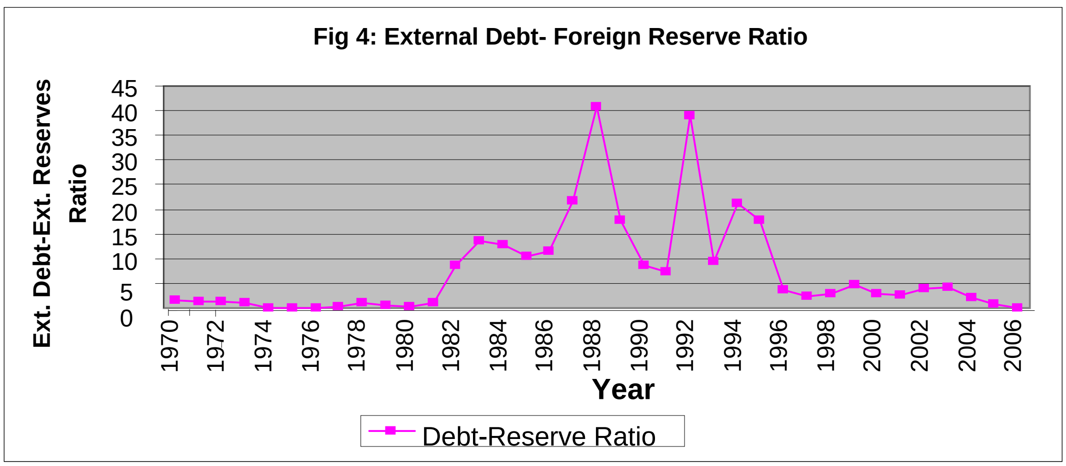


Figure 4 above depicts the external debt to foreign reserves ratio otherwise referred to as the Guidotti-Greenspan rule. The trend shows that between 1982 and 1996 the ratio has increased rapidly due to the loans obtained in the 1980s especially in 1986 to finance the structural adjustment programme (SAP). This led to declining foreign exchange reserves due to debt servicing obligations. With the successful negotiation with the Paris and London club, Nigeria was able to secure debt relief which has reduced the pressure on reserves as observed in the trend of external debt to reserves ratio. Countries may need to hold reserves more than their short-term debt due to many reasons, for example, differences in macroeconomic fundamentals; the structure and quality of private risk management and financial sector supervision; the exchange rate regime; and the size and currency composition of the country's external debt.

IV. Analytical Framework

This paper tests three competing models of external reserves holding using encompassing technique to determine which model best explains international reserves holding behaviour of the country's central bank. This is justified by the fact that the three motives enunciated by the models have been applied in Nigeria's reserves holding at different times, which may have spilled the effect of a particular holding motive to another period when that motive may have given way to another. This technique has the advantage of revealing which motive is superior and has the most significant impact on the economy. The final specifications of the buffer, mercantilist and monetary reserves holding models are stated respectively as follows: [4]

The Buffer Stock Model: $lnR^* = \alpha_0 + \alpha_1 \ln\sigma + \alpha_2 \ln r + e$ (1)

The Mercantilist Model: $IR = \beta_o + \beta_1 GRRE + \beta_2 RER + \beta_3 TOT + \mu$ (2)

Monetary Model: $R = k_0 + k_1 PL + k_2 RDI + k_3 DBH + k_4 Mss + e$ (3)

where, in equation (1), R* is external reserves, σ and r are the standard deviation of reserve increment, and opportunity costs of holding reserves, respectively. In equation 2, IR is external reserves, GRRE is the growth rate of real exports, RER is the real exchange rate and TOT is the terms of trade. In equation (3), R is reserves, PL is the price level (proxied by CPI), RDI is real domestic income (proxied by real GDP), DBH is domestic bond holding, and Mss is domestic money supply. *α, β, k and m* are parameters of the three international reserve holding models.

The thrust of the encompassing principle pioneered by Mizon (1984) and Mizon and Richard (1986) is to ascertain whether a maintained model can explain the features of its competitors. It is a non-nested test based on the principle that a model should account for the salient features of different and perhaps rival models. The use of this test, unlike the orthodox arbitrary model selection approach, provides an empirical basis for selecting a model from a group of competing models. It also discerns between coefficient variation that is not explained by the model at hand and coefficient that is. In addition, the encompassing test is sensitive to data nuances or distinctions. The encompassing

[4] See Frenkel and Jovanovic (1981) for the Buffer Stock model, and Lee (2005) and Gab-Je Jo (2007) for the Mercantilist model; and Khan and Ahmed (2005) and Elhairaika and Ndikumana (2007) for the Monetary model.

test is carried out by first estimating the joint model which includes all the regressors from the three models. Accordingly, synchronising these models following Mizon (1984) and Mizon and Richard (1986) gives the following nested model:

$$R = C + \sum_{1=0}^{n} \alpha_i y_i + \sum_{1=0}^{n} \beta_i z_i + \sum_{1=0}^{n} \lambda_i x_i \tag{4}$$

