An Empirical Assessment of Liquidity Management Instruments in Nigeria

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Abstract

The paper assesses the response of monetary policy target variables to liquidity management instruments, using a non-linear autoregressive distributed lag (NARDL) model. The analysis focuses on the short end of liquidity management and provides evidence of long-run asymmetric effects of liquidity management instruments, notably, the monetary policy rate (MPR) and excess reserves of banks on the inter-bank rate. The findings show that the impact of discretionary and autonomous liquidity factors remains symmetric. In addition, the policy target rate is more sensitive to a monetary contraction than accommodation.

Keywords: Liquidity Management, Monetary Policy Rate, Interbank Rate, Non-Linear Autoregressive Distributed Lag Models

JEL Classification: E43, E44, E51, E52, E58

I. Introduction

THe attainment of price stability as the ultimate objective of monetary policy in Nigeria is enshrined in the Central Bank of Nigeria (CBN) Act, 2007. The Act also empowers the Bank with instruments of liquidity management. In practice, however, the CBN targets complementary goals, including the pursuit of a stable exchange rate, promotion of economic growth, and financial stability. Meeting these broad objectives requires effective liquidity management (LM), which is part of the initial stages of the chain of events that culminate in the ultimate objectives of monetary policy. Liquidity management is conducted within a framework that identifies policy targets and the instruments for achieving them. It is a necessary activity of the Central Bank of Nigeria, given the liquidity swings from its official activities[1] and the flow of autonomous liquidity, periodic disbursements of funds to the three tiers of government, foreign investment flows, and currency inflows from commodity export. The practice involves the use of open market operation (OMO), discount window lending, and unconventional monetary policy to influence the level of bank reserves, and the interbank rate according to the prevailing policy stance. The interbank rate is critical, not only because it is influenced by the Bank's monetary policy, but also represents the short rate on any yield curve and has been found to have significant impact on the term structure (Tule, 2014). Targeting the

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[1] This is reserved for open market operations, foreign exchange market interventions, bank rescue, lending to government, and quantitative easing.

interbank rate apparently makes the interbank and the collateralised discount markets useful for monetary policy (Freixas & Jorge, 2008; Nather, 2019).

The sources and consequences of excess liquidity in Nigerian banks are well documented in the literature (Ukeje et al., 2015) and the implication of the high cost of liquidity management is also discussed in Nwosu et al. (2018). The frontier of knowledge is expanded by looking at the effectiveness of liquidity management instruments focusing on the interbank rate under the assumption that a bank's liquidity is equivalent to its excess reserves[2] since required reserves are largely stable. Also, the monetary policy rate is a signaling rate but plays a significant role in the evolution of the inter-bank rate by determining both idiosyncratic and aggregate recourse to the discount window.

The overall objective of the study is to assess the effectiveness of liquidity management instruments of the CBN focusing on the monetary policy target rate, notably, the average interbank rate. Specifically, the study aims at assessing the effectiveness of liquidity management instruments relative to autonomous liquidity factors in the evolution of the inter-bank rate. Among the motivations for the study are the persistent excess liquidity in banks and the high cost of liquidity management in Nigeria, persistent deviation of monetary aggregates from targets, inflationary pressures, volatility of interbank rates, and the spread of deposit and lending rates. These are critical challenges to domestic monetary policy. The study concentrates on the short end of monetary policy and asks the following questions: to what extent is the interbank rate sensitive to liquidity management instruments in Nigeria? and, is the relationship symmetric? Answers are provided by estimating the response of the policy target rate to liquidity factors and comparing results from linear and non-linear autoregressive distributed lag models. This provides a clear understanding of the total effects of liquidity management instruments on policy targets, which is a significant departure from the point estimates in Bulus (2010), Tule (2014), Obi-Nwosu et al. (2017) and Nwosu et al. (2018).

The paper is structured into six sections. Following the introduction, section 2 presents the review of the relevant literature. Section 3 highlights the stylised facts on the CBN's liquidity management Instruments. Section 4 discusses the model and data, while section 5 presents the empirical analysis. Section 6 concludes the paper.

[2] This is also the variable that is closely monitored for the deployment of open market operation (OMO) and/or lending to banks

II. Literature Review

II.1 Bank Liquidity and Liquidity Management

Liquidity is generally conceived to be the ease of trading in an asset(s), and an immediate capacity to meet one's financial commitments. It could also be described as the ability to meet the demand for liability items or loan requests. Liquidity is a critical requirement for financial intermediation and effective monetary policy. For monetary policy, liquidity encompasses bank reserves flowing from all activities of the central bank, maintained by banks with the central bank for clearing and reserve requirements or in the vaults of banks. Excess liquidity is total reserves less reserve requirements. Gray (2006) catalogues sources of (excess) liquidity into foreign reserves build-up, monetary financing, and bank rescue. The discrepancy in liquidity of deposit money banks is either met at the interbank market, where banks borrow from or lend to each other overnight or via the discount window provided by the central bank. Thus, liquidity management entails the central bank's influence on activities at the money market, essentially for the attainment of the nominal interbank rate, often within the corridor width for the standing facilities window. Changes in banks' liquidity with policy instruments are essential for meeting the demand, often split into required reserves and excess reserves, consistent with the policy stance. It follows that the deployment of liquidity management instruments, defined here to include open market operations (OMO), discount window activities, and reserve requirements would induce discretionary liquidity (dl) in banks. However, interbank market activities and the recourse to the central bank's standing facilities are also sensitive to shocks from autonomous liquidity (al) factors, that is, liquidity that emanates from other activities of the central bank. Thus, changes in banks' liquidity are due to both discretionary and autonomous liquidity.

