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

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Abstract

On a 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 US$7.6 trillion in June 2008. 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. The study employed an Autoregressive Distributed Lag (ARDL) approach 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 debunked the existence of buffer stock model for reserves accumulation and provides strong evidence in support of income as the major determinant of reserves holdings in Nigeria.

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Note: The views expressed in this paper are solely those of the authors and do not necessarily reflect the position of their respective places of work.

Introduction

On a 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 US$7.6 trillion in June 2008. Reserves holdings are dominated by few countries. For example, ten major holders of foreign reserves are mostly from Asia. About seven Asian central banks have over US$3.6 trillion in foreign reserves as of June, 2008. The top two, China and Japan accounted for about 80.0 per cent of the total world reserves accumulation. China, which is first on the list, had about US$1.8 trillion in foreign reserves as of June 2008. Algeria which was the tenth in the list had about US$126.9 billion. Singapore has the highest percentage of reserves to GDP (104.4%), followed by Taiwan (78.2%), Hong Kong (75.1%) and Malaysia (55.5%). [1]

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. This represented about 276.9 percent increase within the period. The largest reserves holder in Africa is Algeria. Other important holders are: Libya, Nigeria, Morocco, Egypt and South Africa. [1] Nigeria’s foreign reserves rose from US$5.5 billion in 1999 to US$62.40 billion in July 2008 before falling to US$34.8 billion in September 2011. This made Nigeria the twenty-fourth largest reserves holder in the world in 2008. [2]

In 1999, Nigeria’s foreign reserves stood at a meager US$5.50 billion; however, it rose by 80.0 per cent to US$9.90 billion in the year 2000. It further increased by 5.3 percent in 2001 to US$10.42 billion. It then declined in 2002 and 2003 to US$7.99 billion and US$7.47 billion, respectively or by 23.3 and 6.6 percent, respectively. The fall in reserves within these
periods was largely attributed to inadequacy of foreign exchange receipts, as well as huge fiscal spending and the resultant pressure on the country’s debt payment obligations. It is also important to note that Nigeria is a monocultural economy with heavy reliance on crude oil revenue whose price is exogenously determined. Hence, the stock of foreign reserves is largely determined by the prevailing situation in the international oil markets. Between the year 2003 and 2004, reserves experienced a dramatic upward trend as it rose from US$7.47 billion to US$16.96 billion. This indicated a significant increase of 127.0 percent. The increase was due largely to huge receipt from crude oil sales coupled with the prudent fiscal and monetary policy stance of the National Economic Empowerment and Development Strategy (NEEDS) introduced in 2004. In 2005 and 2006 the reserves positions were US$28.28 billion and US$42.23 billion, respectively, representing increases of 66.8 and 49.2 percent, respectively. The positive out-turn was accentuated by a combination of factors including continuous discipline on fiscal and monetary policy measures, high oil prices in the international markets, as well as low debt service burden resulting from the successful debt deal that reduced the country’s debt profile from US$35.9 billion in 2004 to US$3.5 billion in 2006. The reserves rose to US$43.48 billion in 2007 and reached an all-time high of US$62.40 billion in July, 2008. [3] It is, however, pertinent to mention that the ultimate source of accretion of foreign reserves in Nigeria remains the oil. Nigeria has recently experienced favorable international oil prices. Oil prices have climaxed to US$117.84 in June 2008. The high oil prices in the international markets are mostly complemented by the colossal reduction in the country’s debt portfolio and the deepening of both the financial and capital markets.

This pace of reserves accumulation is occurring without regard to its diminishing marginal benefits and rising marginal costs. This has led to a debate on what are the determinant factors of reserves accumulation. This study is therefore an attempt to measure the determinants of reserves holdings in Nigeria. To achieve this, the study is organized into five sections. After the introduction, the next section reviews relevant literatures on foreign reserves management. Section three explains the methodology while section four presents the empirical results and section five concludes the study as well as proffers some recommendations.

**Review of Some Related Literature**

Foreign exchange reserves are foreign currency deposits of central banks or other monetary authorities. [4] 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 Breton Wood’s systems, the US dollar was pegged to gold and gold standard was abandoned, hence the dollar appears as good as gold and therefore became the fiat and most significant reserves currency. In today’s world, large foreign reserves symbolizes the country’s strength, as it indicates the strong backing of the country’s currency, hence, attracts confidence of the international community in the country, while low foreign reserves signals the opposite.

