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Does Sterilization Policy Exert an Upward Pressure on Interest Rate as Dictated by Theory? A Nigerian Example

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Abstract

The implications of capital inflows on the economy and the fall out of the policy geared towards addressing these phenomena, especially the impact of the policy on interest rate motivated us in this study. Under the framework of ARDL and using monthly series over a period of 2010M1-2021M3, our findings showed that in the short-run, sterilization policy leads to rising interest rate in the current period. However, after a lag, sterilization policy depresses interest rate. We equally found that in the long-run, sterilization policy pushes interest rate up. In another direction, we observed a negative relationship between money supply and interest rate both in the short-run and in the long-run and the exogenous variables in the model influence interest rate significantly. We therefore recommend that different measures should be adopted to cushion the effect of unsustainable capital inflows to avoid repeated need for further sterilization and the increasing cost of sterilization in the long-run. It is also our advice that exogenous variables should be factored in when fashioning out a desirable interest rate in line with economic reality.

Keywords: Sterilization policy, Monetary policy, Capital inflows, Exchange rate, Interest rate, ARDL.
JEL Classification: E52; F38; F31; B23.

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Ethical: This study follows all ethical practices during writing.

Contents

Contribution of this paper to the literature

This study contributes to the existing literature by exploring whether the implementation of sterilization policy raises domestic interest rate in Nigeria as suggested by theory. We conducted this study by adopting a relevant proxy for sterilization policy which previous studies did not put into consideration.

1. Background to the Study

Capital inflows have become a veritable means of cushioning the effects of shortfall in revenue, especially for countries that usually experience adverse balance of payments position. This is mainly a case with most developing countries that are in dire need of additional resources to tide over occasional liquidity constraints. The current upsurge in capital inflows in developing countries, as observed by Calvo and Reinhart (1998) is a recent development. In the past, the study contended that the nature of capital that flows into the economies of developing countries used to be in the form of official transfers. Several factors have been noted to be responsible for this rising inflows; a major one been the relaxation of impediments to capital mobility across countries. Much as capital inflows are needed as a way of obtaining additional resources, they however come with some negative consequences if not well managed. As noted by Lee (1997) rising capital inflows has a tendency to cause an increase in monetary aggregates which is subject to diverse consequences such as domestic currency appreciation, rising inflation and so on. This situation arises as the monetary authorities intervene in the reserve accretion through purchase of foreign exchange. Such practice leads to rise in the monetary base of the domestic commercial banks, thus giving rise to growth in monetary aggregates.

Capital inflows in Nigeria have been increasing over the years, particularly since the country's discovery of oil in commercial quantity, though with some years of decline. Apart from the proceeds from the oil sector which has been noted as the major source of liquidity in the country, other sources of capital inflows include, among others; foreign direct investment, foreign portfolio investment, Diaspora remittances and growth in the external debt. Worthy of note is the recent upsurge in remittances which accounts for a large share of the country's gross domestic product (GDP). On realizing the importance of Diaspora remittances, the Central Bank of Nigeria (CBN) which is the official monetary regulatory authority has been putting measures on ground to attract remittances. Currently, the CBN, in order to shore up remittances, has been offering five naira for every dollar sent from abroad. Consequently, the country's reserves have improved owing to this policy.

From Figure 1 below, it can be seen that there is a rising trend in the sources of capital inflows in Nigeria since the start of the current democratic dispensation in 1999. These sources include: official development assistance (ODA), remittances (REM), external debt (Ext. Debt), foreign portfolio investment (FPI) and foreign direct investment (FDI). The consolidation of the banking sector and other reforms put in place around 2005 stimulated investor confidence within this period, thus leading to growth in inflows. Between 2007 and 2008, there was growth in the capital market activities due partly to conducive policies and bullish seasons in the advanced market economies which trickled down to the domestic economy in form of investments in the capital market. However, the economic meltdown of 2009 affected the country's capital inflows. Before 2016, external debt was low, however, the regime change in 2015 led to rising external debt which pulled up capital inflows.

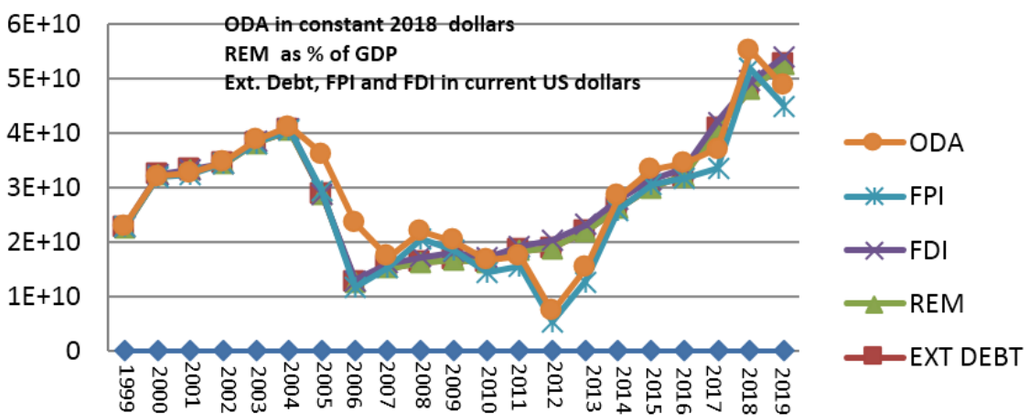

Figure-1. Trend in sources of capital inflows in Nigeria.

Countries witnessing excess and abrupt capital inflows therefore put measures on ground to avoid the likely negative consequences associated with the rising domestic money supply this could trigger off. Several measures are open to countries witnessing capital inflows in order to mitigate the monetary effects of this development. Some of these measures include: exchange rate intervention, fiscal tightening, transfer of government's deposit from the commercial banking system, sterilization policy among others. Among these measures, sterilization policy is usually given preference because of its timeliness of implementation and the absence of political interference associated with it. The popularity of sterilization policy has been noted by Lee (1997) and Reinhart and Reinhart (1998). The term sterilization policy are measures put in place to neutralize the monetary effect of reserve inflows through the open market sales of domestic securities and increases in reserve requirements (Takagi & Esaka, 1999).