II.2 Liquidity Management Processes

Liquidity management (LM) encompasses the rules central banks follow to steer the amount of bank reserves in order to control their price (that is, short-term interest rates) consistently with their ultimate goal (price stability). It takes place in a framework that determines the choice of instruments, operational and ultimate targets. The choice of an operational target is a macroeconomic problem since variables in the framework must not only be controllable but must also relate to target macroeconomic variables in a meaningful way (Bindsell, 2004). LM literarily links the daily monetary operations of the central bank to the overall economy by influencing the yield curve referring to the spread of long-term rate from the short term-rate(Bhattacharyya & Sahoo, 2011). The central bank influences the nominal short-term (inter-bank) rate and given the state of inflation, also the real rate. But other rates, especially long-term rates are largely silent in the model. Yet, they are the most important for aggregate demand and inflation. Thus, the relationship between liquidity management and the economy requires not only the monetary policy transmission mechanisms (MPT), but the mechanism that connects the policy rate with medium and long-term rates as well. This is anchored on the expectations hypothesis of the term structure (EHT), which provides the first connection between liquidity management and the macroeconomy, linking the relationship between the policy target rate and rates of different maturities. The theory holds that, in the absence of arbitrage opportunities in financial markets, counterparty credit risk, liquidity factors or a term premium related to the uncertainty about the future path of short-term interest rates, long-term interest rates, would equal the average of the current and successive short rate anticipated by economic agents. The simplest form is expressed as follows:

$$l_t = \frac{1}{2}(s_t + E_t s_{t+n}) + e_{t+1} \tag{1}$$

where l_t is the nominal long-term rate and E_t is an expectation operator, conditional on time t information that includes the current short-term rate, s_t and expected future short rate, n periods apart. Thus, a rise in long-term interest rates indicates that monetary policy has tightened and vice versa. Equation 1 is easily re-written as

$$Es_{t+n} - s_t = 2(l_t - s_t) + e_{t+1} \tag{2}$$

which relates the expected change in the short rate to the slope of the yield curve. In other words, the spread between short and long-term rates reflects the market expectations about the future path of the short-term rate, the policy rate. The veracity of EHT, therefore, lies in testing whether the hypothesis is true or not, which is obtained by validating the spread coefficient in equation 2.

If we assume an economy's monetary system that is characterised by the following Philips curve:

$$\pi_{t+1} = \pi_t + v_y y_t + b_z z_{t+1} + e_{t+1} \tag{3}$$

which expresses expected inflation by the previous level of inflation, the previous level of the output gap, $\mathrm{v_y} > 0$, expected exogenous factors anticipated by the central bank and an error term. The output gap:

$$y_{t+1} = v_y y_t + rer + b_z z_{t+1} - q_i i_t + \lambda_{t+1} \tag{4}$$

is explained by the previous output gap, the real exchange rate ($rer = e - \pi$), the expected level of exogenous factors and the real interest rate[3] ($i_t = ibr - \pi_t$)

The monetary policy rate is based on the Taylor rule:

$$s_t = f(y_t, \pi_{t+1}) \tag{5}$$

relating the policy rate adjustment to the output gap and expected inflation.

If we assume also that the central bank always achieves its target rate, i.e., $s_t = i_t = ibr$, the substitution of equation 5 into 1-4 brings to bear the relationship between liquidity management and the macroeconomy economy. The central bank influences the short-term interest rate and the term structure, via the expectations hypothesis. The evolving change in the term structure and liquidity condition influences aggregate credit, broad money supply, aggregate demand, and inflation. The transmission channels of monetary policy are well discussed in Mishkin (1996) and the relative effectiveness of the channels in Nigeria is also extensively discussed (CBN, 2011).

II.3 Quantity and Price Approach to Liquidity Management

The framework for liquidity management is generally either quantity targeting, price targeting or a combination of both. Quantity targeting relies on the direct impact of quantities, such as broad money supply on the targets. Thus, it prescribes targets for reserve money, bank reserves, aggregate credit, and broad money supply, derived mostly from a monetary programme. The outcomes are compared with the targets and the success defined in terms of hitting those targets at the end of the period. The theoretical foundation for quantity monetary targeting is the Fisher-Philips quantity-oriented monetary policy implementation that "builds the bridge between broad monetary aggregates and the central bank balance sheet" Bindseil (2004). The approach presumes money to be exogenously determined by the central bank and is controlled according to the following equation:

$$Ms = kB \tag{6}$$

where Ms is money supply and B is base money, comprised of currency-in-circulation and bank reserves, k is the money multiplier, or some reciprocal of the currency reserve ratio. The multiplier stands for the number of times the money supply changes from an adjustment to the money base. Thus, the money supply is exogenously determined by the central bank and is partly the reason behind the monetary policy rule (McCallum, 1988, 2003), which accords significance to bank

[3] This is more appropriately the long-term rate

reserves as the monetary policy target, against the direct target of short-term interest rate.

The quantity approach to liquidity management is challenged, however, by the randomness of the money multiplier (Peter et al., 2013; Muhammed et al., 2014; Michael, 2012) and the instability of the velocity of money, stemming often from innovations in financial products. These tend to affect the exogeneity of money supply and/ or its effectiveness on inflation control and growth.

