Determinants of Foreign Reserves in Nigeria: An Autoregressive Distributed Lag Approach

David Irefin[1] **and Baba N. Yaaba**[2]

On global scale, central banks' holdings of foreign reserves have escalated sharply in recent years. World international reserves holdings have risen significantly from US$1.2 trillion in 1995 to nearly US$10.0 trillion in June 2011. Dominant among these reserves are concentrated in the hands of few countries. Ten major holders of foreign reserves are mostly from Asia. Oil exporting countries in Africa and the Middle East are not left out in this trend. Nigeria's foreign reserves rose from US$5.5 billion in 1999 to US$62.40 billion in July 2008, making Nigeria the twenty-fourth largest reserves holder in the world. This pace of reserves accumulation is occurring without regard to its diminishing marginal benefits and rising marginal costs. This study used an Autoregressive Distributed Lag (ARDL) approach to run a slightly modified econometrics 'Buffer Stock Model' of Frenkel and Jovanovic (1981) to estimate the determinants of foreign reserves in Nigeria with focus on income, monetary policy rate, imports and exchange rate. The results debunked the existence of buffer stock model for reserves accumulation and provide strong evidence in support of income as the major determinant of reserves holdings in Nigeria.

Key Words: Foreign reserves, central bank, financial crisis, Nigeria.
JEL Classification: C22, F30, F31

1.0 Introduction

The holdings of foreign reserves by central banks have increased sharply in recent years. World international reserves holdings rose from US$1.2 trillion in 1995 to nearly US$10.0 trillion in June 2011. These reserves are concentrated in the hands of few countries mostly from Asia. About seven Asian central banks had over US$5.89 trillion in foreign reserves as at June, 2011. The top two, China and Japan accounted for more than 80.0% of total world reserves. China, which is first on the list, had about US$3.597 trillion in foreign reserves as at June 2011. Hong Kong the last on the list had about US$122billion. Singapore has the highest percentage of reserves to GDP (104.4%), followed by Taiwan (78.2%), Hong Kong (75.1%) and Malaysia (55.5%).

Oil exporting countries in Africa and the Middle East are not left out in this trend. In Africa, foreign reserves increased from US$39.0 billion in 1995 to US$147.0 billion in 2005, representing about 276.9% increase. . The largest reserves holder in Africa is Algeria. Other important holders are Libya, Nigeria, Morocco, Egypt and South Africa (ECB, 2006a). Nigeria's foreign reserves rose from US$5.5 billion in 1999 to US$62.40 billion in July 2008, making Nigeria the twenty-fourth largest reserves holder in the world. However, the reserves fell to US$34.8 billion in September 2011 (www.cenbank.org).

This pace of reserves accumulation is occurring without regard to its diminishing marginal benefits and rising marginal costs. This led to the debate on the determinant factors. Thus,this study is an attempt to measure the determinants of reserves holdings in Nigeria. To achieve this, the study is organized into five sections. After this introduction, the next section reviews

[1]David Irefin is a Professor of Economics in the Department of Economics, University of Maiduguri
[2]Yaaba is a Senior Statistician in the Department of Statistics, Central Bank of Nigeria, Abuja

relevant literature on foreign reserves management. Section three explains the methodology, while section four presents the empirical results and section five concludes the study.

2.0 Review of Some Related Literature

According to IMF (2009), Foreign exchange reserves are foreign currency deposits of central banks or other monetary authorities. They are assets of central banks held in different reserves currencies such as the dollar, pound sterling, euro, yen etc. These reserves currencies are used to back central bank's liabilities, such as the local currency issued, the reserves deposits of various deposit money banks (DMBs), government or other financial institutions.

Foreign reserves are used to support monetary and foreign exchange policies, in order to meet the objectives of safeguarding currency stability and the normal functions of domestic and external payment systems. From the onset, foreign reserves were held in gold, but with the advent of the Bretton Wood system, the US dollar was pegged to gold and the gold standard was abandoned. Hence, the dollar, appearing as good as gold, became the fiat and most significant reserves currency.

In today's world, large foreign reserves partly symbolizes the country's strength, as it indicates the strong backing the currency of the country has. Hence, it attracts confidence of the international community in the country, while low a foreign reserve signals the opposite.

The central bank has the statutory responsibility of managing a country's foreign reserves. This responsibility is either enshrined in the country's constitution or an act of law (ECB, 2006a). In Nigeria for example, the CBN Act of 2007 constituted the legal framework within which the CBN carries out its mandate of, among others, the responsibility to manage the country's foreign reserves.

Approaches to the management of reserves vary from country to country depending on the objectives at hand. In the context of fixed or managed exchange rate regimes, the traditional objectives have mostly been formulated with respect to monetary policy and exchange rate management (Carlos et al, 2004). In this case, foreign reserves acts as a buffer against capital outflows in excess of the trade balance. This makes foreign reserves management secondary to macroeconomic objectives, as liquidity is always the target. This also enables the monetary authority intervene in the foreign exchange market at any given time. Holding foreign reserves under both fixed and floating exchange rate regimes also acts as a "shock absorber" in terms of fluctuations in international transactions, such as variations in imports resulting from trade shocks, or in the capital account due to financial shocks. According to ECB (2006b), the holding of foreign reserves as self-insurance against currency crisis is especially important if a currency is overvalued. Mexico, Korea and Russia, for example, all share relatively recent experiences with destabilizing runs on their currency during a financial crisis. The study, however, argued that this is less relevant to undervalued currencies such as those in most Asian countries.