Central Bank has the statutory responsibility of managing the country’s foreign reserves. This responsibility is either enshrined in the country’s constitution or an act of law. [1] In Nigeria for example, Central Bank of Nigeria (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. [5] 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 monetary authorities to 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, [1] 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. However, this is less relevant to undervalued currencies such as those in most Asian countries. To corroborate the argument, Lawrence, [6] noted that the prominent reason that has 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. Lawrence, [6] also provides other reasons for holding foreign reserves that do not necessarily require large amounts. For example, 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 even then, precautionary motives of foreign reserves holding is not significant in advanced economies due to flexible exchange rates 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 [7] noted that: “Reserves matter because they are the key determinants 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 reduces 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”. [7]

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 foreign exchange market to influence 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 a variety of mixed regimes, whichever method a country adopts, has its inherent consequences. [8] Therefore, there is need for intervention to smooth exchange rate fluctuations. On the other uses of foreign reserves, International Relations Committee, Task Force, [9] 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, servicing the nation’s external debt and financing domestic fiscal expenditure. However, in recent times, an active approach to foreign reserves management tends to lay more emphasis on the 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. [5]

In agreement with the profit making approach to reserves management, Peter and Machiel, [10] state that for over a decade, 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 this submission, ECB, [1] noted two developments that have been witnessed in recent times with regards to foreign reserves management: 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 components of foreign assets into areas that have no link with foreign reserves holdings. 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 fund) or save for future generations (saving fund) or for early settlement of external debt. Another example is the creation of heritage fund, such as in Singapore, or in the 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 was also the case of Taiwan where US$15.0 billion was allocated for banks in the province to use in 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 years, with US dollar still maintaining the lead with about 63.3 percent in December 2007, while the Euro increased its weight from 18.0 percent in 1999 to 26.5 percent in 2007. The US dollar is still by far the most common foreign reserves currency. The reason for the dominance of the dollar over other currencies according to ECB, [1] 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 countries 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 meantime. In conformity with ECB, [1] George, [11] 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 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, [12] identified two categories of risks: namely: external market-based risk and operational risk. External market-based risk consists of liquidity risks, credit risks, currency risks and interest rate risks, while the operational risk consists of control system failure risks, financial error risks, financial misstatement risks and loss of potential income.

ECB, [13] 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. To support this position on foreign reserves accumulation and inflation, Calvo, [14] 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. [15] According to them, most countries that accumulate foreign reserves faster, usually finance such accumulation with government budget surplus and thus manage to escape high inflationary pressure. They examined data from the World Bank on about one hundred countries and discovered that there was no link between the accumulation of foreign reserves and inflation. Bird and Rajan, [16] 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, [17] in his study, estimated the cost of holding reserves for all developing countries to be about 1.0 per cent of GDP.

On interest rate and reserves, Bird and Rajan, [16] 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 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 funds 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.
Empirical Literature

There is no doubt about the usefulness of foreign reserves as a tool to avoid crises as argued by Fischer, [7] 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 cost. 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. There are therefore questions about what constitutes adequate foreign reserves. Frenkel [18] 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 [19] 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 include 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 imports for three to four months. According to the International Monetary Fund, [20] the guideline of three months of imports has been in force for few years; 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 argued 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).

According to Rodrik [21] and Garcia and Soto, [22] 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 lends its support to this approach. [23] The last measure is reserves equal to 5-20 percent of M₂. 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 sector. [24; 22] However, Comelli [25] argued that empirical analysis of all the three methods explained above, confirmed that international reserves of most countries are in excess, particularly that of the Asian economies. However, it should be noted that, determining the optimal level of foreign reserves has no straightforward 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 Breton Woods regime. Heller [26] estimated the optimal stock of reserves by equating the marginal cost and marginal benefit of holding reserves following rational optimizing decision. He compared actual reserves with this result for each country to check for the adequacy of reserves. Frenkel and Jovanovic [27] 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 [28] confirmed the applicability of buffer stock model in the modern regime of floating exchange rate as it was during the Breton 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 [29] adopted Frenkel and Jovanovic’s model for fifteen countries in Asia and Latin America and submitted that the volatility of exchange rate is an important determinant of reserves accumulation and that financial crisis of the late 1990s produced no structural breaks. IMF [12] standardized the buffer stock model and applied it on the emerging market economies of Asia. The study concluded that reserves accumulations were driven by increases in current account and capital flow. Aizeman and Marion [30] 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. Avner and Lederman [31] used a model that determined both monetary policy and international reserves. They introduced a reserves constraint into a standard monetary model. They concluded, based on their result, that myopic central banks may raise interest rate to satisfy the constraint and that forward looking central banks would probably raise interest more. They added that strict monetary policies as widely witnessed recently would help in building more precautionary reserves that serves the purpose of allowing future monetary policies to better stabilize inflation and output and also lower the likelihood of potential financial crisis.