Thus, the focus of liquidity management on bank reserves is not on its account but to influence the interbank rate within the corridor width for the standing facilities window. But where a central bank combines the two approaches, questions are generally raised on the rationale and relative effectiveness as discussed in Li-gang and Zhang (2007).

II.3.1 Direct and Indirect Liquidity Management

The process of liquidity management can be either direct or indirect, depending on the overall policy direction of the central bank. Direct methods include regulations and directives such as credit guidelines, interest rate controls, credit ceilings, and directed lending (William et al., 1996). This method is often considered repressive and inefficient in an environment characterised by full external account convertibility. The indirect approach allows the use of market-based instruments, like open market operation and standing facilities to influence liquidity in banks. It can be described as an approach that enhances the role of prices in the economy, providing direction to the central banks' view on inflation, the output gap or both. The process requires a *monetary policy rate (MPR)* to signal the policy stance. Taylor (1993) proposed setting such policy rates in terms of deviations of inflation and output from their trends, according to the respective weights accorded them by the policy stance. Literally, a policy tightening, causing a rise in the policy rate is expected to raise the interbank rate from the squeeze in banks' reserves. The objective is to influence banks' lending capacity[4], to curb the aggregate demand that is widening the output gap and/or pushing the boundaries of inflation. Seemingly, liquidity management is a chain reaction with potential breaks. First, the policy instrument is expected to influence the level of reserves that matches the demand for reserves. But the demand for reserves is also subject to cost and scale variables influencing financial intermediation generally, which are factored into short rates. Secondly, changes in bank reserves and the ensuing inter-bank rate are expected to influence other rates, liquidity conditions, the lending capacity of banks and aggregate demand. We test the efficacy of policy instruments on bank reserves in this paper.

[4] Like the monetary targeting, where there are options for acquiring liquidity such as foreign capital inflows or foreign loans, these restrictions may not hold for banks.

II.3.2 Liquidity Management and the Central Bank's Balance Sheet

The central bank makes investments in government bills and securities, conducts foreign operations, grants liquidity to banks, the government and the private sector, and conducts monetary policy. These activities create liabilities to the government and counterparties, currency in circulation, reserves, and capital on its balance sheet. An excess demand for the central bank's money is established when the stock of liabilities is greater than that of the assets. The central bank meets this demand mainly through open market operation (OMO), collateralised lending at the discount window (DW) or direct lending to banks[5]. Similarly, an excess of assets over liabilities induces excess liquidity that will need to be mopped up with the same instruments. It is thus, important, for the purpose of analysing liquidity management, to distinguish banks' liquidity, which is generated from liquidity management instruments from that which is influenced by autonomous factors. Table 1 reveals the main sources of autonomous liquidity, al, and policy/or discretionary liquidity, dl.

Table 1: Autonomous and Discretionary Factors Affecting Bank Reserves

Autonomous Liquidity Factors (al)	
Assets	**Liabilities**
Net Foreing Assets (nfa)	Currency in Circulation (cic)
Net Domestic Assets(nda)	Government Deposits(gd)
Investments in securities (sec)	Other Liabilities(ol)
Net float (nf)	Capital Account (ca)
Other assets	
Discretionary Liquidity Factors (dl)	
Open Market Operation (omo) (I)	Open Market Operation (omo)(W)
Standing Lending Facilities(SL) (I)	Standing Deposit Facilities (sd)(W)
	Bank Reserves(tr)

Autonomous liquidity flows from other core functions of the central bank asides from the use of traditional liquidity management instruments. It includes liquidity flow from foreign assets holding and its use for foreign exchange intervention, direct lending or investments in government securities, bank rescue operations, net float, and other asset items. From the liability side are those items, that are not part of bank reserves, such as currency in circulation, government and private sector deposits, holdings of central bank bills and capital. Since transactions on the items are conducted with the currency that is issued by the central bank, autonomous liquidity potentially keeps liquidity management active and progressively expensive[6]. The general

[5] This largely is adopted when traditional instruments become ineffective.

[6] The cost of liquidity management at the CBN has grown significantly over time, because of the implementation of heterodox monetary policies.

practice is for central banks to forecast and estimate autonomous liquidity as well as the demand for reserves, to guide the implementation of monetary policy.

Under normal financial conditions, dl is generated largely from open market operations, lending facilities, and currency reserves. These become the main (official) source of fluctuations in bank reserves and the interbank rate. Bank reserves, tr_s, are evidently a residual item on the Bank's balance sheet. Yet, it is an important one, being the vehicle for connecting the central bank's liquidity management with the broader macroeconomy. Apparently, the supply function of bank reserves can be expressed by the following identity:

$$tr_s = omo + (sl - sd) - al = rr_s + er_s \tag{7}$$

Equation 7 reads: the central bank estimates autonomous liquidity and applies policy instruments such that the supply of reserves meets the demand, divided between required reserves rr_s and transactions balances or excess reserves, er_s. In Nigeria, rr_s comprises the currency reserve ratio, crr and the liquidity ratio, lr. The ratios are met either through self-effort or via the recourse to the Bank's discount window. The crr is a prescribed fraction of some liability items of counterparties, maintained at the central bank according to the maintenance period, and lr is a prescribed fraction of banks' assets, maintained in the form of near-cash items. Although rr_s are technically not part of the daily liquidity management operations of the Bank, they directly affect the quantum of reserves that can be deployed for loans, and are, therefore, critical to the evolution of the inter-bank rate. Reserves over and above the rr_s constitute the excess or working reserves er_s, which is the component that is traded at the inter-bank funds market and/or invested at the standing deposit facilities. In this study, however, we assume that total reserves of banks accumulate from discretionary/policy liquidity, dl, and autonomous liquidity, al, and the reason for making the assumption is the aggregate impact of the central bank's activities on bank reserves.