In Nigeria, the CBN, in order to sterilize systemic liquidity, mainly adopts foreign exchange sales. As a follow up to this, the Bank also issues government bills and bonds in the primary market in addition to influencing the reserve position of commercial banks through change in the cash reserve ratio (CRR). In addition to these, Okpanachi (2013) observed that the CBN uses the repos and exchange rate swaps as well as withdrawal of public sector funds from the deposit money banks to mitigate the impact of rising inflows. In particular, the CBN has been using the open market operation (OMO) consistently just as she usually deliberates on the position of the cash reserve ratio in line with current money supply situation in each of her monthly monetary policy committee meetings.

Operationally, sterilization policy entails the monetary authorities altering the net domestic assets (NDA) in order to influence the change in net foreign assets (NFA). Thus, a rise in NFA indicates that the monetary authorities should anticipate rising money supply due to foreign exchange intervention. Consequently, the NDA is reduced to mitigate the effect of the rising money supply. However, the reverse is the case when the NFA falls. In Figure 2 below, within the period of 2018-2019 when capital inflows rose high, the CBN has been engaging in sterilization exercise as could be seen in the reduction in NDA owing to rising NFA. The band between NFA and NDA widens in any period when capital inflows associated with NFA rose very high.

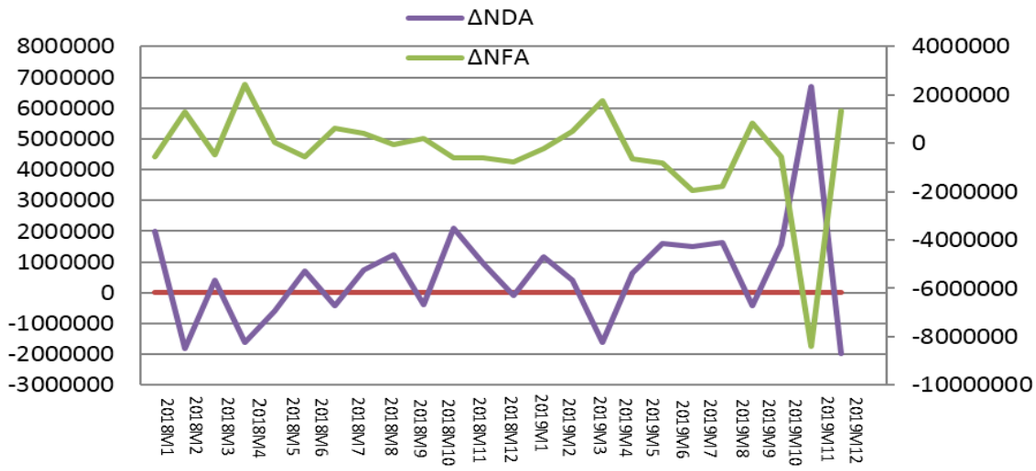

Figure-2. The relationship between ΔNDA and ΔNFA.

Notwithstanding the role of sterilization in neutralizing the monetary impact of capital inflows, it comes with its peculiar costs. The limits to the use of sterilization have been noted by Lee (1997) to include the fact that sterilization cannot be effective in the face of increasing capital mobility. The study also observed that sterilization policy can hardly work over a longer period if shocks are persistent as sterilization is not fashioned out to handle the underlying causes of shocks. One major fall out of sterilization that attracted our attention in this paper is that by reducing the NDA through open market sale of domestic bonds, interest rate differential can widen which leads to further round of capital inflows. Okpanachi (2013) corroborated this position as the paper contended that sterilization policy can hardly neutralize permanently, the risks relating to high and persistent flows. This is partly owing to the offsetting decrease in domestic assets that give rise to higher domestic interest rates in relation to foreign rates. Consequently, as noted by Ljubaj, Martinis, and Mrkalj (2010) the monetary authorities will find themselves in a vicious circle of implementing sterilization policy. The potential rise in domestic interest rate as a consequence of implementing sterilization policy therefore agitated our minds. We seek to investigate if this situation holds empirically and what monetary implications it portends, especially in Nigeria where domestic interest rate is comparatively high.

We are further motivated by the choice of a proxy for sterilization policy. Previous studies have always used the coefficient of NFA to proxy sterilization policy. It is our view that the argument for using the coefficient of NFA as proxy for sterilization policy can only hold water when investigating the degree of sterilization using the monetary policy reaction function, where any change in NFA is neutralized with a corresponding change in NDA. However, if the objective is in finding the impact of sterilization policy on any monetary policy variable, then the coefficient of NFA as a proxy for sterilization becomes weak. Using NFA to proxy sterilization in such study amounts to investigating the impact of capital inflows on the variable of interest which defeats the objective of sterilization policy. We thus depart from previous studies by applying total sterilization as a proxy for sterilization policy. The formula for calculating total sterilization was obtained from Lavigne (2008). The beauty of adopting this proxy is that, unlike the coefficient of NFA, it incorporates the two main measures to influence the reserve position of commercial banks, namely: the open market operation (OMO) and the cash reserve ratio. As observed by Lavigne (2008) "a measure of the total effects of all sterilization policies should integrate both market-friendly and non-market-friendly policies designed to limit domestic money multipliers".