Ibrahim [32] investigated the impact of change in external reserves position of Nigeria on domestic investment, inflation and exchange rate between 1986 and 2006. He used a combination of ordinary least square and vector error correction models. The results show that changes in reserves influence only foreign direct investment and inflation rates. They proposed broader reserves management strategies which includes investment of reserves in the domestic economy. Alasan and Shaib [33] examined the management of external reserves and economic development in Nigeria between 1980 and 2008 using ordinary least square estimation technique. The result shows that while gross domestic product is positively related to external reserves, non-oil import is inversely related to reserves.

Ramachandran [34] 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 found 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 [27] produced biased estimates but when he adopted GARCH the result of the estimated coefficient were closer to the theoretical predictions.

The buffer stock model of Frenkel and Jovanovic [27] is given as:
\[ dR(t) = \mu dt + \sigma dW(t) \]  
(1)

Where: \( R_t \) = reserves held in time t  
\( W_t \) = standard Weiner process with zero mean and variance t  
\( \mu \) = deterministic part of the instantaneous change in reserves  
\( \sigma \) = standard deviation of the Weiner increment in reserves

At each point in time the distribution of reserves holdings \( R(t) \) is characterized by
\[ R(t) = R^* - \mu t + \sigma dW(t) \]  
(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:
\[ R^* = \sqrt{\frac{2c\sigma^2}{(2\rho^2)^{0.5}}} \]  
(3)

Where: \( c \) = fixed cost of adjustment  
\( \rho \) = opportunity cost of holding reserves  
\( \sigma \) = standard deviation of change in reserves
The estimating equation can be re-written as:
\[ \log R_t = \beta_0 + \beta_1 \log \sigma_t + \beta_2 \log r_t + \mu_t \] (4)

Where: \( \mu_t \) is error term.

Equation 4 is considered as the benchmark for reserve determinant equation in most of the empirical studies. The theoretical prediction suggest \( \beta_1 = 0.5 \) and \( \beta_2 = -0.25 \). Past studies, however, arrived at different result for the elasticities. [28; 34] 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.

However, for a developing economy like Nigeria, there is need to extend the model to incorporate scale and some 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:

\[ \log R_t = \beta_0 + \beta_1 \log Y_t + \beta_2 \log IM_t + \beta_3 \log MPR_t + \beta_4 \log EXR_t + \mu_t \] (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.

**Model Specification**

Autoregressive Distributed Lag (ARDL) developed by Pesaran, Shin and Smith [35] is deployed to estimate Frenkel and Jovanovic’s [27] “buffer stock” econometric model but with 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. [35] Secondly, it provides unbiased estimates of the long run model as well as valid t-statistics even when some of the regressors are endogenous. [36] Thirdly, it has good small sample properties. In other words, it yields high quality results even if the sample size is small.

The ARDL \((p, q_1, q_2 \ldots q_k)\) model following Pesaran, Shin and Smith [35] can be written as follows:

\[
\Omega(L,P)Y_t = \alpha_0 + \sum_{i=1}^{k} \beta_i (L,q_i) X_{it} + \delta^* w_t + \mu_t
\] (6)

Where:

\[
\Omega(L,P) = 1 - \Omega_1 L - \Omega_2 L^2 - \cdots - \Omega_p L^p
\] (7)

\[
\beta_i (L, P) = \beta_{i0} + \beta_{i1} L + \beta_{i2} L^2 + \cdots + \beta_{iq_i} L^{q_i}, \quad i = 1, 2, \ldots, k.
\] (8)

\( Y_t \) is the dependent variable; \( \alpha_0 \) is a constant; \( L \) is a lag operator such that \( L Y_t = y_{t-1} \); and \( w_t \) is a \( s \times 1 \) vector of deterministic variable such as the seasonal dummies, time trends or exogenous variables with fixed lags.