$$tr_s = dl + al = rr_s + er_s \tag{8}$$

and could be considered in a functional form as:

$$tr_s = \mathrm{f}(\overset{+}{al}, \overset{-}{omo}, \overset{-}{sl_r}, \overset{+}{ibr}, \overset{+}{rr_s}) \tag{9}$$

This indicates the positive effects of autonomous liquidity on bank reserves, and the negative effects of net sales of bills to the banks, except where it is a net purchase, in which case, the relationship will be positive. Although it can be both ways, we assume that open market operation in Nigeria is often a mop-up exercise due to the excess liquidity in banks, such that the specified expectation holds. The equation also indicates the negative impact of the borrowing rate from the central bank, the market (interbank) rate and the positive impact of reserve requirements on the supply of reserves.

The demand for reserves by banks is derived from required and excess reserves. Although reserve accumulation by banks is also sensitive to risk-taking, investment opportunities and market structure (Hoffman & Sigaux, 2020), we considered banks' liquidity to be influenced by the size of and the macroeconomic fundamentals driving financial intermediation. Similarly, if the required reserve is a fraction c of total deposits, $c = rTD = rr_s$, then

$$tr_{\mathrm{d}} = c + er; \tag{10}$$

or

$$tr_{\mathrm{d}} = f(\overset{+}{c}, \overset{-}{ibr}, \overset{+}{sl_r}) \tag{11}$$

showing the positive effects of required reserves, the negative impact of the inter-bank rate and the cost of running short of reserves. The equality of the supply and demand for reserves generates the market equilibrium rate, the inter-bank market rate.

$$tr_{\mathrm{s}} = tr_{\mathrm{d}} = \mathrm{f}(al, omo, sl_r, ibr, c) = \mathrm{f}(c, ibr, sl_r) \tag{12}$$

From equations 8 to 12, the interbank rate is easily determined, where monotonic preference is assumed for the ibr:

$$ibr = f(\overset{-}{al}, \overset{+}{omo}, \overset{-}{sl_r}, \overset{+}{c}) \tag{13}$$

indicating the negative impact of autonomous liquidity on the interbank rate, the positive effect of excess liquidity mop-up, the negative effect of discount lending and the positive impact of reserve requirements. Equation 13 is the baseline model for the analysis. We include the monetary policy rate, mpr , as an explanatory variable, because it does determine the corridor width for the standing facilities as well as the relative patronage of banks at the standing facilities and the interbank market. Similarly, OMO and standing facilities are lumped under discretionary liquidity factors, while the cash reserve ratio is proxied by the banks' excess reserves, the reason being that CRR is often fixed for a considerable period but has a significant influence on excess reserves.

II.4 Empirical literature

Bianchi and Bigio (2017) develop a new tractable model of banks' liquidity management and the credit channel of monetary policy. They find that banks finance loans by issuing demand deposits, and because loans are illiquid, deposit transfers across banks must be settled with reserves. Deposit withdrawals are random, and banks manage liquidity risk by holding a precautionary buffer of reserves. They show how different shocks affect the banking system by altering the trade-off between profiting from lending and incurring greater liquidity risk. Through various tools, monetary policy affects the real economy by altering that trade-off. In a quantitative application, they studied the driving forces behind the decline in lending and liquidity hoarding by banks during the 2008 financial crisis. Their analysis underscores the importance of disruptions in interbank markets followed by a persistent decline in credit demand.

Freixas et al. (2011) provide a model of an interbank market which is affected by uncertainty about the distribution of liquidity shocks. Their model captured variation in banks' liquidity needs during the 2007-2009 global economic crisis. They provide a theoretical justification for the Federal Reserve's interest rate management and an explanation of how it contributed to the stability of the Fed Funds market. Freixas and Cornelia (2005), in the context of cross-border interbank markets, and Heider et al. (2009), in the context of recent crises, also examines the role of asymmetric information about banks' quality in the interbank market. Both studies show how an interbank market can freeze when the highest-quality banks stop borrowing due to severe adverse selection.

Van der Ghote (2018) develop a dynamic macroeconomic model of financial intermediation in which short-term funding is subject to liquidity risk. In the model economy he developed, financial intermediaries provide both settlement services to households and financial intermediary services between households and non-financial firms. The provision of settlement services exposes them to random withdrawal shocks on their short-term liabilities, financial intermediaries demand bank reserves, which are liquid assets whose quantity supplied and returns depend on monetary policy. He studied the real effects of targeting the width of the corridor between the official lending and borrowing rates of bank reserves. The study reveals that narrower interest rate corridors of bank reserves increase liquidity ratios when financial intermediaries on aggregate are net lenders of reserves, but decrease liquidity ratios when the opposite happens, and that narrower interest-rate corridors always increase leverage multiples.