1.1. Some Stylized Facts

The aftermath of capital inflows is to influence the reserve position of the capital recipient country. Nigeria's foreign reserves has been experiencing fluctuations over the years in line with the country's capital inflows. Figure 3 below shows that the country's reserves rose between 2007 and 2008. This was partly owing to the high global demand for oil which resulted in reserve accretion of that period. However, with the onset of recession around 2008 coupled with the militants' activities in the country's oil rich region of Niger Delta which crippled oil production, reserves began to witness a downward trend only to start picking up from 2012. The amnesty programme executed by the then administration within 2010 which was used to quell the militancy in the Niger Delta region led to an improvement in oil production, and this rubbed off on the country's reserves. As observed by Aghalino (2012) the amnesty programme was successful as could be witnessed in improved oil production and reduction in bunkering activities in the Niger Delta region. From 2013, the reserve position began to show rising trend up till 2014 partly due to increased oil price and relatively consistent policy of the then administration. As the leadership of the country changed baton in 2015, reserve position began to dwindle owing to the delay in the take off of the administration which affected the policy direction and thus eroded investors' confidence. Beginning from 2018, the reserves improved up till 2019 after which it experienced a downward trend. Currently, the reserves has depleted in such a way that the government has been clamoring for external debt procurement to shore up the reserves.

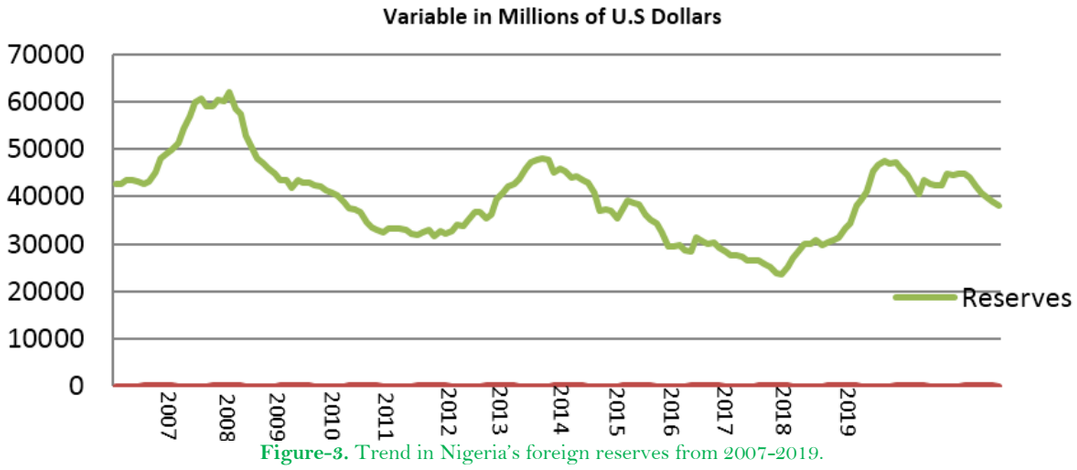

Figure-3. Trend in Nigeria's foreign reserves from 2007-2019.

Evidence in Figure 4 shows that the Treasury bill rate rose in 2019 up to around the third quarter and this growth corresponds with growth in external reserves. Apart from sterilizing the reserve inflows through the OMO, the government both at the state and federal level has been floating bonds to raise funds and all these led to the rising trend in the Treasury bill rate. Usually, Treasury bills rate are offered at a rate higher than the market rate. The essence of offering rates higher than the market rate is to make the bond attractive to investors because if foreign rates are more attractive, the subscription rate will be low and that could frustrate the sterilization effort of the monetary authorities. The success of the bond sell through the OMO is expected to neutralize the monetary impact of reserves accumulation. As reserves position began to decline around 2020 as depicted in Figure 3 above, OMO exercise began to slow down as evidenced from the declining trend in the Treasury bill rate.

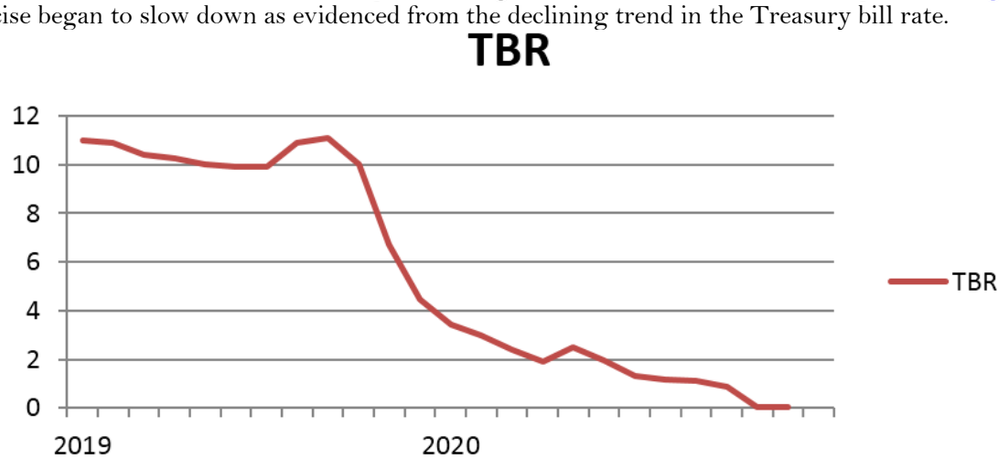

Figure-4. Trend in Treasury Bill Rate from 2019M1-2020M12.

Aizenman and Glick (2008) contended that reserves accumulation has some monetary implications. The study noted that when the monetary authorities purchase foreign reserve assets, funding arrangement of this policy should be made. Usually, the funding could be in the form of increasing the reserve money base or by reducing the net domestic assets. The former choice has the potential of being inflationary, while the later has impact on the domestic reserve money base. Lavigne (2008) noted that when a central bank purchases foreign exchange as a way of neutralizing the domestic currency appreciation, she can issue bonds in the domestic market to dampen the effect of this measure. Accordingly, such sterilization measure soaks up the domestic money supply arising from such purchase, thus effectively neutralizing its impact on domestic interest rates and inflation. In summary, the intervention of the monetary authorities to increasing capital inflows usually leads to rising money supply. Figure 5 below shows that since 1999, the broad money supply has been witnessing rising trend. Consequently, monetary authorities react by using different measures to mitigate the impact of this development on the macroeconomic environment.