The \( x_{it} \) in equation (6) is the independent variable where \( i=1, 2, \ldots, k \).

In the long-run, we have \( y_t = y_{t-1} = \cdots = y_{t-p}; x_{it} = x_{i,t-q} \ldots = x_{i,t-q} \) where \( x_{i,t-q} \) denotes the \( q^{th} \) lag of the \( i^{th} \) variable.

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

\[
y = \alpha_0 + \sum_{i=1}^{k} \beta_i x_i + \delta^* w_t + v_t
\] (9)

The long-run coefficient for a response of \( y_t \) to a unit change in \( x_{it} \) is estimated by:

\[
\beta_i = \frac{\hat{\beta}_i (L,q_i)}{\alpha(L,P)} = \frac{\hat{\beta}_{i0} + \hat{\beta}_{i1} L + \hat{\beta}_{i2} L^2 + \cdots + \hat{\beta}_{iq_i} L^{q_i}}{1 - \hat{\beta}_1 L - \hat{\beta}_2 L^2 - \cdots - \hat{\beta}_p L^p}, \quad i = 1, 2, \ldots, k
\] (10)
Where $\hat{p}$ and $\hat{q}_i$ 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
$$
\delta' = \frac{\hat{b}(\hat{p}, \hat{q}_1, \hat{q}_2, \ldots, \hat{q}_k)}{1 - \hat{a}_1 - \hat{a}_2 - \cdots - \hat{a}_p},
$$
(11)

Where, the numerator ($i.e.$ $\hat{p}, \hat{q}_1, \hat{q}_2, \ldots, \hat{q}_k$) denotes the ordinary least square estimate of $\delta$ 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:
$$
\Delta y_t = \Delta a_0 - \sum_{j=1}^{\hat{p}-1} \Omega_j \Delta y_{t-j} + \sum_{i=1}^{k} \beta_{i0} \Delta x_{it} - \sum_{i=1}^{k} \sum_{j=1}^{\hat{q}_i-1} \beta_{ij} \Delta x_{it-j} + \delta' \Delta w_t - \Omega(1, \hat{p})ECM_{t-1} + \mu_t
$$
(12)

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

Where $\Delta$ is the first difference operator and $\Omega^*$, $\beta^*$ and $\delta'$ are the coefficients of the short run dynamics of
the model’s convergence to equilibrium while $\Omega(1, \hat{p})$ measures the speed of adjustment.

Following equations (6) and (8), the ARDL format of equation 5 becomes:
$$
\Delta \log R_t = \beta_0 + \sum_{i=1}^{m} \beta_1 \Delta \log R_{t-i} + \sum_{i=1}^{n} \gamma_1 \log R_{t-i} + \sum_{i=1}^{p} \beta_2 \Delta \log M_{PRt-i} + \sum_{i=0}^{q} \gamma_2 \log M_{PRt-i} + \sum_{i=0}^{q} \beta_3 \Delta \log EXR_{t-i} + \gamma_3 \log M_{PRt-i} + \gamma_4 \log EXR_{t-i} + \mu_t
$$
(13)

Where $\Delta$ is the first difference of the variables, $t$ is time, $t-1$ is lag one (previous quarter), $\log$ is the natural logarithm, $\beta_0$ is Constant, $\sum$ is summation, $\beta_i$ to $\beta_6$ and $\gamma_i$ to $\gamma_6$ 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
positively related to reserves while monetary policy rate (MPR) has an inverse relationship with the
dependent variable (R). Exchange rate (EXR) is ambiguous.

A general error correction representation of equation (13) is represented as:
$$
\Delta \log R_t = \beta_0 + \sum_{i=1}^{m} \beta_1 \Delta \log R_{t-i} + \sum_{i=1}^{n} \gamma_1 \log R_{t-i} + \sum_{i=1}^{p} \beta_2 \Delta \log M_{PRt-i} + \sum_{i=0}^{q} \gamma_2 \log M_{PRt-i} + \sum_{i=0}^{q} \beta_3 \Delta \log EXR_{t-i} + \gamma_3 \log M_{PRt-i} + \gamma_4 \log EXR_{t-i} + \gamma EC_{t-1}
$$
(14)

Where: EC = error correction representation of the ARDL model.