To corroborate the argument of ECB (2006a), Lawrence (2006), noted that the prominent reason that have been put forward for the on-going rapid accumulation of external reserves, particularly

in the Emerging Market Economies (EMEs) of Asia, is to insure against currency crisis by allowing relevant authorities to support their own currency. This is in order to avoid the re-occurrence of the currency crisis of the late 1990s. According to him, other reasons for holding foreign reserves do not necessarily require large amounts. He further argued that, foreign reserves may serve an immediate purpose of either fighting inflation or deflation, but large foreign reserves accumulation serves little purpose other than precautionary and that even the precautionary motives of foreign reserves holding is not significant in advanced economies due to flexible exchange rate and strong macroeconomic policies. He, therefore, posited that foreign reserves accumulation is not necessary as it is practiced. Others, however, argued that stockpiling of foreign reserves is critical in this era of open capital markets as a means of safeguarding against capital account crisis. In this regard, Fischer (2001) noted that: "Reserves matter because they are the key determinant of a country's ability to avoid economic and financial crisis. This is true of all countries, but especially the emerging markets that are open to volatile international capital flows. The availability of capital flow to offset current account shocks reduce the amount of reserves a country needs. But access to private capital is often uncertain, and inflows are subject to rapid reversals, as we have seen in recent years. We have also seen in the financial crisis of the late 1990s and the recent global financial crisis that, countries with robust foreign reserves, by and large, did better in withstanding the contagion than those with smaller foreign reserves" (Fischer, 2001).

Traditionally speaking, as observed earlier, most countries hold foreign reserves in support of the exchange rate policy. This is to ensure foreign exchange stability. In most cases reserves are used to intervene in the foreign exchange market to influence the exchange rate. Since exchange rate regime is bi-polar in nature. A country either practices floating exchange rate, with its inherent exchange rate volatility or fixed exchange rate with its attendant difficulties in absorbing changes in equilibrium real exchange rate. Although, between these two extremes are variety of mixed regimes, but whichever method a country adopts, of course, has its inherent consequences (Michael et al 2006). Therefore, there is need for intervention to smooth exchange rate fluctuations.

International Relations Committee, Task Force (IRC, 2006) identified other uses of foreign reserves that necessitate its accumulation and management by the central banks as: payment for the importation of goods and services, service the nation's external debt and finance domestic fiscal expenditure.

However, in recent times, an active approach to foreign reserves management tends to lay more emphasis on generation of further wealth (profit). This occurs when monetary policy, exchange rate and debt management issues are of less concern to central banks; when vulnerabilities in the financial and corporate sectors are negligible; when government vigorously pursues a flexible exchange rate policy; when it has a credible fiscal policy and institutional framework as well as highly developed domestic financial markets. Here, the foreign reserves portfolio is divided into active and passive parts. While the passive portfolio deals with macroeconomic objectives

focusing mainly on liquidity, the active portfolio is used for profit making, taking cognizance of liability management objectives (Carlos et al 2004).

In agreement with the profit making approach to reserves management, Peter and Machiel (2004) states that, over a decade now, management of foreign currency reserves has changed its focus from the objectives of maintaining liquidity and principal preservation, to that of maximizing total profit. They identified long term government bonds, global government bonds, investment-grade credits, high yield bonds and equities as among investments with high return, though with their associated risks.

To support the submission of Michael et al (2004a), ECB (2006a) noted two developments that have been witnessed in recent times with regards to foreign reserves management to include: management of foreign reserves by way of venturing into a more diversified range of instruments with longer maturity period, as well as the channeling of sizeable component of foreign assets into areas that has no link with foreign reserves holding. They cited the creation of oil funds by countries such as Norway, Russia, Venezuela, Kuwait and Oman, which are established either to stabilize the country's oil revenue (stabilization funds) or save for future generations (saving funds) or for early settlement of external debt. Another example is the creation of heritage fund, such as in Singapore, or in case of China where more than US$60.0 billion was injected into three state-owned commercial banks, so as to increase their capital base to facilitate privatization. There is also the case of Taiwan where US$15.0 billion was allocated for banks in the province to use in the major investment projects.

On currency diversification, there is relative stability in the shares of foreign reserves currencies in the global foreign exchange assets in recent year, with US dollar still maintaining the lead with about 63.3 % in December 2007, while the euro increased its weight from 18.0 % in 1999 to 26.5 % in 2007 (Figure 1).

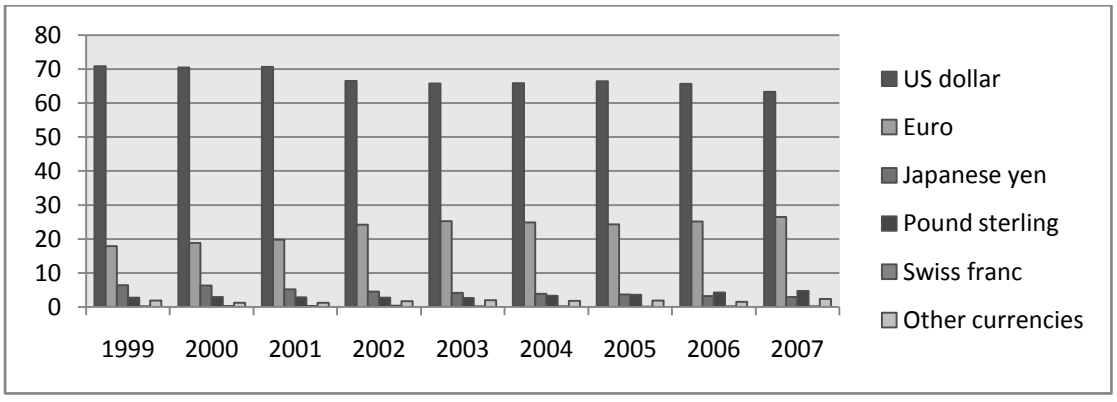

Figure 1: Official Foreign Reserves: Currency *Shares (as % of total identified holdings)*
Source: *CIA Fact Book, 2007*

The US dollar is still the most common foreign reserves currency. The reason for the dominance of the dollar over other currencies according to ECB (2006) is not far from the fact that: (1) US fixed income markets and financial markets are broader, deeper and more liquid comparatively

to those of the euro area and Japan. (2) There is strong evidence in support of the fact that, the largest foreign reserves accumulators will continue to use dollar as intervention currency, at least in the main time.

In conformity with ECB (2006), Rodrick (2006) argued that foreign reserves are also managed to earn reasonable rates of return without exposing the reserves to excessive risk. However, central banks in carrying out this policy task exposed foreign reserves to a variety of financial and non- financial risks. Exposure to risks also occurs due to the fact that central bank's main activity of ensuring price stability requires adequate financial backing.