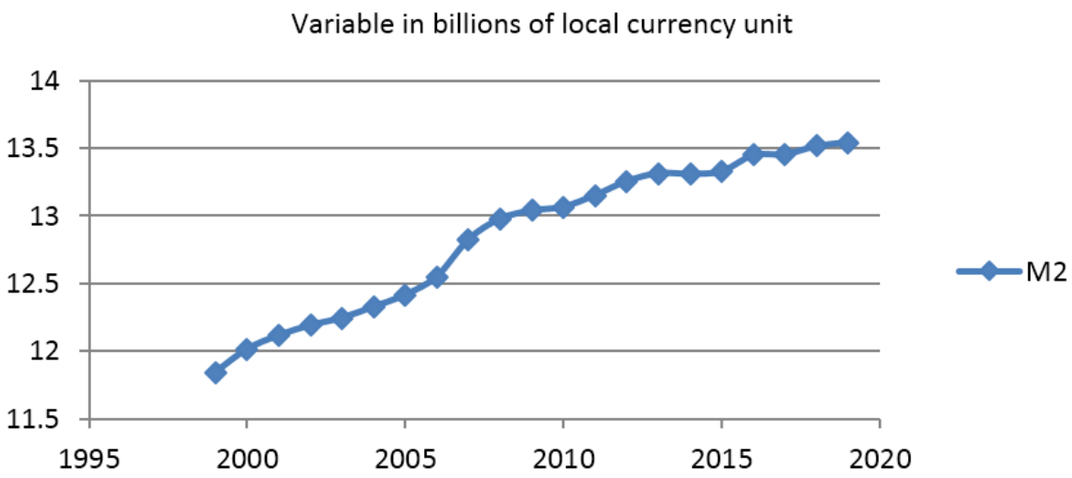

Figure-5. Trend in Nigeria's broad money supply (M2).

2. Literature Review

In this study we reviewed the basic literature at both country-specific and cross-country level.

2.1. Empirical Literature

The need to mitigate the monetary impact of capital inflows has led to several studies on sterilization across different countries. Using a multivariate dynamic regressions and a sample of quarterly data from 28 countries over the period 1990-2010, Bleaney and Devadas (2013) showed that broad money is sterilized to a significantly smaller degree than reserve money. In a study for Nigeria, Okpanachi (2013) showed that the degree of sterilization is significantly high. However, Chung, Hwang, and Wang (2014) revealed that Chinese monetary authorities sterilize almost all of the effects of international capital inflows and this study is in line with previous studies for China. Using the Vector Autoregressive (VAR) model, a cross-country analysis by Blanchard, Adler, and De Carvalho Filho (2015) revealed that the global financial cycle drives gross flows and exchange rate movements in most countries of the sample. Begum (2014) investigated the extent of sterilization of Bangladesh Bank and found that there exist a long run relationship between NDA and NFA. In a study for Pakistan, Khushk, Gilal, and Taherani (2015) finds that the Central Bank partially sterilizes its foreign exchange operation and for Egypt, Elhendawy (2015) showed the existence of a long-run positive relationship between sterilization and inflation.

In a country-specific study for Algeria, Djedaiet and Ayad (2017) showed evidence of full sterilization by the Algerian Bank, while in another cross-country study involving some emerging market economies; Ponomarenko (2019) found an incomplete sterilization. Arya, Cavoli, and Onur (2020) examines the relationship between foreign exchange rate and sterilization in 28 emerging market economies and showed that greater fixity of the exchange rate and sterilized intervention can potentially encourage capital inflows. In another for Nigeria, Nzeh, Nwogwugwu, Uzoechina, Chiedo, and Anyachebelu (2020) showed that the degree of sterilization is relatively high and significant and that there is also significant but low capital mobility. The degree of capital mobility is higher than that reported by Okpanachi (2013). Hoang, Nguyen, and Nguyen (2020) evaluated the effectiveness of sterilization in Vietnam and found that the State Bank of Vietnam (SBV) has not been able to fully neutralize the impact of inflows on the domestic money supply.

For Botswana, Mannathoko (2020) investigated why monetary policy failed to contain inflation in the 2000s decade. Findings showed how a series of policy decisions from 1999 led to substantial loss of monetary policy autonomy, large offsetting inflows, unsustainable sterilization costs, high inflation and real exchange rate appreciation. Nzeh et al. (2020) investigated the effectiveness of sterilization policy in controlling money supply and capital inflows in Nigeria. Findings of the study show that the sterilization policy of the CBN is effective in regulating money supply and depressing capital inflows both in period of normal capital inflows and in period of intensive capital inflows. In another study for Nigeria, Jume (2021) assesses the monetary policy response of the Central Bank of Nigeria (CBN) to increases in capital inflows. Results show that the CBN successfully offset 95 per cent of capital inflows in the period of analysis.

3. Analytical Framework

The analytical framework that guided our study is an adaptation of Edwards and Khan (1985). A major issue in the model is the altering of the conditions for money market equilibrium to include the effects of sterilization of capital inflows. Through this, the model examines how effective the sterilization exercise can place an upward pressure on domestic interest rates, thus returning interest rates at the level that existed before the capital inflows episode. One main assumption of the model is that the higher the capital mobility, the more the domestic interest rate will be influenced by external factors but as capital mobility decreases, interest rate is driven more by domestic variables. As modified by Cavoli (2005) the model can be explained as follows:

$$i_t = \mathrm{K} i_t^* + (1-\mathrm{K})\tau_t \qquad 0<\mathrm{K}<1 \qquad (1)$$

Equation 1 above represents the structural interest rate equation and it states that the domestic interest rate (i_t) is a weighted average of international monetary conditions (i^*_t) and domestic monetary conditions (τ_t). In the equation, K is a parameter that represents a country's level of capital mobility which lies between zero and one. The exogenous variable, represented by i^*_t, is measured by uncovered interest parity (UIP). This is expressed Equation 2 below as follows:

$$i^*_t = it^f + (e^e_{t+1} - e_t) \qquad (2)$$

Where t^f is a foreign-currency interest rate and e_t is the log of the current period exchange rate expressed in relation to the home price of external currency. The expected fall in the value of exchange rate in the next time period is represented by e^e_{t+1}.