Following Pesaran et al, [35] there are two procedures involved in estimating equation in the
ARDL model. First, the null hypothesis of the non-existence of the long run relationship
among the variables is defined by:
$$
H_0: \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0.
$$

$H_0$ is tested against the alternative of $H_1$; not $H_0$.
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 conducting Wald test 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).
[2] If the calculated F-statistics lies below the
lower level of the band, the null cannot be
rejected, indicating a 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. If the F-statistics falls within the
band, the result is inconclusive. ARDL
approach, unlike other techniques such as Engle
and Granger [37] and Johansen and Juselius
Approach, [38] do not necessarily require the
pre-testing of the variables included in the
model. [35]
Data Sources and Description

The study used secondary data obtained from the statistical bulletin of the Central Bank of Nigeria (CBN) [39] and National Bureau of Statistics (NBS). [40] The data span from the first quarter of 1999 to fourth quarter of 2011. The major variables for which data is collected are defined below. A foreign reserve (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 Gross Domestic Product and imports. Gross Domestic Product (GDP) 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 (MPR) is an anchor rate; it is the rate at which 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 reserves accumulation, various scholars have used different financial variables (i.e. interest rate and lending rate) as proxy for the opportunity cost. Ben-Bassat and Gottlieb [41] used the difference between the real rate of capital and yield on reserves. Collana [42] used short term interest rate as proxy for opportunity cost of reserves holdings. Suvojit [43] used monthly yield on cut off price of 91 days Treasury bill. The opportunity cost of holding reserve in our case, is proxied by monetary policy rate, since CBN which manages reserves has no alternative sources of investment other than its duty of lender of last resort. The ways and means that CBN 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 CBN lends to the DMBs. Exchange Rate is the price at which the domestic currency (Naira) exchanges for US dollar.

Empirical Results

Although ARDL does not require pretesting of the data, we decided to determine the order of integration of all the data before implementing the model. Table 1 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>
<thead>
<tr>
<th>Variable</th>
<th>ADF test statistics based on SBC</th>
<th>P-P test statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level</td>
<td>First Difference</td>
</tr>
<tr>
<td>R</td>
<td>-1.39939**</td>
<td>-0.253086</td>
</tr>
<tr>
<td>Y</td>
<td>1.786341</td>
<td>-10.28576*</td>
</tr>
<tr>
<td>MPR</td>
<td>-1.027445</td>
<td>-6.577622*</td>
</tr>
<tr>
<td>IM</td>
<td>0.67614</td>
<td>-6.84504*</td>
</tr>
<tr>
<td>EXR</td>
<td>-1.651867</td>
<td>-5.559932*</td>
</tr>
</tbody>
</table>

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

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), hence lend support to the use of ARDL.

We now estimate the second part of equation (13). Table 2 displays the calculated F-statistics (F-statistics = 3.918) which shows that the null of no co-integration can be rejected at 1.0% level because it is higher than the upper bound critical value of 3.79 as tabulated in Pesaran et al, [35]
implying that there exists a long-run relationship or co-integration between reserves and its determinants. Having established the co-integration relationship, the next step is to estimate the long-run coefficients by estimating an ARDL of order m, n, o, p, q (1, 1, 1, 1, 0) in the first part of equation (13).

Table 2: Estimated Long-Run Coefficients ARDL (1,1,1,1,0)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>t-Statistic</th>
<th>Prob-Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.173</td>
<td>-0.196</td>
<td>0.846</td>
</tr>
<tr>
<td>LR(-1)</td>
<td>0.866</td>
<td>14.494</td>
<td>0.000</td>
</tr>
<tr>
<td>LY(-1)</td>
<td>0.240</td>
<td>2.366</td>
<td>0.023</td>
</tr>
<tr>
<td>LMPR(-1)</td>
<td>-0.007</td>
<td>-0.085</td>
<td>0.933</td>
</tr>
<tr>
<td>LIM(-1)</td>
<td>-0.072</td>
<td>-2.146</td>
<td>0.038</td>
</tr>
<tr>
<td>LEXR</td>
<td>-0.087</td>
<td>-0.422</td>
<td>0.675</td>
</tr>
</tbody>
</table>

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 trend under 5 variables for 0.05 are 2.62 - 3.79. They are Obtained from Pesaran et al. (2001) CI(iii) Case III.