Where y_i denotes the set of regressors, $(\alpha_i, \beta_i, \lambda_i)$ represents the coefficients for all i=0,…,n. Notice that equation 4 encompasses equations 1, 2 and 3 but these equations (1, 2 and 3) do not nest or encompass one another. If the model represented by equation 1 is correct, $\alpha_1 = \alpha_2 = 0$ whereas if the model represented by 2 is correct, $\beta_1 = \beta_2 = \beta_3 = 0$. Lastly, if the model represented by equation 3 is the correct one, $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0.\, a_1 = a_2 = a_3 = a_4 = 0$.

IV.1 Unit root test

The Augmented Dickey Fuller (ADF) and Phillips Perron (PP) tests are used to test the stationarity of the variables. For the ADF, the null hypothesis is that the variables being considered have unit root against an alternative that they do not. The ADF model is specified below:

$$\Delta y_t = \alpha_0 + \alpha_1 T + \gamma y_{t-1} + \beta_i \sum_{i=1}^{p} \phi_t \Delta y_{t-1} + \mu_t \tag{5}$$

$$\phi_t = -\sum_{k=t+1}^{p} \gamma_k \quad \text{and} \quad \gamma = \left(\sum_{i=1}^{p} \gamma_i \right) - 1 \tag{6}$$

Where y_t is the variable being considered, T is the time trend (allowed only if significant), and μ_t is a random error term. The Schwarz Information Criteria (SIC) is used to select the lag length (p) after testing for first and higher order serial correlation in the residuals. The lagged variables controls for possible autocorrelation of the residuals.

The Phillips Perron (PP) test uses models similar to the Dickey Fuller tests but employs the Newey and West (1994) non-parametric method to control for possible autocorrelation rather than the inclusion of lagged variable method employed in the ADF test. The Phillips-Perron test is computed based on estimation of the non-augmented Dickey-Fuller test denoted by equation 8, and modifies the t-ratio of the coefficient of the lagged dependent variable so that autocorrelation does not influence the asymptotic distribution of the test statistic.

$$\Delta y_t = \alpha y_{t-1} + x_t'\delta + \epsilon_t \qquad (7)$$

Where x_t' are optional exogenous regressors, α and δ are parameters to be estimated, and the ϵ_t is assumed to be white noise.. The PP test is an alternative non-parametric test method of controlling for serial correlation when testing for a unit root.

IV.2 Co-integration and Error Correction Model (ECM)

The study relied on the Johansen and Juselius and the Engle and Granger cointegration tests to establish the existence of a long-run relationship among the variables. Subsequently, we employ the ECM which incorporates the full short run dynamics of the model to correct for disequilibrium and is given as:

$$\Delta Y_t = X_t'\beta + \gamma\Delta z_t + \boldsymbol{\lambda}(y_{t-1} - \boldsymbol{\theta} z_{t-1}) + \varepsilon_t \qquad (8)$$

The model describes the variations in Y_t around its long run trend in terms of a set of I(0) exogenous factors X_t, the variation of Z_t around its long run trend, and the error correction $(y_{t-1} - \theta z_{t-1})$ which is the equilibrium error in the co-integrated model. . The nature of the error correction term $(y_{t-1} - \theta z_{t-1})$ is what determines the nature of the co-integration relationships amongst the variables (Engsted and Bentzen, 1997). The $(y_{t-1} - \theta z_{t-1})$ is known as the error correction term since the deviation from long run equilibrium is corrected gradually through a series of partial adjustments. This paper uses data from 1970 to 2009 which are sourced from the Central Bank of Nigeria (CBN) Statistical Bulletin (various issues) and the CBN annual Report and Statement of Account (various issues).

V. Empirical Analysis and Results

V.1 Estimated Model and Time-Series Diagnostics

The ADF test on the variables reveals that they are stationary at first difference, that is, they are I(1). The PP test carried out reinforces the ADF test results (see appendix Tables 1 and 2 for the unit root test results). Table 1 reports the values of the F-statistic for the three models. The buffer stock model and mercantilist model were found to be significant at 1 per cent and 5 per cent level respectively. However, the buffer stock model performed best as its F statistic is the most statistically significant of all the models. It is pertinent to note that the difference between the F-statistic of the buffer stock model and its rival models is quite large. Hence, despite the Nigerian government's drive towards promoting export led growth and domestic monetary stability, the role of external reserves as a backup mechanism against unforeseen contingencies remains glaring as revealed from the encompassing test. We conclude on the basis of the Mizon-Richard encompassing principle that the buffer stock model has the best overall fit with the Nigerian data, as it was the only model whose variables were most significant when the sum of the estimated coefficients were computed from the nested model.