Bruna (2012) examines the choice of exchange rate regimes and accumulation of foreign exchange reserves in the balance sheets of central banks and its consequences on the overall excess of banking system liquidity for the Czech

Republic, Poland, and Hungary during 1999 to 2009. The analysis focused on the main differences in the countries' exchange rate policies, the level of their liquidity surplus, cost of sterilisation, main sources of liquidity absorption and volatility of exchange rates. The study finds that absorption is influenced by the volume of excess liquidity and cost of sterilisation, which reflect the level of the main policy rate. The trend in the growth of currency in circulation is a key source of liquidity absorption in all the central banks. Decumulation of foreign exchange reserves is a limited source of absorption due to the lower liquidity of foreign exchange markets in the three countries. As expected, the trend in the appreciation causes a decrease in the backing of currency in circulation and bank reserves by net foreign assets but these items are still fully backed by the assets of central banks.

Mairafi and Hassan (2018) reveal that a bank's liquidity has a significant influence on banking outcomes such as the bank's performance, bank's risk-taking behaviour, moral hazard, and other financial risks. However, they found empirical evidence that all of these are majorly skewed towards developed markets and recommend further studies to provide additional insight for understanding the impact of liquidity on the performance, risk-taking behaviour, and moral hazard for banks. Thus, policymakers, banking regulators, shareholders and other stakeholders will be properly guided on the potential impact of banks' liquidity and their performance and risk-taking behaviour.

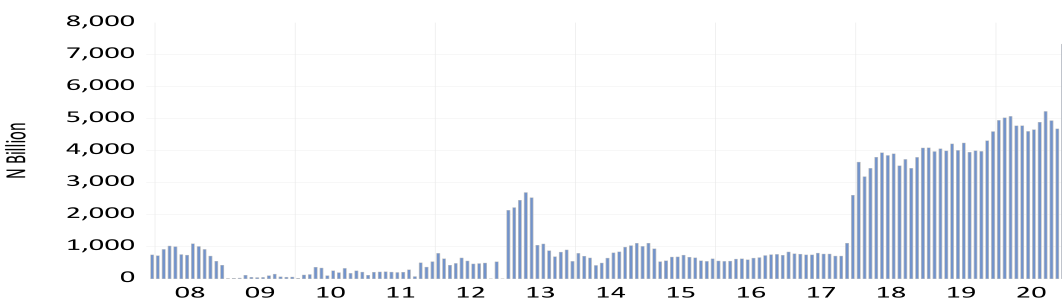
Biety (2003) asserts that the objective of liquidity management is to gear banks towards a financial position that enables them to meet their financial obligations as they arise. While the overall objective of monetary policy is the maintenance of monetary and price stability, the specific objectives of liquidity management according to the CBN are: ensuring solvency at all times for settlement of all cash outflow commitments (both on and off-balance sheet) on an ongoing daily basis; ensuring that funding is minimum, by avoiding raising funds at market premiums or through the forced sale of assets; ensuring compliance with the statutory liquidity and reserve requirements through the development of adequate management information system and internal control; optimising the refinancing structure and coordinating the issuance of own instruments in the money and capital markets; and optimising intra-group cash flows such as liquidity "pooling", to reduce dependency on external refinancing (CBN, 2011). A comprehensive liquidity management programme, therefore, requires the establishment of a sound liquidity management policy, improvement of funding strategies, development of contingency funding strategies to ensure that liquidity gaps are backed up, development of alternative scenarios in liquidity planning, and measurement of mismatches through gap analysis (Edem, 2017).

III. Liquidity Management Instruments in Nigeria

The institutional framework for liquidity management in Nigeria is derived from the CBN Act of 2007. The Act recognises price stability as the ultimate objective of liquidity management and grants the Bank instrument autonomy for its attainment. In practice, however, the Bank pursues other goals such as exchange rate and financial stability, economic growth, and full employment. The task of monetary policy and the direction for liquidity management is vested in the Monetary Policy Committee (MPC), which makes a prescription on the monetary policy rate, standing facilities, and reserve requirements that in turn influence the scale of open market operations.

With the adoption of the structural adjustment programme (SAP) in 1986, and the short-term (one-year) monetary policy framework (1986-2001), liquidity management instruments mostly included open market instruments using Nigerian Treasury Bills (NTBs) (Ibeabuchi, 2007) and CBN Bills. Currently, NTBs, are issued for 90-day, 180-day and 365-day tenors but mostly as short-term debt instruments for the Federal Government. CBN Bills are issued by the CBN but with the voluntary participation of individual counterparties, with the sale and purchases leading to withdrawal and injection of liquidity. Following the surge in banks' liquidity since the global financial crisis, holdings of CBN bills expanded from ₦0.43 billion in 2008 to ₦7, 333. 58 billion in 2020. Thus, open market operations have mostly been for liquidity mop-up. Figure 1 indicates a modest holding of CBN bills during the 2008 and 2011 periods, principally a reflection of the liquidity crunch that was observed during the 2007-2009 Global Financial Crisis (GFC). The holdings, however, grew significantly afterward on the back of the progressive implementation of heterodox monetary policy measures.

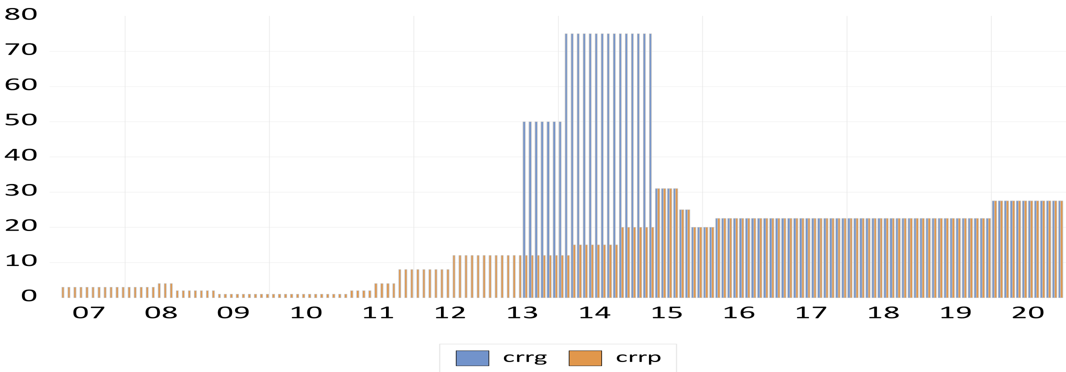
Figure 1: CBN Bills Holding



Source: Central Bank of Nigeria.