From Table 2, LR(-1) is the lag of reserves which qualifies the equation as autoregressive, LY(-1) is the lag of income proxied by gross domestic product, LMPR(-1) is the lag of monetary policy rate which is the anchor of monetary policy in Nigeria, LIM(-1) is the lag of imports and LEXR is the current value of exchange rate.

The result indicates that the long run overall model is well fitted as the independent variable explained over 98.0% \((R^2)\) movement in the dependent variable. The long-run coefficients show that income exhibits a positive significant relationship with reserves, so is the lag of reserve itself. Monetary policy rate (MPR), exchange rate (EXR) and 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 imports. Thus, any 1.0% increase in imports induces 7.0% fall in reserves and vice versa. Put differently, Nigeria’s external reserve is depleted in favour of importation. Similarly, monetary policy rate (MPR) is negatively related to reserves, although not significant. This is consistent with most empirical studies on the determinants of reserves in Nigeria such as that of Alasan and Shaib [33] which indicate that reserves, are statistically positively related to GDP, but have an inverse relationship with non-oil imports. Although negative relationship provides evidence in support of opportunity cost of reserves holding in Nigeria, such that if there is decline in MPR, deposit money banks tend to borrow more from the CBN hence, restrains CBN from building more reserves. However, the MPR elasticity which is the measure of opportunity cost is found to be -0.007. Some scholars such as Ben-Bassat and Gottlieb [41] have therefore argued that it can take a positive sign. This result is also consistent with that of Ibrahim [32] who found strong evidence in support of opportunity cost of holding reserves in Nigeria, as well as current account variability as a driving force behind reserves accumulation. Exchange rate (EXR) which a priori 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 reality, it was actively managed by CBN for some period. Overall, the result suggests that the most significant factor in determining the level of reserves in Nigeria is income. A 1.0% increase in income induces an 86.6% increase in reserves. Since the major source of income in Nigeria is oil, it can therefore, be concluded that oil revenue is the driving force behind foreign reserves accumulation in Nigeria.
According to the Granger representation theorem, [37] when variables are co-integrated, there must also be an error correction model (ECM) that describes the short-run dynamics or adjustment of the co-integrated variables towards their equilibrium values. The result of the ECM is presented in Table 3. The lagged error term is negative and highly significant. The ECM shows that about 86% disequilibrium is corrected on a quarterly basis by changes in reserves. This implies that, in case of distortion in equilibrium, it takes less than two quarters for equilibriums to be re-established. Similarly, following equation 14, both the short run and long run results yielded the same sign for the selected 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 in the Short run as tabulated in Pesaran, Shin and Smith. [35] To test the stability of the equation and of the estimated parameters, the most often used techniques of cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests were adopted.