In Equation 1 above, τ_t is the domestic nominal interest rate which serves as a (shadow) interest rate. This shadow rate captures conditions of disequilibrium which comes about by excess demand or supply of money. Cavoli (2005) contended that the shadow rate can be calculated as follows:

$$\tau_t = \varsigma + \Pi^e_{t+1} + \vartheta(\mathrm{m}^d_t - m_t) \quad (3)$$

where

ς = full equilibrium real interest rate.

Π^e_{t+1} = expected future inflation rate.

$\vartheta(\mathrm{m}^d_t - m_t)$ = a term that captures monetary disequilibrium.

The interest rate (τ_t) determined domestically can be derived from Equation 3 above. By implication, any excess (shortfall) of money demand (m^d) in relation to money supply (m^s) will lead to a rise (fall) in the interest rate determined domestically. As observed by Cavoli (2005) money demand is a function of the full equilibrium interest

rate, expected future inflation and income (y). The impact of sterilization policy geared towards neutralizing the fall out of reserve inflow enters into the expressions for the money stock and this can be represented as follows:

$$\Delta M_t = (1+\lambda)\Delta F_t \qquad \lambda \leq 0 \tag{4}$$

where

λ = sterilization coefficient which lies between zero and 1.

ΔF = change in Net Foreign Assets.

If we express Equation 4 in log form this becomes:

$$\Delta m_t = (1+\lambda)\,\mathrm{k}\,\Delta f_t \tag{5}$$

Thereafter, the money stock can be specified as thus:

$$\mathrm{m}_t = \Delta \mathrm{m}_t + \mathrm{m}_{t-1} \tag{6}$$

By substitution Equation 5 into Equation 6, this results into Equation 7 as follows:

$$\mathrm{m}_t = (1+\lambda)\kappa\Delta \mathrm{f}_t + \mathrm{m}_{t-1} \tag{7}$$

As noted by Cavoli (2005) the domestic interest rate can be calculated by substituting Equation 8 and 4 into Equation 3 so as to find τ_t which is substituted into Equation 1. Thus, accordingly, deriving the domestic interest rate requires specifying the following equation:

$$\mathrm{i}_t = \phi_0 + \phi_1\, \mathrm{i}^*_t - \phi_2 \Delta \mathrm{f}_t - \phi_3 \mathrm{m}_{t-1} + \phi_4 \pi^e_{t+1} + \phi_5 \mathrm{p}_t + \phi_6 \mathrm{y}_t \tag{8}$$

From 8 above, i = domestic interest rate, i* = foreign interest rate, Δf = change in reserve inflow which proxies sterilization policy, m = money supply, π = expected inflation, p = the price level and y is the growth rate of output.

3.1. Model Specification

Modified from Cavoli (2005) the model that guided our study is specified as follows:

$$PLR_t = \alpha_0 + \beta TSTR_t + \tau X_t + \mu_t \tag{9}$$

In this study, we utilized the Auto-Regressive Distributed Lag (ARDL) bounds co-integration approach developed by Pesaran, Shin, and Smith (2001). The choice of the model was first informed by the order of integration of the series which showed an admixture of I(1) and I(0), thus suggesting the suitability of the model. Secondly, it has been noted that whether the series are purely I(0) or purely I(1), the bounds testing approach can be applied to the model unlike the conventional co-integration techniques. Beyond these, we were also fascinated by the strengths of the model. One of these strengths is the fact that the ARDL co-integration approach has superior properties in small sample (Pesaran & Shin, 1999). Also, despite the endogeneity of some of the model's regressors, the model provides unbiased long-run estimates and valid t-statistics (Narayan, 2005; Odhiambo, 2009b). Finally, a simultaneity method of assessing the short and long-run effects of one variable on the other is guaranteed by the model (Bentzen & Engsted, 2001). In modelling the ARDL, a dynamic unrestricted error correction model (UECM) can be derived via a simple linear transformation. The UECM integrates the short-run dynamics with the long-run equilibrium without losing any long-run information.

According to Pesaran et al. (2001) F-test can be applied to determine the presence of a long-run relationship. This is achieved by restricting the coefficients of the lagged level variables (H_o: $\Psi_1 = \Psi_2 = \Psi_3 = \Psi_4 = \Psi_5 = \Psi_6 = \Psi_7 = 0$). Pesaran et al. (2001) computed two set of asymptotic critical values for ARDL co-integration test. These are the lower bounds critical values *I*(0) and the upper bounds critical values *I*(1). If the calculated F-statistics exceeds the upper bound critical value, we conclude in favour of a long-run relationship regardless of the order of integration. If the calculated F-statistics falls below the lower critical values, we cannot reject the null hypothesis of no co-integration. However, if the calculated F-statistic falls between the two critical bounds, inference would be inconclusive.

Generally, the ARDL approach can be specified as follows:

$$y_t = \eta_1 + yp - 1_{t-1} + \ldots\ldots \eta_p y_{p-1} + \lambda_0 x_t + \lambda_1 x_{t-1} \ldots\ldots + \varsigma_1 x_{t-p} + \mu_{1t} \tag{10}$$

Where t represents the trend values denoted as: $t = 1,2,3,\ldots\ldots T$

μ_t is the error term which is independently and identically distributed with zero mean and constant variance, ie $\mu_t \approx iid(0, \sigma^2)$.