Reserve Requirements: Prescribed private cash reserve ratio (CRR) averaged 4.5 per cent and ranged between 1.0 per cent and 12.0 per cent between 2007 and 2013. Public sector CRR, prescribed in July 2013 stood at 50.0 per cent from the start but was raised to 75.0 per cent in February 2014. The two were merged to 31.0 per cent in May 2015 and declined to 22.5 per cent in December 2019, consistent with the Bank's accommodative monetary policy stance (Figure 2). The rise in the cash reserve ratio reflects the persistent liquidity problems in banks.

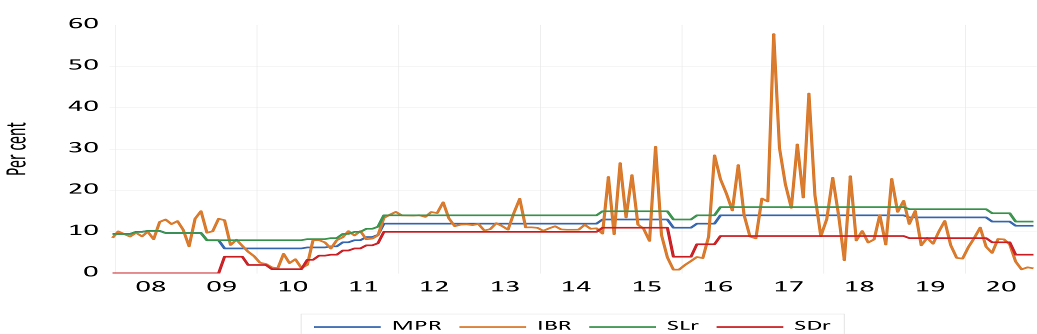
Figure 2: Cash Reserve ratio



Source: Central Bank of Nigeria.

The Monetary Policy Rate (MPR) is set by the MPC to signal the stance of monetary policy. It is based on the Taylor Principle (Taylor, 1993) and has been adjusted several times. During the review period, the MPR alternated between tightening and easing cycles, purposely to guide the inter-bank rate, asset prices, capital flows and the price level. Notwithstanding facilities rates intrinsically linked with it, the MPR is expected to pull the interbank rate towards the relevant standing facilities rate, which enables the CBN to regulate bank reserves and the inter-bank rate. Figure 3 shows the interbank rate mimicking the contours of the MPR, from 2008 to 2014. It showed slight volatility but was largely contained around the corridor width for standing facilities. However, from 2014 the rate oscillated significantly following an economic slowdown and recession that disrupted banking system liquidity and the efficacy of traditional monetary policy instruments.

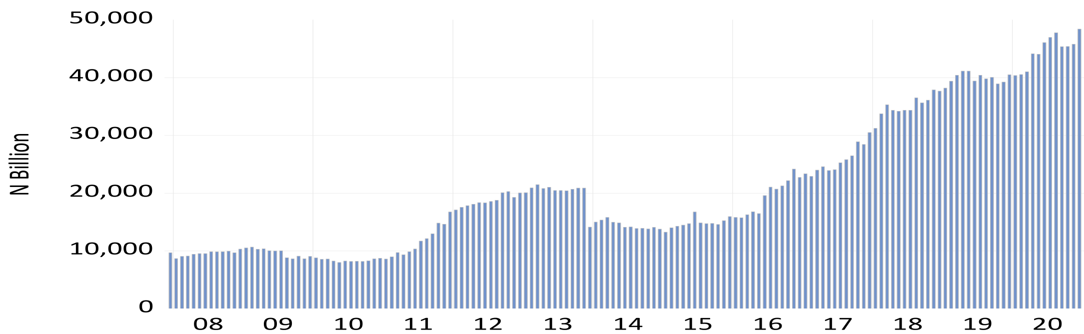
Figure 3: Monetary Policy Rate, Interbank and Standing Facilities Rates



Source. Central Bank of Nigeria.

Balance sheet policies (BP) are evoked when traditional monetary policy instruments – MPR, OMO and SF become ineffective at influencing banks' liquidity, the interbank rate and aggregate demand. This appeared to be the case between 2014 and 2016 when the inter-bank rate oscillated significantly. Consequently, the use of balance sheet or *unconventional monetary policy (UMP)* measures intensified to stabilise the financial system and the economy. The measures mostly involved quantitative and credit easing, including bank rescue, or direct lending to the government and the private sector. These tend to expand the Bank's balance sheet and induce structural excess liquidity in the banking system. Figure 4 shows a modest rise in the CBN balance sheet by assets between 2008 and 2010, and a phenomenal expansion following the massive liquidity support to banks, the purchases of bad assets during the 2008/2009 GFC and significant real sector intervention programmes by the CBN[7]. The implication of balance sheet expansion on economic variables has been more effective when the balance sheet is less concentrated (Kure et al., 2019).