In this regards IMF (2001) identified two categories of risks; namely: external market-based risks and operational risk. According to the report, external market-based risk consists of liquidity risks, credit risks, currency risks and interest rate risks, while the operational risks consists of control system failure risks, financial error risks, financial misstatement risks and loss of potential income.

ECB (2006) however, identified risks of foreign reserves accumulation to include inflationary pressure, over investment, assets bubbles, complications in the management of monetary policy, potentially sizeable capital losses on monetary authorities' balance sheets, sterilization costs, segmentation of the public debt market and misallocation of domestic bank's lending (table 1).

To support the position of ECB (2006), on foreign reserves accumulation and inflation, Calvo (2002), noted that, the accumulation of foreign exchange reserves leads to monetary expansion and hence inflation. This is, however, in contrast with the submission of Victor and Vladimir (2006). According to them, most countries that accumulate foreign reserves faster usually finance such accumulation with government budget surplus and thus managed to escape high inflationary pressure. They observed data of about one hundred countries from the World Bank and discovered that there was no link between the accumulation of foreign reserves and inflation.

Bird and Rajan (2003), observed that reserves hoarding involves significant costs as the country is swapping high yielding domestic assets for a relatively lower yielding foreign one. They, however, argued that the cost might be reduced with a greater degree of regional monetary cooperation. Rodrik (2006), in his study, estimated the cost of holding reserves for all developing countries to be about 1.0 % of GDP.

On interest rate and reserves, Bird and Rajan (2003), observed that, while the level of foreign reserves can be influenced by some economic fundamentals, interest rates can in-turn influence the level of foreign reserves. For instance, if interest rates are lower than the foreign rates, the holders of foreign exchange are likely to divert their holdings into a relatively higher return ventures, hence keep their money where they are earned i.e. abroad. Conversely, if interest rates are higher relative to foreign rates, the foreign exchange earners will prefer to keep their fund at home, hence whatever they earned abroad is immediately repatriated back home. To this end

therefore, there is the need to keep interest rate at a competitive level so as to discourage capital outflows.

On cost structures and the foreign reserves level, they noted that the profitability of business and the growth of exports can be indirectly affected by the country's cost structure, through influencing the competitiveness of the products. Hence, it will be difficult for countries with high cost structure to build foreign reserves through exports. A good example is the United States, which is being affected negatively due to the high cost of items such as vehicles and electronic goods. Therefore, the competitiveness of a country is a primary determinant for the sustainability of foreign reserves accumulation.

On institutional arrangements in relation to foreign reserves management, Medhora (1992) and Siregar & Ramkishen (2003) explained that the management of foreign reserves includes the legal foundation and internal governance. The management of foreign reserves is mostly governed by an act or law and this serves as the legal framework for asset management and investment operations. Since all the decisions regarding management of foreign reserves are of strategic nature, the management, particularly at the top, define and set the overall parameters for foreign reserves management operations, as well as the framework for the control of risk. The investment activities and performance are often monitored by the board. The decisions regarding implementation of investment strategies are usually undertaken by the investment committee (IMF, 2001).

2.1 Empirical Literature

There is no doubt as to the usefulness of foreign reserves as a tool to avoid crises as argued by Fischer (2001), but there is a limit to the amount of foreign reserves needed to prevent the financial crisis, going by the fact that holding large foreign reserves can imply costs. If foreign reserves accumulation is driven, for instance, by precautionary motives, it should stop at the stage where the optimal level has been reached. This, however, does not happen in the present circumstance. This thus raises the question about what constitutes an adequate foreign reserve. Frenkeland Jovanovic (1981) states that most of the rules for a country's demand for foreign exchange reserves consider real variables, such as imports, exports, foreign debt, severity of possible trade shocks and monetary policy considerations. Similarly, Shcherbakov (2002) states that, there are some common indicators that are used to determine the adequate level of foreign reserves for an economy. According to him, some of these indicators determine the extent of external vulnerability of a country and the capability of foreign reserves to minimize this vulnerability. These indicators includes: import adequacy, debt adequacy and monetary adequacy.

The traditional and most prominent factor considered in determining foreign reserves adequacy is the ratio of foreign reserves to imports (import adequacy). This represents the number of months of imports for which a country could support its current level of imports, if all other inflow and outflow stops. As a rule of thumb, countries are to hold reserves in order to cover their import for three to four months. According to the International Monetary Fund (IMF,

2000), the guideline of three months of imports has been in force for a few years now. However, with the Asian crisis of the late 1990s this measure has been questioned by experts. Currently some are of the view that twelve months of imports is adequate, while others argue that the number of months of coverage is of limited importance, since the focus is on the external current account. This group argued that foreign reserves adequacy should focus on the vulnerabilities of capital accounts. Countries that are vulnerable to capital account crisis should hold foreign reserves sufficient enough to cover all debt obligations falling due within the succeeding year. This is known as the Calvo, Guidotti and Greenspan's rule (reserves equal to short term external debt). See Greenspan (1999).

According to Rodrik and Velasco (1999), and Garcia and Soto (2004), a country is considered prudent, if it holds foreign reserves in the amount of its total external debt maturing within one year. The reserves to short-term debt measure have been proved empirically relevant to currency crisis prevention. The feedback on the outreach activities conducted by the IMF and the World Bank lend its support to this approach (Marion, 2005). The last measure is reserves equal to 5-20 % of M_2. This benchmark is very useful for economies with high risk of capital flight and those that want to shore up confidence in the value of local currency. It is also useful for the economies that have weak banking sectors (Summers, 2006; IMF, 2000). However, Comelliet al (2006) argued that, empirical analysis of all the three methods explained above, confirmed that the international reserves of most countries are in excess particularly that of the Asian economies (Table 3). However, it should be noted that, determining the optimal level of foreign reserves has no straight forward measurement factors. It sometimes depends also on institutional factors such as the degree of capital mobility or financial liberalization.

Various models have been developed to measure the determinants of foreign reserves. The most widely used of these models in the literature is the "buffer stock model". The model implies that the authorities demand reserves as a buffer to curb fluctuations in external payment imbalances. This is to avoid macroeconomic adjustment cost arising from imbalances in the external payments. The advantage of the model over others is its adaptability to both fixed and floating exchange regimes. The model is as relevant in a modern floating exchange regime as it was during the Bretton Woods regime.