Table 1: The Mizon-Richard Encompassing Test (1986)

Model	Variables	P(F-Statistic)
Buffer Stock Model	$\sum_{i=0}^{2} \alpha_i$	0.000199
Mercantilist Model	$\sum_{i=0}^{2} \beta_i$	0.027969
Monetary Model	$\sum_{i=0}^{4} k_i$	0.740861

Source: Authors' Computation

We specify an augmented buffer stock-based reserves holding equation which follows closely the specification of Parent and Gosselin (2005); where reserves depend on the opportunity cost, terms of trade, money supply, capital account variability, and current account variability. The modified version is stated as[5]:

$$R_t = \beta_0 + \beta_1 OC_t + \beta_2 TOT_t + \beta_3 Mss_t + \beta_4 CAV_t + \beta_5 CUV_t + \mu_t \qquad (9)$$

Where R_t is international reserves, OC_t is the opportunity cost, TOT_t is terms of trade, Mss_t is money supply, CUV_t is current account vulnerability, and CAV_t denotes capital account vulnerability[6]. Opportunity cost is the variable that

[5] Our model differs slightly in that we consider money supply as an explanatory variable and thus expect money supply to significantly influence accumulation of reserves via the interest rate channel. The terms of trade was included in view of Nigeria's overdependence on crude oil earnings which invariably distorts the balance of payment account as a result of its fluctuations and thus affects reserve holding.

[6] Share of exports in output was used to capture current account variability while the ratio of broad money to GDP was used to capture capital account variability (See Parent and Gosselin (2005)).

captures the earnings forgone if the reserves were invested and this is measured by government bond yield or discount rate. Terms of trade which is the relationship between prices of exports and prices of imports is measured by the ratio of export and import prices. Money supply is the amount of money in the economy measured by broad money (M2). Capital and current account variability are proxied by the ratio of broad money to GDP and trade openness, respectively. A priori, it is expected that OC, CUV, CAV, and Mss should have positive signs while TOT is expected to be negatively related to external reserves. The sign of the opportunity cost variable has been observed to produce inconclusive results from the literature. This variable according to Edwards (1985) is often found to be insignificant in the empirical literature. However, Ben-Bassat and Gottlieb (1992) show that the opportunity cost, if measured correctly (according to its theoretical definition), turns out to be a strong determinant of external reserves demand. Thus, we expect the opportunity cost variable to be a positive function of international reserves.

The co-integration analysis provides potential information about the long-run equilibrium relationship of the model. This technique is pivotal and necessary in estimating an equilibrium relationship with non-stationary variables. Having confirmed from the unit root test that some of the variables are I(1), the Johansen and Engle and Granger (EG) methodology to test for co-integration is used. The ADF and PP test is conducted to assess whether the error term or residuals of the long run estimates have unit root or not (See appendix table 3). The null hypothesis is that the residuals from the static long run equation has a unit root. The test is carried out with no exogenous variable for both the ADF and PP test. The maximum lag length equals 9 for the ADF test while bandwidth 9 was selected on the basis of Newey-West, utilizing Bartlett Kernel for the PP test. As observed from the results of the ADF and PP tests, the ADF and PP test statistic are -4.73125 and -4.743996 respectively with p-value of 0.000. The test statistic for both the ADF and PP tests are statistically significant at 1%. This result provides evidence to support the existence of a long run co-integrating relationship between international reserves and the variables being considered.

The Johansen co-integration test indicates the presence of at least one co-integrating relationship in the model as revealed by the trace and maximum eigenvalue statistic which rejects the null hypothesis against the alternate hypothesis at the 5 per cent level (Tables 2 and 3). This shows that there exists a long run relationship between international reserves and the variables considered in the model. The Chow break point test conducted showed that only the structural adjustment programme in 1986 had a significant effect on the model while the change from military to democratic administration in 1999 and financial crisis in 2007/2008 were insignificant[7]. Analogous to the Johansen test, the E-G co-integration result also revealed the existence of a stable long run relationship between the variables in the estimated model. The ADF and PP unit root test of the long run estimated model's residual was found to be significant at 1 per cent.

Table 2: Unrestricted Co-integration Rank Test Result

Null Hypothesis	Trace Statistic	Critical Value at 5%	Null Hypothesis	Maximum-Eigen Value Statistic Statistic	Critical Value at 5%
r=0	175.6353*	146.76	**r=0**	51.16061*	49.42
r≤1	124.4747*	114.90	**r≤1**	33.47834	43.97
r≤2	90.99632*	87.31	**r≤2**	30.79480	37.52
r≤3	60.20152	62.99	**r≤3**	24.38579	31.46
r≤4	35.81573	42.44	**r≤4**	19.63096	25.54
r≤5	16.18477	25.32	**r≤5**	9.650536	18.96
r≤6	6.534233	12.25	**r≤6**	6.534233	12.25

Note: r implies number of cointegrating vectors. Trace statistic indicates 3 cointegrating equations at the 5% level while the maximum-eigenvalue statistic shows 1 cointegrating equation. Asterix (*) denotes rejection of the null hypothesis at 0.05 level.