Adopting Equation 9 above and by applying the ARDL approach to cointegration as exemplified in Equation 10, the ARDL that captures our objective is specified in Equation 11 as follows:

$$\begin{aligned} PLR_t = {} & \varphi_0 + \Psi_1 PLR_{t-1} + \Psi_2 TSTR_{t-1} + \Psi_3 M2_{t-1} + \Psi_4 INFLR_{t-1} + \Psi_5 EXCHR_{t-1} + \Psi_6 WOP_{t-1} + \Psi_7 FORINT_{t-1} \\ & + \sum_{j=1}^{k} \theta_{1j} \Delta PLR_{t-j} + \sum_{j=0}^{k} \theta_{2j} \Delta TSTR_{t-j} + \sum_{j=0}^{k} \theta_{3j} \Delta M2_{t-j} + \sum_{j=0}^{k} \theta_{4j} \Delta INFLR_{t-j} + \sum_{j=0}^{k} \theta_{5j} \Delta EXCHR_{t-j} + \sum_{j=0}^{k} \theta_{6j} \Delta WOP_{t-j} \\ & + \sum_{j=0}^{k} \theta_{7j} \Delta FORINT_{t-j} + e_{ti} \end{aligned} \tag{11}$$

Where: PLR = Prime lending rate, TSTR = Total sterilization, M2 = broad money supply (as a proxy for money supply), INFLR = Inflation rate, EXCHR = Exchange rate, WOP = wop oil price and FORINT = Foreign interest rate. θ_1 to θ_7 and Ψ_1 to Ψ_7 are the short-run and long-run parameters respectively. Δ is the first difference operator while *k* is the lag order. The residuals e_{it} are assumed to be normally distributed and white noise. The presence of a long-run relationship implies that we have to specify the Error Correction Model (ECM). With this, we will be able to estimate both the short-run and the long-run coefficients. The ECM is thus specified in Equation 12 as follows:

$$PLR_t = \varphi_0 + \Psi_1 PLR_{t-1} + \Psi_2 TSTR_{t-1} + \Psi_3 M2_{t-1} + \Psi_4 INFLR_{t-1} + \Psi_5 EXCHR_{t-1} + \Psi_6 WOP_{t-1} + \Psi_7 FORINT_{t-1} + \sum_{j=1}^{k} \theta_{1j} \Delta PLR_{t-j} + \sum_{j=0}^{k} \theta_{2j} \Delta TSTR_{t-j} + \sum_{j=0}^{k} \theta_{3j} \Delta M2_{t-j} + \sum_{j=0}^{k} \theta_{4j} \Delta INFLR_{t-j} + \sum_{j=0}^{k} \theta_{5j} \Delta EXCHR_{t-j} + \sum_{j=0}^{k} \theta_{6j} \Delta WOP_{t-j} + \sum_{j=0}^{k} \theta_{7j} \Delta FORINT_{t-j} + \delta ECT_{t-1} + e_{ti} \quad (12)$$

where: ECT is the error correction term and δ is the speed of adjustment

3.2. Variables and Data Sources

We employed monthly series covering a period of January 2010-March 2021. Prime lending rate was used instead of the official rate because prime lending rate moves in tandem with economic activities in Nigeria. The monetary policy rate which is the official rate is determined by the monetary authorities in their monthly committee meetings and in most cases these rates are left unaltered for several months. As can be seen in Appendix 1 below, the MPR stayed at 13.5% from March 2019 through April 2020. However, the prime lending rate has been fluctuating with different values all through the sample period, indicating that it is more attuned to the dynamics of the economy. In a similar vein, the Bureau De Change (BDC) exchange rate of domestic currency to the dollars was used because of its dynamic nature in the country's economy, being the rate that most economic agents patronize. International price of Bonny Light crude oil brand was used because that is Nigeria's crude oil brand. The foreign variables such as foreign interest rate and world oil price are included in the model to control for exogenous change in the global economic stance given that Nigeria is integrated to the world economy and she is import dependent such that she could be more susceptible to external shocks. Following Kim and Roubini (2000) we employed US Federal Fund rate (FFR) to proxy foreign interest rate. Also we followed Vinayagathasan (2013) that employed world oil price as proxy for expected inflation. Data on all the variables were sourced from the Central Bank of Nigeria Statistical Bulletin, except data on foreign interest rate that was obtained from the Federal Bank of St Louis.

4. Interpretation of Results and Discussion of Findings

4.1. Descriptive Statistics

The summary statistics of the variables used in the study are displayed in Table 1 below. The basic characteristics of the data over the study period are displayed in Table 1 and finding revealed that the variable that exhibited the highest mean is M2 with a value of 20,298,885 and with the value of 7,142,150 as the standard deviation. This result indicates a spread in the variable. On the other hand, we found TSTR to display the lowest mean, having the mean value of -2467.784 and a standard deviation of 1009555. TSTR also has the highest range of 23151707 which implies that over the study period, the variable exhibits some volatility in its trend.

Table-1. Result of Descriptive statistics.

	PLR	TSTR	EXCHR	FORNINT	INFLR	M2	WOP
Mean	16.23422	-2467.784	273.1013	1.577273	12.06089	20298885	5464427.
Median	16.65000	34100.37	222.9300	1.577273	11.70000	18965534	146.2281
Maximum	19.05000	2093049.	494.7000	2.490909	18.72000	38036535	38036535
Minimum	0.000000	-10529329	151.8500	0.500000	7.700000	10446374	75.06000
Std. Dev.	2.043495	1009555	115.4450	0.533675	2.983592	7142150.	12204595
Skewness	-4.380362	-8.471639	0.347535	-0.005709	0.443115	0.638267	1.820496
Kurtosis	31.85221	89.35932	1.568082	1.816326	2.331946	2.694889	4.433321
Probability	0.000000	0.000000	0.000804	0.019430	0.031300	0.007868	0.000000
Sum	2191.620	-333150.8	36868.67	212.9318	1628.220	2.74E+09	7.38E+08
Sum Sq. Dev.	559.5671	1.37E+14	1785890.	38.16446	1192.844	6.84E+15	2.00E+16

In order to ensure our variables behave well, we carried out a test of stationarity of the series. This test is particularly helpful in the choice of the model to be adopted. We considered both the Augmented Dickey-Fuller test (ADF) and the Phillips-Perron test (PP) in our study and our results were evaluated based on a 5% level of significance. Stationarity results in Table 2 below indicate that foreign interest rate exhibited stationarity at level under the ADF but non stationarity under PP. Also, total sterilization is stationary at level, but other variables are non stationary at level, that is, they are I(0). In Table 3 below, after a first difference, all the series become stationary, that is, they become I(1).