Heller (1966) estimates the optimal stock of reserves by equating the marginal cost and marginal benefit of holding reserves following rational optimizing decision. He compares actual reserves with his results for each country to check for the adequacy of reserves. Frenkel and Jovanovic (1981) in their effort to determine the optimal stock of reserves modified Hellar's model based on the principles of inventory management. Using pooled time series for the period 1971-1975 for twenty two countries, they concluded that the estimated elasticities were close to their theoretical predictions.

In their study, Flood and Marion (2002) confirmed the applicability of the buffer stock model in the modern regime of floating exchange rate as it was during the Bretton Woods era. They submitted that with greater exchange rate flexibility and financial openness, the model will

perform better if these variables were well represented. Disyatat and Mathieson (2001) adopted Frenkel and Jovanovic model for fifteen countries in Asia and Latin America and submitted that the volatility of the exchange rate is an important determinant of reserves accumulation and that the financial crisis of the late 1990s produced no structural breaks.

IMF (2003) standardized the buffer stock model and applied it on the emerging markets economies of Asia. The study concluded that reserves accumulations were driven by increases in current account and capital flow. Aizenman and Marion (2003) used the buffer stock model on sixty four countries over the period 1980 to 1996 and found that the standard variables in the model explain about 70.0 percent of the movement in the observed reserves holding without country fixed effects and 86.0 percent with country fixed effects.

Ramachandran (2005) applied the buffer stock model for India covering the period April 1993 – December 2003, which was characterized by flexible exchange rate, and high level of capital flows. He finds that the standard measure of volatility defined as the fifteen years rolling standard deviation of change in trend adjusted reserves used by Frenkel and Jovanovic (1981) produces biased estimates but when he adopted the GARCH approach result of the estimated coefficient were closer to the theoretical predictions.

The buffer stock model of Frenkel and Jovanovic (1981) is given as:

$$dR(t) = \mu dt + \sigma dW(t) \quad (1)$$

Where: Rt = reserves held in time t

Wt = standard Weiner process with zero mean and variance t

μ = deterministic part of the instantaneous change in reserves

σ = standard deviation of the Weiner increment in reserves

At each point in time the distribution of reserves holdings R (t) is characterized by

$$R(t) = R^* - \mu t + \sigma dW(t) \quad (2)$$

where: R^* is the optimal stock of reserves, which is obtained by minimizing two types of costs viz: i) the cost of adjustment, which is incurred once reserves reach an undesirable lower bound; and ii) foregone earnings on reserve holdings. The optimal stock of reserves is obtained by minimizing these two costs and it yields an expression:

$$R^* = \sqrt{[2c\sigma 2/\ (2r\sigma 2)0.5]} \quad (3)$$

where:

c = fixed cost of adjustment

r = opportunity cost of holding reserves

σ = standard deviation of change in reserves.

The estimating equation can be re-written as:

$$Log\ R_t = \beta_0 + \beta_1 log\sigma t + \beta_2 log r_t + + \mu_t \quad (4)$$

where μ_t is white noise.

Equation 4 is considered as the benchmark for reserves determinant equation in most empirical studies. The theoretical prediction suggest $\beta_1 = 0.5$ and $\beta_2 = -0.25$.

Past studies, however, arrived at different results for the elasticities (Flood and Marion 2002, and Ramachandran 2004). The difference in the result were attributed largely to the sensitivity of the model to different proxies for the opportunity cost of holding reserves, estimation methods and modification of the original model by adding new variables.

For a developing economy like Nigeria, there is need to extend the model to incorporate other variables that are peculiar in the determination of reserves holdings. Hence, variables such as Gross Domestic Product (GDP), imports, monetary policy rate which is an anchor of monetary policy and exchange rate are included in the estimation equation. Thus, the equation becomes:

$$LogR_t = \beta_0 + \beta_1 logY_t + \beta_2 logIM_t + \beta_3 logMPR_t + \beta_4 logEXR_t + \mu_t \quad (5)$$

where R= foreign reserves, Y = Gross Domestic Product, IM = Import, MPR = Monetary Policy Rate and EXR = Exchange Rate.

The justification for including additional variables for Nigeria is that, for instance, reserves holdings are positively related with the level of international transactions hence the importance of variables such as imports and exchange rate.

3.0 Model Specification, Data Sources and Description

3.1 Model Specification

The Autoregressive Distributed Lag (ARDL) model developed by Pesaranet al (2001) is deployed to estimate Frenkel and Jovanovic's "*buffer stock"* econometric model, but with a slight modification. The choice of ARDL is based on several considerations. First, the model yields consistent estimates of the long run normal coefficients irrespective of whether the underlying regressors are stationary at I(1) or I(0) or a mixture of both. In other words, it ignores the order of integration of the variables (Pesaran et al, 2001). Secondly, it provides unbiased estimates of the long run model as well as valid t-statistics even when some of the regressors are endogenous (Harris & Sollis, 2003). Thirdly, it has good small sample properties. In other words it yields high quality results even if the sample size is small.

The ARDL (p, q_1, q_2 …qk) model following Pesaranet al (2001)[3] can be written as follows:

$$\Omega(L,P)y_t = \alpha_0 + \sum_{i=1}^{k} \beta_i(L,q_i)\, x_{i,t} + \delta' w_t + \mu_t \quad (6)$$

[3] See Pesaranet al, 1997, 1998 and/or 2001 for more detail

Where:

$$\Omega(L,P) = 1 - \Omega_1\delta_1 L^1 - \Omega_2\delta_2 L^2 - \cdots - \Omega_p L^p \quad (7)$$

$$\beta_1(L,\ P_1) = \beta_{i0} + \beta_{i1}L^1 + \beta_{i2}L^2 + \cdots + \beta_{iqi}L^{qi},\ i = 1,2,\ldots,k,. \quad (8)$$

$y_t$is the dependent variable; $\alpha_0$is a constant; L is a lag operator ; and w_t is a $s \times 1$ vector of deterministic variables such as seasonal dummies, time trends or exogenous variables with fixed lags.