Table 3: Normalized Cointegrating Vector

	IR	OC	CAV	CUV	MSS	TOT	C
Coefficient	1.0000	-0.474444	-2.005006	0.183960	0.627984	-2.159690	-2.149297
SE		(0.05775)	(0.05992)	(0.03437)	(0.03643)	(0.06408)	(0.10037)

Log Likelihood: 234.7324

V.2 Long run and Contemporaneous Error Correction Model Estimates

From Table 4, the estimated long run effect of a 1 per cent increase in money supply on external reserves while keeping the other variable constant is approximately 1.03 per cent while the long run elasticity of capital account variability is 0.93 per cent. The long run elasticity of opportunity cost in the model in terms of its influence on reserves is 0.036 while that of current account variability is 0.953 per cent. The Table indicates an adjusted R-square value which suggests that the regressors explain about 95% of the variations in external reserves while the F-statistic, an indicator of the overall significance of the model, shows that the model employed is statistically significant at 1% confidence level. The D-W statistic of 1.98 falls within the acceptance region of the null hypothesis of the absence of autocorrelation. Further analysis of the model shows that the coefficient of current account variability (proxied by the ratio of export to imports) which measures exposure to external shocks is statistically significant with a positive sign.

[7] Dummy variable was used to capture the various regimes. The results from the Chow Break point tests and VECM are available on request.

This conforms to the results obtained by Parent and Gosselin (2005) and Choi, et al (2007).

The coefficient of capital account variability, captured by the ratio of broad money to GDP, departs from theory as it carried an unexpected negative sign even though it is statistically significant. This may be attributable to the persistent capital flow variations which induced external sector deficit via the capital account and thus require reserves financing. The terms of trade (TOT), as expected, is positively related to reserves holding but is not statistically significant. The opportunity cost variable measured by the discount rate is also not statistically significant and is not in conformity with theoretical expectation as it has a positive sign thus contradicting the findings of Flood and Marion (2002), Frenkel and Jovanovic (1981) and Ben-Bassat and Gottlieb (1992). The coefficient of money supply carried expected positive sign. This implies that international reserves holding are a positive function of domestic money supply.

According to *a priori* expectation, there is a short run negative relationship between changes in reserves holdings and one period-lagged and two-period lagged value of changes in terms of trade (TOT). Both carried the expected negative sign and are highly significant at the one percent confidence level. The one period lag of the change in the opportunity cost variable (OC) carries the expected positive sign indicating that it is positively related to reserves though it is not statistically significant in explaining current level reserve holding.

The one-period lag of the change in the money supply variable is statistically significant but with a wrong sign. The change in the current account variability measure carries the expected positive sign and is significant at the ten percent level. The two-period lagged change in capital account variability (CAV) is statistically significant at ten percent but also carries an unexpected negative sign. The error correction estimate of 0.9551 indicates that 95% of the preceding period's disequilibrium is eliminated in the current period, with contemporaneous response captured by difference terms. The disequilibrium error term (ECM (-1)) was found to be statistically significant and negative as expected. The significance of the error correction model buttresses and confirms the presence of a long run relationship among the variables.

Table 4: Long run and Short run Demand for Reserves

Independent Variables	**Long Run Demand Equation**		**Short run Demand Equation**	
	Coefficient	Prob.	Coefficient	Prob.
Constant	-5.5989 (2.2095)**	0.0352	0.0799 (0.6503)	0.5219
Log of Current account variability	0.9539 (4.1074)*	0.0003		
Log of Capital account variability	-0.9396 (-3.2033)*	0.0033		
Log of Opportunity cost	0.0366 (0.0627)	0.9504		
Log of Terms of Trade	0.7176 (1.3168)	0.1982		
Log of Money supply	1.0306 (4.9051)*	0.0000		
First difference Log of Capital Account variability with two period lag			-0.1869 (-1.8848)***	0.0721
First difference Log of Current Account variability			0.2476 (1.7871)***	0.0871
First difference Log of Opportunity cost with one period lag			0.7371 (1.0286)	0.3144
First difference Log of Money supply with one period lag			-0.3372 (-1.6970)***	0.1032
First difference Log of terms of trade with one period lag			-0.8291 (-1.7813)***	0.0881
First difference Log of terms of trade with two period lag			-1.3564 (-3.3963)*	0.0025
First difference Log of Reserves with one period lag			0.8218 (3.8520)*	0.0008
Error correction mechanism (ECM(-1))			-0.9551 (-3.9939)*	0.0006
R-squared	0.9565		0.6120	
Adjusted R-squared	0.9475		0.4602	
Durbin-Watson stat	1.9837		1.7376	
Prob (F-statistic)	0.0000 (106.430)		0.0032 (4.032)	
Mean dependent var.	9.8701		0.3047	
S.D. dependent var.	3.0152		0.7871	

*Source: Authors' Computation; t-statistic are in parenthesis; *, **, *** implies significant at 1%, 5% and 10% confidence level respectively.*

Overall, four of the variables are found to be statistically significant and of the right signs and the general goodness of fit is acceptable for the differenced variables. The value of the R-square shows that the model accounts for about 61% of the changes in the demand for reserves holdings, while with respect to the adjusted R-square, the regressors accounted for 46% of the variations in the dependent variable.