### Table 3: Error Correction Estimates of the ARDL Model

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.077762</td>
<td>-0.04067</td>
<td>-1.9118</td>
</tr>
<tr>
<td>ECM</td>
<td>-0.14062</td>
<td>-0.06653</td>
<td>-2.11364</td>
</tr>
<tr>
<td>D(DLR(-1))</td>
<td>0.259519</td>
<td>-0.1754</td>
<td>1.47962</td>
</tr>
<tr>
<td>D(DLR(-2))</td>
<td>0.180253</td>
<td>-0.18514</td>
<td>1.51377</td>
</tr>
<tr>
<td>D(DLR(-3))</td>
<td>-0.000356</td>
<td>-0.18963</td>
<td>-0.00188</td>
</tr>
<tr>
<td>D(DLR(-4))</td>
<td>0.322149</td>
<td>-0.19728</td>
<td>1.63299</td>
</tr>
<tr>
<td>D(DLY(-1))</td>
<td>-0.009935</td>
<td>-0.20601</td>
<td>-0.04822</td>
</tr>
<tr>
<td>D(DLY(-2))</td>
<td>0.145156</td>
<td>-0.189</td>
<td>0.76801</td>
</tr>
<tr>
<td>D(DLY(-3))</td>
<td>0.270128</td>
<td>-0.18008</td>
<td>1.50002</td>
</tr>
<tr>
<td>D(DLY(-4))</td>
<td>0.412412</td>
<td>-0.19107</td>
<td>2.15838</td>
</tr>
<tr>
<td>D(DLMPR(-1))</td>
<td>0.097355</td>
<td>-0.17191</td>
<td>0.5663</td>
</tr>
<tr>
<td>D(DLMPR(-2))</td>
<td>0.097052</td>
<td>-0.16187</td>
<td>0.59958</td>
</tr>
<tr>
<td>D(DLMPR(-3))</td>
<td>-0.190784</td>
<td>-0.16138</td>
<td>-1.1822</td>
</tr>
<tr>
<td>D(DLMPR(-4))</td>
<td>-0.162654</td>
<td>-0.1629</td>
<td>-0.99848</td>
</tr>
<tr>
<td>D(DLIM(-1))</td>
<td>-0.059179</td>
<td>-0.04754</td>
<td>-1.24493</td>
</tr>
<tr>
<td>D(DLIM(-2))</td>
<td>-0.019898</td>
<td>-0.04639</td>
<td>-0.4289</td>
</tr>
<tr>
<td>D(DLIM(-3))</td>
<td>0.04438</td>
<td>-0.04557</td>
<td>0.97383</td>
</tr>
<tr>
<td>D(DLIM(-4))</td>
<td>0.008091</td>
<td>-0.04367</td>
<td>0.18526</td>
</tr>
<tr>
<td>D(DLEXR(-1))</td>
<td>0.603001</td>
<td>-0.55589</td>
<td>1.08475</td>
</tr>
<tr>
<td>D(DLEXR(-2))</td>
<td>0.595922</td>
<td>-0.61601</td>
<td>0.9674</td>
</tr>
<tr>
<td>D(DLEXR(-3))</td>
<td>0.881633</td>
<td>-0.71738</td>
<td>1.22896</td>
</tr>
<tr>
<td>D(DLEXR(-4))</td>
<td>1.218052</td>
<td>-0.60577</td>
<td>2.01074</td>
</tr>
</tbody>
</table>

$R^2 = 0.596$  \[ F\text{-Statistics} = 1.544 \]
CUSUM (Figure 1) 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 of 5%. On the other hand, CUSUMSQ (Figure 2) instead uses 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, graphs of CUSUM (Figure 1) and CUSUMSQ (Figure 2) show that the parameters of the analyzed equation are stable given that the recursive errors lie within the two critical lines of both tests.

Conclusion and Recommendations

The study used an Autoregressive Distributed Lag (ARDL) approach (also known as bound testing approach) to co-integration to run a slightly modified econometrics 'buffer stock model' 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 a long run relationship among the determinants of reserves in Nigeria. It debunked the existence of buffer stock model for reserves accumulation and lends support to income as the major determinant of reserves management in Nigeria. However, since the major source of income is oil, it can therefore be concluded that oil revenue is the driving force behind foreign reserves accumulation in Nigeria.

In view of these findings, coupled with the fact that oil which is the country’s major revenue spinner, is an exhaustible asset, and the fact that the international community is seriously...
searching for a viable alternative to oil as source of energy, we hereby proffer the following recommendations:

i. There should be a constitutional provision or legislative act supporting savings of excess oil receipts over budgetary provision. This will further boost reserves accumulation;

ii. There should be changes in the assets portfolios of reserves, since most central banks across the globe have now moved into more dynamic instruments to achieve their returns objectives within certain acceptable risk parameters. Central Bank of Nigeria should follow suit by further diversifying the currency composition of reserves and portfolio management away from the dollar to other currencies such as the Pound Sterling, the Euro, Yen, Yuan and Saudi Riyal. The current situation where over 90.0 percent of reserves are held in the US dollar exposes the country to unacceptable risks and vulnerability that could arise from the probable nominal losses in the balance sheet arising from depreciation of the US dollar.

iii. Reserves should also be utilized to finance domestic infrastructural development. This will help in building more reserves. A good example is India where a sizeable portion of foreign reserves was used to finance infrastructure. Infrastructural development is capable of boosting productivity as well as diversifying the country’s export base from oil.

References:

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43. Suvojit LC. The optimal level of international reserves - the case of India. [internet]. Available from http://www.igidr.ac.in/money/mfc-11/Chakravarty_Suvojit.pdf