The $x_{i,t}$in equation (6) is the i independent variable where $i = 1,2 \ldots k$. In the long-run, we have $y_t = y_{t-1} = \cdots = y_{t-p}$; $x_{i,t} = x_{i,t-1} = \cdots = x_{i,tq}$ where $x_{i,tq}$denotes the q^{th} lag of the i^{th} variable.

The long-run equation with respect to the constant term can be written as:

$$y = \alpha_0 + \sum_{i=1}^{k}\beta_i x_i + \delta' w_t + v_t \quad (9)$$

The long-run coefficient for a response of y_t to a unit change in $x_{i,t}$is estimated by:

$$\beta_i = \frac{\widehat{\beta}_i(l,\hat{q}_i)}{\Omega(l,\hat{p})} = \frac{\widehat{\beta}_{i0}+\widehat{\beta}_{i1}+\ldots\widehat{\beta}_{i\hat{q}}}{1-\widehat{\Omega}_1-\widehat{\Omega}_{2-\cdots-\widehat{\Omega}_{\hat{p}}}}, \quad i = 1,2,\ldots,k \quad (10)$$

where$\hat{\mathrm{p}}\ and\ \hat{\mathrm{q}}_i$ are the selected (estimated) values of p and q_i and $i = 1,2,\ldots,k$

Similarly, the long-run coefficients associated with the deterministic/exogenous variables with fixed lags are estimated using the following equation

$$\delta' = \frac{\widehat{\delta}(\hat{p},\hat{q}_1,\hat{q}_{2,\ldots,\hat{q}_k})}{1-\widehat{\Omega}_1-\widehat{\Omega}_{2-\cdots-\widehat{\Omega}_p}}, \quad (11)$$

where, the numerator $(i.e.\ \hat{p},\hat{q}_1,q_{2,\ldots,}\hat{q}_{k,})$denotes the ordinary least square estimate of δ in equation (6) – the selected ARDL model.

The error correction representation of the ARDL is obtained by transforming equation (6) in terms of lagged levels and differences of $y_t, x_{1t}, x_{2t}, \ldots, x_{kt}$ and w_t, hence we have:

$$\Delta y_t = \Delta\alpha_0 - \sum_{j=1}^{\hat{p}-1}\Omega_j\,\Delta y_{t-j} + \sum_{i=1}^{k}\beta_{i0}\,\Delta x_{it} - \sum_{i=1}^{k}\sum_{j=1}^{\hat{q}t-1}\beta_{ij}\,\Delta x_{i,t-j} + \delta'\Delta w_t \quad -$$
$$\Omega\left(1,\hat{P}\right)ECM_{t-1} + \mu_t \quad (12)$$

ECM is defined as $ECM_t = y_t - \hat{\alpha} - \sum_{i=1}^{k}\hat{\beta}_i x_{it} - \delta' w_t$

where Δ is the first difference operator and Ω^*j, β^*ij and $\delta^{'}$ are the coefficients of the short run dynamics of the model's convergence to equilibrium while $\Omega(1,\hat{\mathrm{p}})$ measures the speed of adjustment.

Following equations (6) and (8), the ARDL format of equation 5 becomes:

$$\Delta logR_t =$$
$$\beta_0 + \sum_{i=1}^{m}\beta_1\Delta logR_{t-i} + \sum_{i=1}^{n}\beta_2\Delta logY_{t-i} + \sum_{i=1}^{o}\beta_3\Delta logMPR_{t-i} + \sum_{i=1}^{p}\beta_4\,\Delta logIM_{t-i} +$$
$$\sum_{i=0}^{q}\beta_5\,\Delta logEXR_{t-i} + \gamma_1 logR_{t-1} + \gamma_2 logY_{t-1} + \gamma_3 logMPR_{t-1} +$$
$$\gamma_4 logIM_{t-1} + \gamma_5 logEXR_{t-1} + \mu_t \quad (13)$$

whereΔ = first difference of the variables, t = time, t-1 = lag one (previous quarter), Log = Natural logarithm, β_0 = Constant, $\sum$ = summation, β_1 to β_5 and γ_1 to γ_5 are the coefficients of their respective variables. Other variables are as defined earlier.

The apriori expectations of the variables in a buffer stock model are that; income (Y) and imports (IM) are expected to be positively related to reserves while monetary policy rate (MPR) is expected to have an inverse relationship with the dependent variable (R). Exchange rate (EXR) is ambiguous.

A general error correction representation of equation (13) is formulated as follows:

$$\Delta logR_t = \beta_0 + \sum_{i=1}^{n} \beta_1 \Delta logR_{t-i} + \sum_{i=1}^{n} \beta_2 \Delta logY_{t-i} + \sum_{i=1}^{n} \beta_3 \Delta logMPR_{t-i} + \sum_{i=1}^{n} \beta_4 \Delta logM_{t-i} + \sum_{i=0}^{n} \beta_5 \Delta logEXR_{t-i} + \gamma EC_{t-i} \quad (14)$$

where EC = error correction representation

According to Pesaranet al (2001), there are two procedures involve in estimating equation (13). First, the null hypothesis of the non-existence of the long run relationship among the variables is defined by H_o: $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0$. H_o is tested against the alternative. Rejecting the null hypothesis implies that there exists a long run relationship among the identified variables irrespective of the integration properties of the variables. This is done by computing F-test (or Wald statistics) with an asymptotic non-standard distribution. Then, two sets of critical values are tabulated with one set assuming all variables are I(1) and the other I(0). This provides a band covering all possible classifications of the variables into I(1) and I(0)[4]. Now, if the calculated F-statistics lies below the lower level of the band, the null cannot be rejected, indicating lack of co-integration, if it lies above the upper level of the band, the null hypothesis is rejected implying that there is co-integration but if the F-statistics falls within the band, the result is inconclusive. It is important to state here that the ARDL approach, unlike other techniques (such as Engle and Granger (1987) and Johansen and Juselius(1990)), does not necessarily require the pre-testing of the variables included in the model (Pesaran et al, 2001).