To check for the constancy of the ECM we carry out stability tests via recursive estimates. The output obtained from the CUSUM and CUSUM of squares test showed that the estimates fell within the acceptable 5% significance. The CUSUM test is based on the cumulative sum of the recursive residuals using on 2 lags. This option plots the cumulative sum together with the 5% critical lines. The test finds parameter instability if the cumulative sum goes outside the area between the two critical lines/bounds. The CUSUM of squares test provides a plot of the variable at a particular period against another and the pair of 5 percent critical lines. As with the CUSUM test, movement outside the critical lines is suggestive of parameter or variance instability. The cumulative sum of squares is generally within the 5% significance lines, suggesting that the residual variance is somewhat stable. The CUSUM and CUSUM of square test results are shown in the appendix.

VI. Concluding Remarks

International reserves holding in the absence of sovereign wealth fund serves as a buffer against unforeseen contingencies and as such the role of its determinants towards policy fine-tuning and formulation cannot be ignored. International reserves holding in Nigeria can be observed to be driven by inter alia global crude oil production and prices, net capital inflows and imports. This paper examined the determinants of international reserves holding in Nigeria, where a huge amount of foreign reserves is necessary and is expected to play a pivotal role in, among others, the country's overall macroeconomic policies, assessment of its credit worthiness, managing its external debt service obligations and the insulation of the domestic economy in the event of contagion and spillover effects of abrupt capital flight occasioned by a regional or global economic slowdown.

Adopting a dynamic modeling approach through the use of co-integration and error correction (ECM) framework, subsequent on testing the appropriate theory of reserves demand through the Mizon-Richard encompassing test, we find evidence of both precautionary and mercantile motives behind holding reserves in Nigeria. Specifically, the need to ensure current account viability is mostly the reason why Nigeria holds international reserves. The results confirm that variations in the current account component of the balance of payments and past levels of reserves drive reserves holding in the short run. In the long run, current account variability and the money supply determine the demand for international reserves. Therefore, the central bank can minimize the variability of the current account by taking measures that enhance exports through support for quality and competitiveness of non-oil export commodities in the international markets. Hence, there is need to design optimal strategies that maximise non-oil export revenues. This external resource inflow through export revenues can be utilised to enhance domestic investment, particularly to stimulate diversification of exports away from primary products to manufactures and services. Such measures would ensure that the domestic economy is better insulated from crude oil-related external disturbances and the source of reserves accumulation becomes reasonably stable.

Furthermore, the empirical result suggests that Nigeria should reposition its reserves management strategies within a broader economic development policy framework, particularly due to the significance of the money supply as a determinant of international reserves holding. While macroeconomic stabilisation remains a key macroeconomic policy target, the impact of expansionary monetary policy on reserves and other intervening macroeconomic variables should be constantly taken into account. In relation to previous studies, which in addition to the fact that they did not consider the model with the best fit from amongst competing models, this study applies an encompassing technique to Nigerian data to fill this gap. In addition, a modified long run demand for reserves equation that takes into consideration the determinants of Nigeria's external reserves holding within a buffer stock approach that incorporates terms of trade and money supply as explanatory variables.

Finally, areas that this paper have not dwelt on which may have direct or indirect implications for the examination of reserves holding determinants include among others, the optimal level of external reserves holding in Nigeria, the currency composition of reserves, the adequacy and cost of international reserves holding, insurance value of reserves, oil price volatility and its implication for international reserves holding. Another area of research could be to examine the interactions between the financial system and the process of foreign exchange reserves accumulation.