Figure 4: Central Bank of Nigeria Assets



Source: Central Bank of Nigeria.

III.1 Autonomous and Discretionary Liquidity Factors

The expansion in the Bank's balance sheet reflects the growth of structural liquidity (SL) in banks. Figure 5 indicates an increase in autonomous liquidity, rising to over ₦48 trillion at the end of December 2020, relative to discretionary liquidity (DL), which was just above ₦7 trillion. Clearly, structural liquidity could be a major cause of the rise in the cost of liquidity management by the central bank as indicated in Nwosu et al. (2018).

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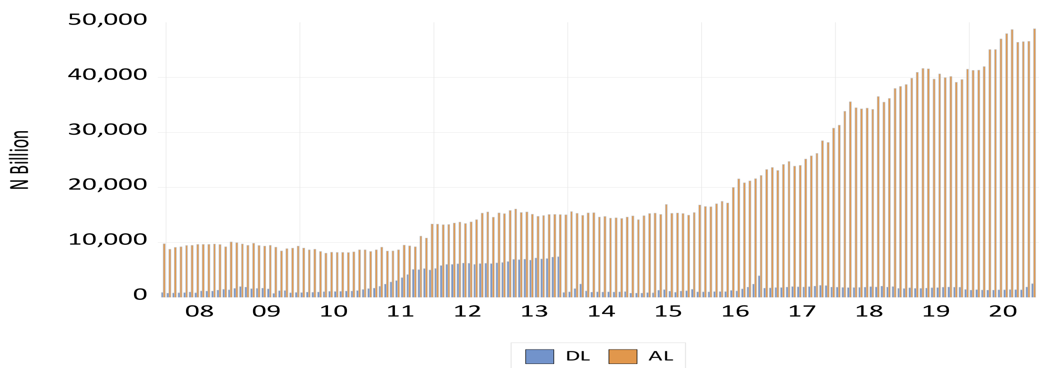
[7] There are currently over thirty real sector intervention programmes, supported by the Central Bank of Nigeria.

Figure 5: Component of Banks' Liquidity (₦Billion)

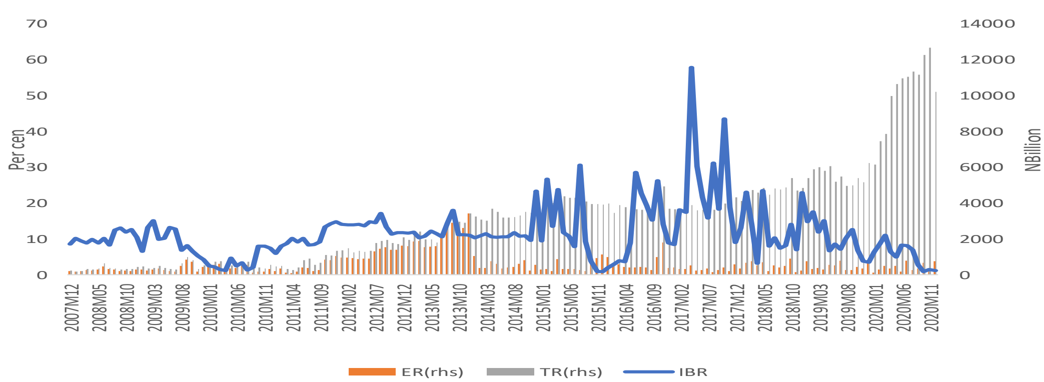


Source: Central Bank of Nigeria.

III. 2 The Responses of Policy Target Variables

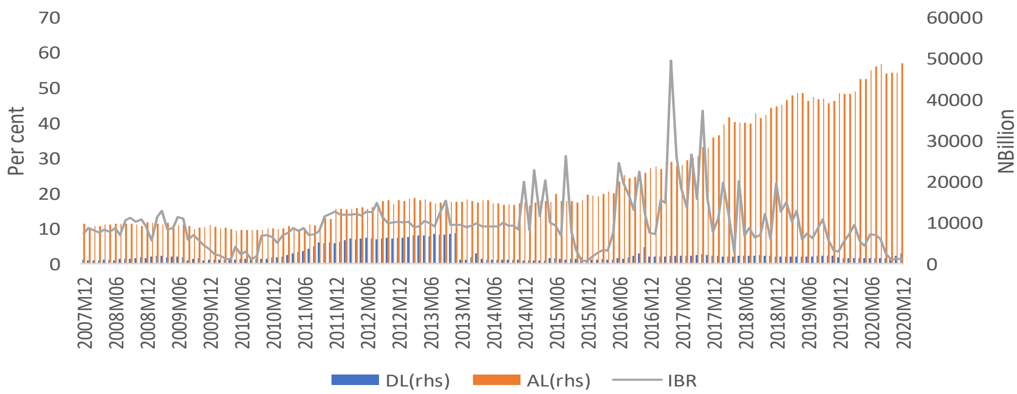
The central bank's liquidity management should have some discernable influence on bank reserves, the term structure, asset prices, aggregate demand, and the price level. Figure 6a shows an inverse movement of the interbank rate with liquidity in banks, represented by total and excess reserves, the volatility of the rate notwithstanding. The expected negative relationship is, however, more pronounced with total reserves, making required reserves a significant determinant of the banks' reserves. Similarly, Figure 6b shows the interbank rate to be more sensitive to autonomous liquidity than discretionary liquidity, reinforcing the significance of autonomous liquidity in liquidity management and the need for its appropriate forecast for effective liquidity management.