3.2 Data Sources and Description

The study used secondary data obtained from the publications of Central Bank of Nigeria (CBN) and National Bureau of Statistics (NBS). The data span from the first quarter of 1999 to second quarter of 2011.

The major variables for which data is collected are defined below:

Foreign reserves (R) is the total assets of central bank held in different reserves currencies abroad. The reserves currencies includes; US dollar, Pound Sterling, Euro, Japanese Yen etc. The common scale variables used in the model are GDP and imports.

Gross Domestic Product is the total value of goods and services produced in the country within a given period. Imports are the total monetary value of goods and services imported into the country on quarterly basis. Monetary Policy Rate is an anchor rate. In other words, it is the rate at which the central bank lends money to the deposit money banks (DMBs).

The opportunity cost plays an important role in the determination of reserves. Although, most empirical studies did not find significant opportunity cost effect in reserve accumulation.

[4] The critical values are available in Pesaran et al, 2001

Different scholars have used different financial variables (i.e. interest rate and lending rate) as proxy for the opportunity cost. Ben-Bassat and Gottlieb (1992) used the difference between the real rate of capital and yield on reserves. Collana (2004) used short term interest rate as proxy for opportunity cost of reserves holdings. Suvojit (2007) used monthly yield on cut off price of 91 days treasury bills. The opportunity cost of holding reserve is proxied by monetary policy rate (MPR) in our case, since the CBN, which manages reserves has the duty of lender of last resort. The ways and means, which can serve as a viable alternative has since been curtailed by one of the WAMZ convergence criteria, which provide that CBN should not lend to the central government an amount more than five percent of her previous year revenue.

MPR is the rate at which the CBN lends to the DMBs.

Exchange rate is the price at which the domestic currency (naira) exchanges for US dollar are used.

4.0 Empirical Results

Although, ARDL does not require pretesting of the data but we decided to determine the order of integration of all the data before running the ARDL. Figure 2(appendix) shows the trend of the data, while Table 3 shows the results of the Augmented Dickey-Fuller(ADF) and Phillips Perron (PP) unit root tests for the order of integration of the variables under investigation.

Table 3: Unit-Root Test (Augmented Dickey-Fuller and Phillips-Perron)

Variable	ADF test statistics based on SBC		P-P test statistics	
	Level	First Difference	Level	First Difference
R	-1.39939**	-0.253086	-1.038022	-6.230879*
Y	1.786341	-10.28576*	1.484007	-8.223247*
MPR	-1.027445	-6.577622*	-1.027445	-6.577622*
IM	0.67614	-6.84504*	0.770733	-6.866988*
EXR	-1.651867	-5.559932*	-1.678823	-5.559932*

*Notes: * and ** significant at 1% and 5%, respectively.*

The table shows that while reserves based on ADF test is integrated of I(0), income, monetary policy rate, imports and exchange rates are of order I(1), thereby lending support to the use of ARDL.

Table 4: Estimated Long-Run Coefficients ARDL (1,1,1,1,0)

Dependnte Variable: LR

Variables	**Coefficient**	**t-Statistic**	**Prob-Values**
C	-0.173	-0.196	0.846
LR(-1)	0.866	14.494	0.000
LY(-1)	0.240	2.366	0.023
LMPR(-1)	-0.007	-0.085	0.933
LIM(-1)	-0.072	-2.146	0.038
LEXR	-0.087	-0.422	0.675

R^2 = 0.99	F - Statistics = (4, 39) = 3.918 [0.009]
Adjusted - R^2 = 0.98	Durbin Watson = 1.942

The relevant critical values for unrestricted intercept and no trendunder 5 variables for0.05 are 2.62 - 3.79. They are obtained from Pesaran et al. (2001) CI (iii) Case III.

We now estimate the second part of equation (13). Table 4 displays the calculated F-statistics (F-statistic = 3.918), showing that the null of no cointegration can be rejected at 1.0 percent level, because it is higher than the upper bound critical value of 3.79 as tabulated in Pesaran et al (2001).This implies that there exists a long-run relationship or cointegration between reserves and its determinants. Having established the cointegration relationship, the next step is to estimate the long-run coefficients by estimating an ARDL of order m, n, p, q, r (1, 1, 1, 1, 0) in the first part of equation (13).

The result indicates that the long run overall model is well fitted as the independent variable explained over 98 % ($\overline{R}^2$) movement in the dependent variable. The long-run coefficients show that income exhibits a positive significant relationship with reserves so does the lag of reserves itself. Lag of MPR, exchange rate (EXR) and lag of imports are inversely related to reserves. The significant inverse relationship between reserves and imports debunked the existence of '*buffer stock model'* in the management of foreign reserves in Nigeria. In other words, reserves accumulation is negatively related to the level of imports. Thus, any 1.0 % increase in one period lag of imports induces 7.0 % fall in reserves and vice versa. Put differently, Nigeria's external reserve is depleted in favour of importation.

Similarly, the lag of MPR is negatively related to reserves, although not significant. This is consistent with most empirical studies on the determinants of reserves, although, a negative relationship provides evidence in support of opportunity cost of reserves holding in Nigeria. A decline in MPR in the preceeding period will induce the deposit money banks to borrow more from the CBN, hence restrain CBN from building more reserves. The MPR elasticity, which is the measure of opportunity cost, is found to be -0.007. However, some scholars such as Ben-Bassat and Gottlieb (1992) have argued that it could take positive sign. Exchange rate (EXR), which apriori is ambiguous takes a negative sign showing an inverse relationship with reserves holdings, although statistically insignificant. The insignificance of exchange rate may be that, although exchange rate in Nigeria is said to be market determined but in the real sense of it, it was somewhat managed by the CBN for some period.

Overall, the result suggests that the most significant factor in determining the level of reserves in Nigeria is lag of income. A 1.0% increase in income induces a 24% increase in current period reserves.