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Appendices

Table 1: Augmented Dickey Fuller (ADF) test results

Variables	Levels			First Difference		
	Constant	Constant and Linear Time Trend	None	Constant	Constant and Linear Time Trend	None
LOGCAV	-1.449219	-4.311203*	-1.566846	-4.608564*	-4.601138*	-7.882467*
LOGCUV	-1.087287	-4.298867*	-0.995151	-8.208538*	-8.082986*	-8.004538*
LOGTOT	-3.924254*	-3.811705**	-0.131980	-6.077161*	-6.024033*	-6.139127*
LOGINF	-3.621016*	-3.566739**	-0.937015	-6.607376*	-6.592058*	-6.706326*
LOGMPR	-1.544387	-1.239822	0.259269	-6.761953*	-5.621980*	-6.754719*
LOGOC	-1.484360	-0.425109	0.249532	-7.492004*	-7.674457*	-7.465567*
LOGOP	-2.559691	-2.548273	1.006582	-5.216912*	-5.184439*	-5.006792*
LOGRES	-0.433625	-2.232723	2.143429	-6.268315*	-6.187186*	-5.457983*
LOGMSS	-0.618551	-4.248404*	3.329611	-9.453001*	-9.315844*	-7.483385*

The Null Hypothesis is the presence of Unit Root. Lags were selected based on Schwarz Information Criteria (SIC). Figures with (, ** and *** asterisks indicate the level of significance at 1%, 5%, and 10% respectively. None implies that intercept and trend and intercept were excluded from the test equation. The maximum lag length of 14 was automatically selected based on schwartz information criteria*

Table 2: Phillips-Perron (PP) test results

Variables	Levels			First Difference		
	Constant	Constant and Linear Time Trend	None	Constant	Constant and Linear Time Trend	None
LOG(CAV)	-1.270821	-4.319935*	-1.684176***	-15.02349*	-14.79278*	-8.568879*
LOG(CUV)	-1.203881	-4.303931*	-1.291452	-12.31720*	-12.07743*	-8.342040*
LOG(TOT)	-3.799647*	-3.892762*	-0.319734	-16.33864*	-17.91084*	-12.88637*
LOG(INF)	-3.376475**	-3.307224***	-0.725947	-12.54118*	-13.29508*	-12.67964*
LOG(MPR)	-1.462362	-0.995514	0.433092	-6.883205*	-6.961196*	-6.796436*
LOG(OC)	-1.411391	-1.000194	0.390539	-7.418009*	-7.714889*	-7.361002*
LOG(OP)	-2.575700	-2.543209	1.006582	-5.185611*	-5.146233*	-5.011276*
LOG(RES)	-0.200337	-2.232723	2.977983	-6.476380*	-6.401471*	-5.457778*
LOG(MSS)	-0.429610	-4.271261*	4.306442	-12.06612*	-11.92128*	-7.284769*

*The Null Hypothesis is the presence of Unit Root. The bandwidth was chosen using Newey-West method with Bartlett Kernel spectral estimation. Figures with *, ** and *** asterisks indicate the level of significance at 1%, 5%, and 10% respectively. None implies that intercept and trend and intercept were excluded from the test equation. The maximum lag length of 14 was automatically selected based on schwartz information criteria*

Table 3: Unit root test for the error term obtained from the long run demand for reserves equation estimation

ADF					PP				
Null Hypothesis: ECT has a unit root					Null Hypothesis: ECT has a unit root				
Exogenous: None					Exogenous: None				
Lag Length: 0 (Automatic based on SIC, MAXLAG=9)					Bandwidth: 1 (Newey-West using Bartlett kernel)				
			t-Statistic	Prob.*				Adj. t-Stat	Prob.*
Augmented Dickey-Fuller test statistic			-4.73125	0.0001	Phillips-Perron test statistic			-4.743996	0.0001
Test critical values:	1% level		-2.630762		Test critical values:	1% level		-2.630762	
	5% level		-1.950394			5% level		-1.950394	
	10% level		-1.611202			10% level		-1.611202	
*MacKinnon (1996) one-sided p-values.					*MacKinnon (1996) one-sided p-values.				