4.2. Tests for Stationarity

Table-2. Result of Stationarity at Level.

Variables	ADF t-stat.	PP t-stat.	ADF Critical value at 5%	PP Critical value at 5%	Order of integration
EXCHR	-2.883239	-2.883073	0.9207	0.9319	Non stationary
FORNINT	-2.884477*	-2.883073	0.0345	0.4453	ADF I(0)
INFLR	-2.883408	-2.883073	0.4863	0.5484	Non stationary
M2	-2.883073	-2.883073	1.0000	1.0000	Non stationary
TSTR	-2.885051*	-2.883073*	0.0022	0.0000	**I(0)**
WOP	-2.883073	-2.883073	0.9823	0.9846	Non stationary
PLR	-2.884477	-2.883073	1.0000	1.0000	Non stationary

Note: Figures with asterisks (*) indicate the rejection of the null hypothesis at the 5% level.

Table-3. Result of Stationarity at first Difference

Variables	ADF t-stat.	PP t-stat.	ADF Critical value at 5%	PP Critical value at 5%	Order of integration
Δ EXCHR	-2.883239*	-2.883239*	0.0000	0.0000	I(1)
Δ FORNINT	-2.884665*	-2.883239*	0.0000	0.0001	I(1)
Δ INFLR	-2.883408*	-2.883239*	0.0000	0.0000	I(1)
Δ M2	-2.883239*	-2.883239*	0.0000	0.0000	I(1)
Δ TSTR	-2.883579*	-2.883239*	0.0000	0.0000	I(1)
Δ WOP	-2.578420*	-2.883239*	0.0000	0.0000	I(1)
Δ PLR	-2.884477*	-2.883239*	0.0000	0.0000	I(1)

Note: Figures with asterisks (*) indicate the rejection of the null hypothesis at the 5% level.

As the series show an admixture of I(0) and I(1), we chose the ARDL to conduct the test of co-integration. In Table 4 below, we compared the F-statistic with both the upper and lower critical values at the 5% level. We were guided by the following conditions: if the value of the F-stat. is greater than the upper critical bound I(1), a co-integration exists. On the other hand, if the value of the F-stat. falls below the lower critical bound I(0), there is an absence of a co-integration. Results of finding in Table 4 below show that the F-stat. is 10.82689 which is higher than the upper critical bound (3.61) at the 5% level of significance. With respect to the finding, we conclude that a co-integration exists among the series. As a further confirmation of the co-integrating relationship among the variables, the result of the Error Correction Model (ECM) in Table 5 below indicate that the coefficient of ECM is negative and statistically significant, thus showing that a long-run relationship exists among the variables. The implication of the ECM result is that about 48% of errors generated in each period is automatically corrected by the system in the subsequent period.

4.3. ARDL Bounds Test

Table-4. ARDL bounds test result.

Test Statistic	Value	K
F-statistic	10.82689	6
Critical Value Bounds		
Significance	Lower Bound I(0)	Upper Bound I(1)
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

The short-run results indicate that without a lag, total sterilization positively impacts on prime lending rate even though the value of the coefficient is very minimal. This result is in line with a priori expectation of the rising interest rate owing to the implementation of the sterilization policy. As the monetary authorities float domestic bond as a way to neutralize the monetary impact of capital inflows, money supply is reduced which consequently lead to rising interest rates. The rise in interest rate has the tendency for further capital inflows which may lead to another round of sterilization. Nigeria's case in this direction is amplified by the already high interest rate in the country. However, after a lag, finding shows that a negative relationship exists between total sterilization and prime lending rate. We contend that the negative impact of sterilization after some lag could be due to the additional inflows made possible by increasing interest rate which is not instantaneously sterilized.

We noticed that exchange rate exerts a negative influence on interest rate in Nigeria even though this is not significant. The meaning of this is that as the domestic currency depreciates, interest rate falls. The macroeconomic impact of a depreciating domestic exchange rate could be the reason for the falling interest rate. As the country's currency weakens, there is a lull in business activities which transmits to the lending rate. Foreign interest rate impacts positively on the domestic interest rate. A rising foreign interest rate in relation to domestic interest rate means a capital outflow which impacts on domestic interest rate. The drain on liquidity as a consequence of capital outflow means that interest rate has to rise in order to reverse the outflow. Inflation rate also exhibited a positive impact on interest rate, however, this is not significant. A major headache of the monetary authorities in Nigeria is rising inflation which constantly puts a constraint on them to reduce interest rate even in the face of the destabilizing impact of high interest rate on the macroeconomic environment.

Money supply expectedly impacts negatively on interest rate which is in line with the dictates of theory. As money supply increases, the liquidity in banking sector rises which depresses the lending rate. The impact of oil price on interest rate is mixed. While, it negatively impacts on interest rate in the current period, its impact on interest rate is negative with a lag. The current period result is in line with a priori expectation as rising oil price leads to increased money supply which improves liquidity in the banking system, hence falling interest rate. This is mainly a typical scenario in Nigeria whose major source of revenue is the oil sector. After some periods however, rising oil price leads to fall in interest rate. We contend that this could be due to the policy measures put on ground which drains off the liquidity in the system, thus results in falling interest rate.

4.4. Results of ARDL with Selected Model: (3, 2, 0, 0, 0, 0, 4)

The information in Table 6 shows that all the series exhibited expected outcome. We opine that the reason for this could be because in the long-run when all policy constrains are relaxed the series exhibit their normal behaviour.