According to the Granger representation theorem, when variables are cointegrated, there must also be an error correction model (ECM) that describes the short-run dynamics or adjustment of the cointegrated variables towards their equilibrium values. The result of the ECM is presented in Table 5. The lagged error term is negative and highly significant. The coefficient of -0.14062 indicates an evidence of fast adjustment towards long-run equilibrium (i.e. about 14.1 % disequilibrium is corrected on quarterly basis by changes in reserves). This implies that,in case of distortion in equilibrium, it takes less than two years(i.e. seven quarters and one month) for equilibriums to be re-established. Similarly,following equation 14, both the short run and long run results yielded the same sign for theselected variables except exchange rate, which takes positive sign in the short run. However, while the coefficient of LR is the same in the short run as in the long run, those of income and monetary policy rate are stronger in the short run. This underscores the fact that reserve build-up in Nigeria is mainly a function of income arising from improvement in oil revenue. Other variables gain prominence only in the long-run. This also explains why the F-statistics lies below the lower bound of the critical value as tabulated in Pesaran et al (2001).

Table 5: Error Correction Estimates of the ARDL Model

Dependent variable: ΔlnR			
Regressors	***Coefficient***	***Standard Error***	***t-Statistics***
C	-0.077762	-0.04067	-1.9118
ECM_{t-1}	-0.14062	-0.06653	-2.11364
D(DLR(-1))	0.259519	-0.1754	1.47962
D(DLR(-2))	0.280253	-0.18514	1.51377
D(DLR(-3))	-0.000356	-0.18963	-0.00188
D(DLR(-4))	0.322149	-0.19728	1.63299
D(DLY(-1))	-0.009935	-0.20601	-0.04822
D(DLY(-2))	0.145156	-0.189	0.76801
D(DLY(-3))	0.270128	-0.18008	1.50002
D(DLY(-4))	0.412412	-0.19107	2.15838
D(DLMPR(-1))	0.097355	-0.17191	0.5663
D(DLMPR(-2))	0.097052	-0.16187	0.59958
D(DLMPR(-3))	-0.190784	-0.16138	-1.1822
D(DLMPR(-4))	-0.162654	-0.1629	-0.99848
D(DLIM(-1))	-0.059179	-0.04754	-1.24493
D(DLIM(-2))	-0.019898	-0.04639	-0.4289
D(DLIM(-3))	0.04438	-0.04557	0.97383
D(DLIM(-4))	0.008091	-0.04367	0.18526
D(DLEXR(-1))	0.603001	-0.55589	1.08475
D(DLEXR(-2))	0.595922	-0.61601	0.9674
D(DLEXR(-3))	0.881633	-0.71738	1.22896
D(DLEXR(-4))	1.218052	-0.60577	2.01074
$R^2 = 0.596$	*F-Statistics = 1.544*		

To test the stability of the equation and of the estimated parameters, the most often used techniques of CUSUM and CUSUMSQ tests were adopted.

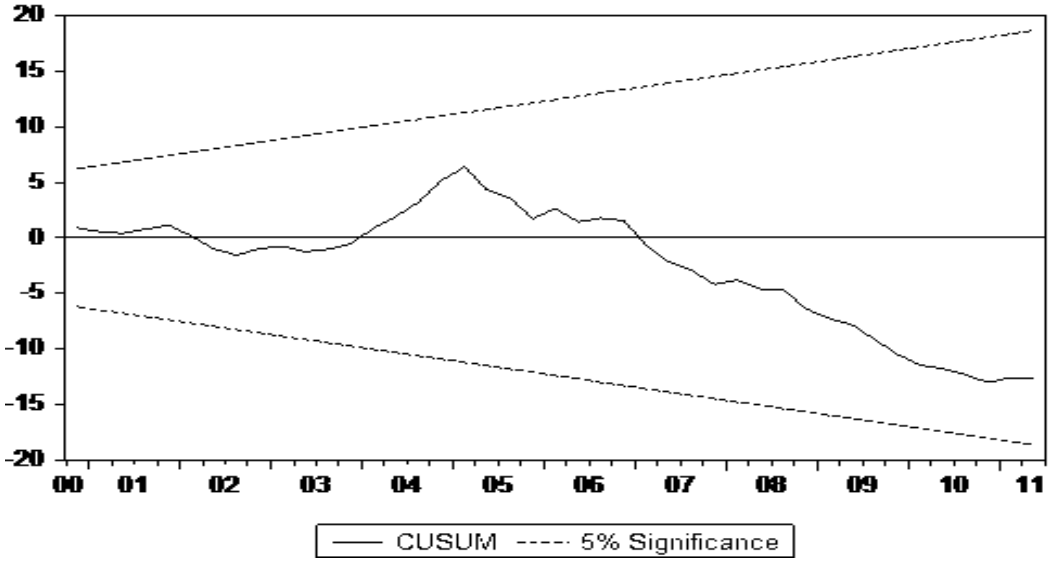

Figure 2: Cumulative Sum of Recursive Residuals Test and

The CUSUM test is based on the cumulative sum of the equation errors in the regression. The software represents graphically the cumulative sum of errors together with the critical lines at 5%. On the other hand, CUSUMSQ instead used recursive double errors. The equation parameters are considered unstable if the whole sum of recursive errors gets outside the two critical lines. By and large, both graphs of CUSUM and CUSUMSQ show that the parameters of the analysed equation are stable given that the recursive errors lie within the two critical lines of both tests.