Source: Authors' Computation

Figure 1: Result from Stability Test

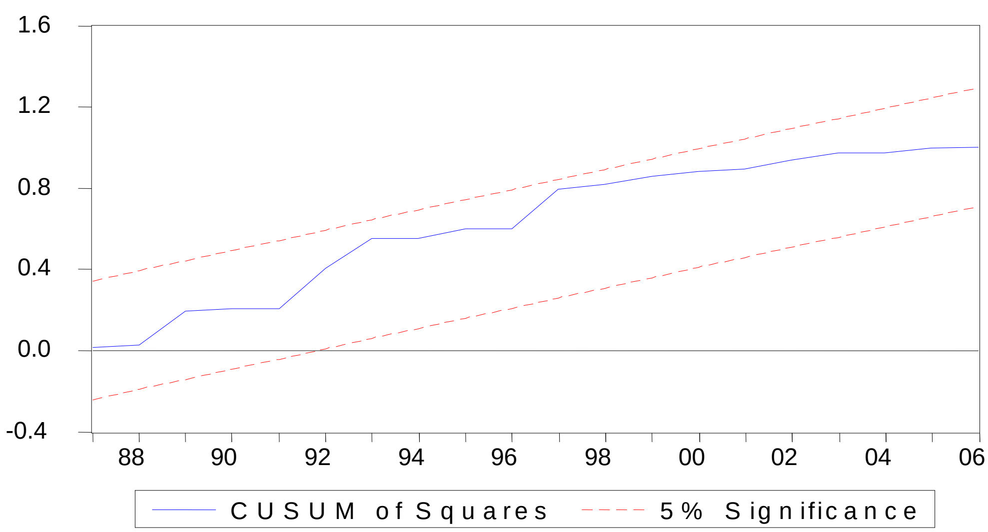
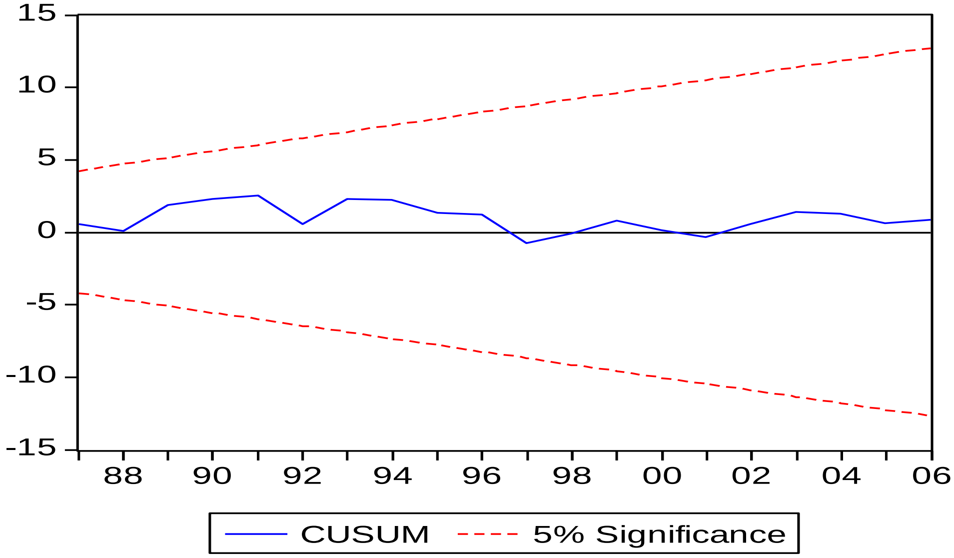


Figure 2: Result from Stability Test



Source: Authors' Computation

Anticipating the Next Crisis: What Can Early Warning Systems Be Expected To Deliver?[++] – A Review

Dakup D. Koplamma*

I. Introduction

The world economy is still struggling to recover from one of the most severe financial and economic crises since the great depression of the 1930s. This financial crisis started from the United State of America and spread into several other countries with varied degrees of impact. The impact on Nigeria's economy, as seen in terms of decline in exports, fall in commodity prices, lower portfolio and FDI inflows, fall in equity market, and decline in remittances from abroad, has necessitated the need to have a rethink on the possible ways to cope, reduce or avoid the negative impact of any future crisis. The essence of this review, however, is to reawaken the general public and the Nigerian policymakers to the need for sound strategies and policies that will brace-up the economy against future occurrences as well as mitigate its impact. A summary of the paper is presented below, followed by comments and lessons for Nigeria.

II. Summary of the Paper

The paper attempts to rekindle the interest of policymakers and the general public towards having early warning systems (EWS) that would anticipate future financial crisis. The authors highlighted how the systems would realistically sound alarms and their effectiveness in various economies.

The study showed from past experiences that even though nearly all economies reflected a confluence of some underlying economic vulnerabilities and specific crisis triggers; crises in advanced and emerging economies were always more costly. The underlying vulnerabilities are often in the form of credit or asset price bubble, and balance sheet mismatch (excessive borrowing in foreign currency, at too-short maturities, or with inadequate capitalization). On the other hand, the crisis triggers could be almost any event - political turmoil, terms of trade shocks, contagion from other countries, or the example of the current crisis, the collapse of the subprime mortgage market.

[++] Written by Atish R.Ghosh, Jonathan D. Ostry, and Natalia Tamirisa and Published in the IMF Finance and Development, September 2009

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The authors emphasise that an early warning system would clearly show the underlying vulnerabilities ahead of time so that the country can come up with necessary measures to prevent the crisis from happening. To them, restricting unhedged foreign currency exposure of banks or borrowers, limiting leverage and requiring higher capital ratios will go a long way to reduce the buildup of vulnerabilities. Though, it was stressed that EWS cannot prevent every vulnerability, but would sound alarm about imminent risk to allow countries to brace themselves against impending crises.

The authors outlined certain steps towards developing an EWS: the first step is determining what events it should warn of. In this step, the authors stress the need to know the likely causes of crisis in the economies of the world. According to them, most crises in emerging markets were caused by, or at least accompanied by sharp reversals of capital flows (especially sudden stops of capital inflows). Though the authors agree that such crises may have an external dimension, but they were more likely to be centered on the financial sector. The authors also added that the sharp declines in output, beyond mere cyclical fluctuations, were likely to be of independent interest to policymakers, regardless of whether they were accompanied by a financial crisis.