Table-5. Short Run Results.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(PLR(-1))	-0.152014	0.132392	-1.148204	0.2533
D(PLR(-2))	0.217696	0.134300	1.620967	0.1078
D(TSTR)	0.000001	0.000000	15.667895	0.0000
D(TSTR(-1))	-0.000000	0.000000	-2.304633	0.0230
D(EXCHR)	-0.000447	0.002303	-0.194128	0.8464
D(FORNINT)	1.737159	0.784671	2.213869	0.0288
D(INFLR)	0.046451	0.041861	1.109660	0.2695
D(M2)	-0.000000	0.000000	-2.039587	0.0437
D(WOP)	-0.000000	0.000000	-2.200915	0.0297
D(WOP(-3))	0.000000	0.000000	1.731812	0.0860
ECM	-0.476992	0.093753	-5.087773	0.0000

Table-6. Long –Run Results.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	15.573695	1.126301	13.827290	0.0000
TSTR	0.000003	0.000001	4.648281	0.0000
EXCHR	-0.000937	0.004825	-0.194278	0.8463
FORNINT	3.641905	1.386389	2.626901	0.0098
INFLR	0.097384	0.085456	1.139582	0.2568
M2	-0.000000	0.000000	-2.411642	0.0175
WOP	-0.000000	0.000000	-4.631758	0.0000

4.5. Results of Robust Tests

To further test the reliability of our model, we test for serial correlation, the normality of the model and model specification. Under the null hypothesis of the absence of a serial correlation, the Breusch-Godfrey serial correlation LM test in Appendix 2 below indicates that we do not have any reason to reject the null, thus showing that our model do not suffer from the problem of serial correlation. Also, under a null hypothesis that the model is well specified, the Ramsey RESET Test in Appendix 2 indicates that we cannot reject the null, revealing that our model is well specified. However, the test of normality indicates that the errors are not normally distributed and this could be attributed to the nature of data set we employed.

5. Conclusion and Recommendations

Our research endeavor is set out to investigate if sterilization policy influences interest rate in the direction inferred by theory in Nigeria. Theoretically, sterilization policy, through its depressing influence on money supply is expected to lead to rise in interest rate. We investigated this assumption using monthly series over a period of 2010M1-2021M3 under the framework of ARDL. Findings revealed that in the short-run, sterilization policy raises interest rate in the current period even though the impact is so negligible. However, after a lag, sterilization policy pushes interest rate to fall but without any visible impact. We also observed that in the long-run, sterilization policy raises interest rate. In another vein, results indicated the existence of a negative relationship between money supply and interest rate both in the short-run and in the long-run. The results of the exogenous variables we employed in the study show that while foreign interest rate exert a positive influence on domestic interest rate, oil price influences domestic interest rate negatively.

With respect to the foregoing results of our findings, we recommend that in the face of rising and unsustainable capital inflows, different measures should be adopted to cushion the effect of this on the macroeconomic environment. The rising interest rate associated with the implementation of sterilization policy is an indication that the continuous use of bonds to sterilize inflows is subject to further rounds of increase in inflows as foreign investors will like to avail themselves of the opportunity provided by the rising interest rate to push more short-term capital into the economy. Apart from the fact that this scenario could lead to repeated rounds of sterilization, the fiscal cost of funding the debt thrown up by the floating of the bond has to be put into consideration. We also recommend that in choosing the interest rate to adopt by the Monetary Policy Committee of the CBN, the impact of exogenous variables such as foreign interest rate and oil price should not be overlooked.

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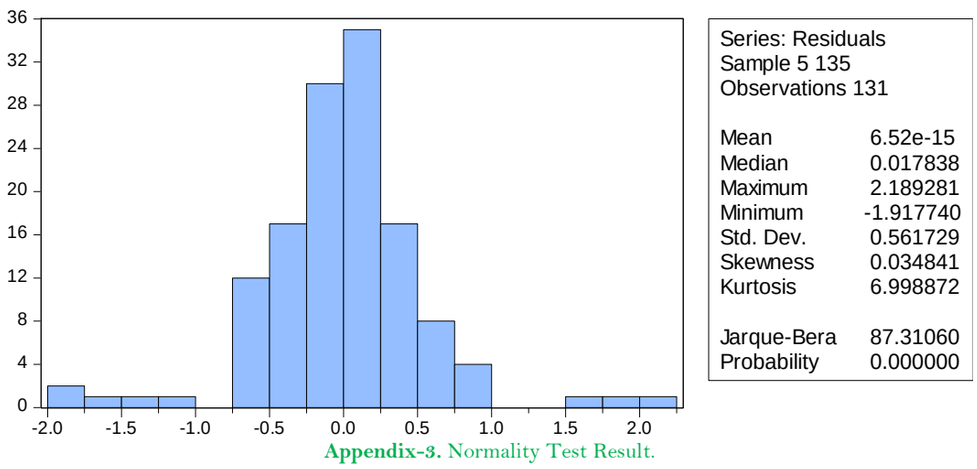
Appendix-1. MPR and Prime Lending Rate Figures for 2019-2020.

Prime Lending Rate												
Year	**Jan.**	**Feb.**	**March**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
2019	16.01	16.08	14.92	18.23	15.33	15.8	15.46	15.4	15.15	15.07	14.91	14.99
2020	14.97	15.04	14.71	14.92	14.73	15.65	12.1	11.76	11.55	11.31	11.6	11.35
MPR												
2019	14	14	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
2020	13.5	13.5	13.5	13.5	12.5	12.5	12.5	12.5	12.5	11.5	11.5	11.5

Appendix-2. Robust tests results.

Ramsey RESET Test			
	Value	**df**	**Probability**
t-statistic	7.512990	114	0.6890
F-statistic	56.44501	(1, 114)	0.4039
Breusch-Godfrey Serial Correlation LM Test			
F-statistic	1.051463	Obs*R-squared	2.393366
Prob. F(2,113)	0.3528	Prob. Chi-Square(2)	0.3022



Appendix-3. Normality Test Result.