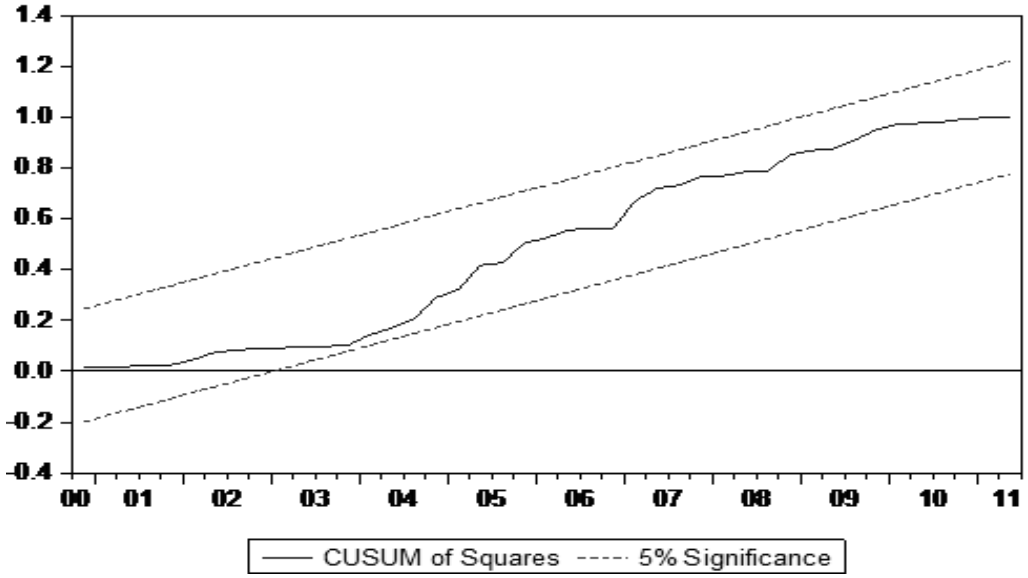

Figure 3: Cumulative Sum of Square of Recursive Residuals Test

5.0 Conclusion

The accumulations of foreign reserves have risen sharply in recent years. It rose from US$1.2 trillion in 1995 to nearly US$10.0 trillion in June 2011. Major holders of foreign reserves are mostly from Asia. However, oil exporting countries in Africa and the Middle East are not left out in this trend. Nigeria's foreign reserves rose from US$5.5 billion in 1999 to US$62.40

billion in July 2008, making Nigeria the twenty-fourth largest reserves holder in the world and fall to US$34.8 billion in September 2011. This pace of reserves accumulation is occurring without regard to its possible diminishing marginal benefits and rising marginal costs.

The study used an Autoregressive Distributed Lag (ARDL) approach (also known as bound testing approach) developed by Perasan et al (2001) to run a slightly modified econometrics *'Buffer Stock Model'* of Frenkel and Jonanovic (1981) to estimate the determinants of foreign reserves in Nigeria with focus on income, monetary policy rate, imports and exchange rate. The result provided a strong evidence for the long run relationship among the determinants of reserves in Nigeria. It debunked the existence of buffer stock model for reserves accumulation and provides strong evidence in support of income as a major determinant of reserves management in Nigeria.

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Appendix

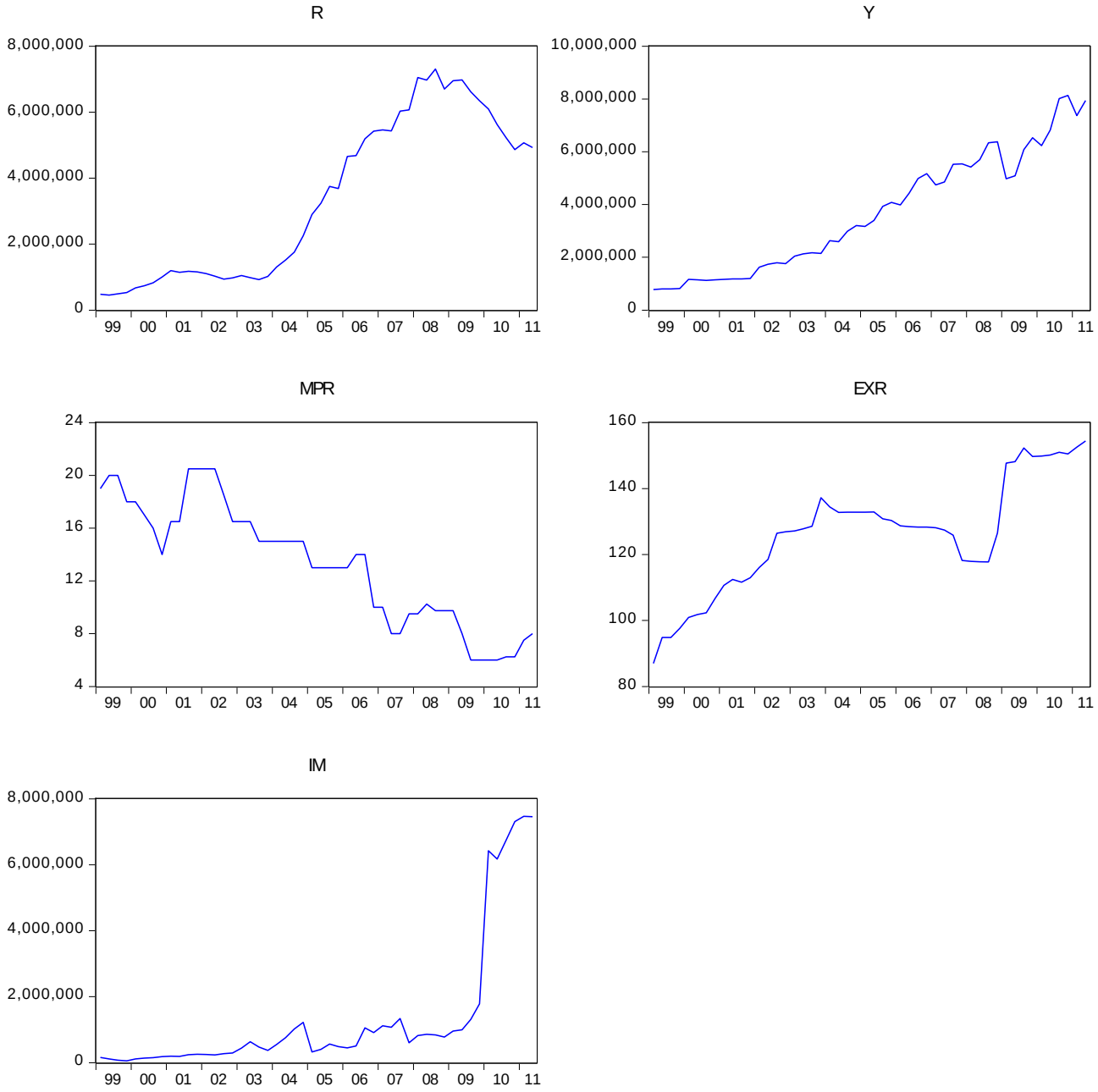

Figure 2: Graphical representation of the variables in the model