The paper further stated that after a crisis had been defined, the next step would be to develop the appropriate analytical toolkit. This toolkit needed to combine formal quantitative analysis with more heuristic methods such as broad-based consultations and judgment. They classified the role of quantitative tools into fourfold: first, providing a means for searching systematically for vulnerabilities; second, exploring linkages, especially through the financial sector that could allow a crisis to mutate and propagate across sectors, markets and across countries; third, quantifying both the likelihood and repercussions of a crisis materializing, given the identified vulnerabilities; and fourth, disciplining and informing the use of judgment. In complementing these quantitative tools, the authors therefore, suggest approaches such as consultations with policymakers, market participants and academics, as well as application of experience-based “rules of thumb”, intuitive judgments, and common sense, which will help spot new sources of vulnerabilities.

According to the authors, policymakers were persuaded by a clear and candid communication of early warnings, substantiated by comprehensive analysis. These analyses needed to include a description of the underlying sources of vulnerability to unwind, and of how these shocks could propagate across sectors, markets, and countries. Furthermore, they suggested that early warnings needed to be accompanied by a clear set of policy options emphasizing trade-offs between addressing different types of risk and underscoring the need for international policy coordination. The paper concludes that communication needed to be carefully calibrated with some messages transmitted in a confidential manner to policymakers while other less sensitive information should be released to the public.

III. Comments

The research on the early warning system was mainly to raise flags about possible worst-case scenarios and present policymakers with options for how best to respond. This required rigorous analysis, sound judgment and sharp communication. However, even a perfectly designed EWS might not predict and prevent all crises.

In addition, the authors noted that crises were caused by a variety of vulnerabilities and triggers in several countries. These included the weaknesses in financial regulation which led to the collapse of the subprime mortgage market in US (2007), governments short-term external (and foreign – exchange-denominated) liabilities and political shocks in Mexico (1994), terms of trade deterioration (asset price deflation) in Thailand (1997) with contagion effect on Indonesia in the same year. Others were tightening of monetary policy, exchange rate depreciation and weaknesses in risk management at the individual bank level in Sweden and Finland (1991). The past experiences in these countries would help us to develop EWS that would sound alarm on imminent risks, which will allow countries brace themselves up against the impending crises and also make policymakers to put contingency plans in place. The likely causes of future crises were not enumerated and the past experiences reflected that of developed and emerging economies only, thus it generally excludes developing countries like Nigeria which were always at the receiving end. Therefore, the authors should look into the causes of future crises and incorporate developing countries whose experiences were different from the developed and emerging economies.

IV. Lesson for Nigeria

The vulnerabilities and triggers earlier mentioned were the main causes of crises in those countries. In Nigeria, there have been observations that the economy is very vulnerable to oil price shocks. Others are political/religious conflicts like the boko haram surge, the militancy in the Niger delta and cases of balance sheet mismatch. These however have resulted in falling productive capacity and welfare. The macro-economic and social challenges posed by the global financial crisis require a much better understanding of the appropriate policy recommendation that could be applied to the situation in Nigeria.

First, the mono-cultural nature of the economy exposes it to external shocks. In other words, the over-dependence on oil at the expense of other sectors reduces the country's capacity to absorb shocks in the wake of such crises. This can be resolved by diversifying the economy for more resilience to future crises. Other sectors of the economy such as agriculture and tourism should be developed. Second, absence of technological innovations that drive growth and development can reduce the country's ability to absorb shocks. Economically, inclined crises would find a ready place in a country that is import dependent. This can be mitigated by rapid technological innovations to transform the economy. The transformation of scientific ideas and technological knowledge into goods and services should be encouraged by all stakeholders. Third, lack of a sound and vibrant financial system (money and capital markets) can expose the country to future crisis. A weak financial system and poor risk management would make the country vulnerable to crisis. A strong and vibrant financial system that performs effective financial intermediation roles in the economy would serve as an in-built stabilizer against any crisis. Fourth, a robust development of the human capital that will provide a means for searching systematically for vulnerabilities and readiness is required. This can be done through scholarship and university funding. In addition to this, government should make consultations with policymakers, market participants and academicians as well as the application of educated guesses, intuitive judgments, common sense, and "out-of-the box" thinking to be able to discover new sources of vulnerabilities.

V. Conclusion

Beyond the technical difficulties of identifying vulnerabilities, the greatest challenge to the development and usage of any EWS is perhaps, persuading policymakers to act on them. This puts a premium on clear and candid communication of early warnings, substantiated by comprehensive analysis. Given the policy implications discussed above and their appropriate attainment by policymakers, Nigeria would be able to predict, prevent and even spot new sources of vulnerabilities, bearing in mind that the next crisis may be different from previous ones.

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