Figure 6a: Inter-Bank Rates (%) and Bank Liquidity (₦'Billion)



Source: Central Bank of Nigeria.

Figure 6b: Interbank rate and Discretionary and Autonomous liquidity



Source: Central Bank of Nigeria.

The graphical evidence presented requires some empirical validity. First, it is important to determine the responsiveness of the policy target rate to liquidity factors. Second, it is also important to determine the responsiveness of other interest rates to changes in the policy target rate. Third, is the need to assess the relative effectiveness of the price and quantity approaches to liquidity management.

IV. Empirical Methodology

IV.1 The Model

The central bank supplies bank liquidity to meet the demand for reserves. Consequently, the interbank market rate emerges to clear the market. Therefore, the target of bank reserves is not its account but for influencing the inter-bank rate towards the relevant standing facilities rate. The inter-bank rate is, therefore, assumed to be sensitive to the monetary policy rate, discretionary and autonomous liquidity factors in the demand for bank reserves as well as the stock of excess reserves. To put some perspective on the dynamics, we assume a linear functional relationship between the dependent variable, the average interbank rate and liquidity factors.

$$y_t = f\sum_{t=1}^{n} x_{it} + e_t \qquad (14)$$

where y_t is the dependent variable and in this case, the average inter-bank market rate, x stands for explanatory variables, $i = 1, 2, 3, ..n$. The error term e_t is an exogenous shock to the dependent variable. We start with an autoregressive distributed lag (ARDL) model for long-run cointegration among the variables, based on preliminary checks on the stochastic properties of the variables. The ARDL model was developed by Pesaran and Shin (1999) and relates changes in a vector of endogenous variable(s) to their levels as well as the history of all the variables in the model.

$$\Delta y_t = \alpha_1 + \sum_{i=1}^{n} \phi_{1y} \Delta y_{t-i} + \sum_{i=0}^{m} \phi_{1x} \Delta x_{t-j} + \varpi_{1yt} y_{t-1} + \varpi_{1xt} x_{t-1} + \upsilon_t \tag{15}$$

y_t is a $kx1$ vector of endogenous variables and Δ is a change operator, x_t is a kxk vector of explanatory variables, α_1 is a $dx1$ vector of deterministic terms, ϕ_t and ϖ_t are the short-and long-run coefficients, respectively, and υ_t is the $kx1$ vector of mutually and serially uncorrelated shocks. The ARDL method estimates $(p+1)^k$ regressions for the optimal lag length for each variable in the model, where p is the maximum number and k, the number of variables in the model. So, with an appropriate lag structure, the cointegration test is carried out by testing the significance of the long-run parameters, equivalent to an F-test of the null hypothesis: $Ho: \varpi_s = 0$, against the alternative $H_1: \varpi_s \neq 0$, $s = 1,2,3,\ldots$,. The rejection of the null hypothesis is based on an F-statistic greater than the uppermost critical values of Pesaran et al. (2001). The presence of symmetric long-run cointegration among the variables would require an error correction reformulation of equation (15) for the long-run and short-run estimates, as well as the adjustment to long-run equilibrium from temporary deviation.

$$\Delta y_t = \alpha_3 + \sum_{i=1}^{n} \phi_{2y} \Delta y_{t-i} + \sum_{i=0}^{m} \phi_{2x} \Delta x_{t-j} + \lambda ect_{t-1} + \varepsilon_t \tag{16}$$

Where λ is the coefficient of the error correction term, ect, which shows the speed of adjustment to long-run equilibrium from a temporary short-run disequilibrium.

The error correction model (16) produces point estimates that obviate the possible asymmetric response of macroeconomic variables. Since Shin et al. (2014), the non-linear autoregressive distributed lag (NARDL) model has become a credible analytical framework for empirical analysis of non-stationary data. NARDL extends the basic ARDL model to show possible asymmetrical responses of the endogenous variables to changes in the explanatory variables. This is captured in the following non-linear representation of equation (15).

$$\Delta y_t = \alpha_4 + \sum_{i=1}^{n} \phi_{3y} \Delta y_{t-i} + \sum_{j=0}^{m} \phi_{3x}^{+} \Delta x_{t=j}^{+} + \sum_{k=0}^{m} \phi_{4x}^{-} \Delta x_{t=k}^{-} + \varpi_{2yt} y_{t-1} + \varpi_{2xt}^{+} x_{t-1}^{+} + \varpi_{3xt}^{-} x_{t-1}^{-} + \upsilon_t \tag{17}$$

where;

$$x_t^+ = \sum_{j=1}^{t} \Delta x_j^+ = \sum_{j=1}^{t} \max(\Delta x_j, 0) \tag{18}$$

and

$$x_t^- = \sum_{j=1}^{t} \Delta x_j^- = \sum_{j=1}^{t} \min(\Delta x_j, 0) \tag{19}$$

x_t^+ and x_t^- are partial sums of positive and negative changes in x_t on y_t. The bounds test for cointegration is also an F-test of Pesaran *et al.* (2001) for large samples and Narayan (2005) for small samples, equivalent to testing the null hypothesis, $H_0 : \varpi_{2yt} = \varpi_{2xt}^+ = \varpi_{3xt}^- = 0$ against the alternative, $H_0 : \varpi_{2yt} = \varpi_{2xt}^+ = \varpi_{3xt}^- \neq 0$.

The rejection of the null hypothesis indicates the presence of long-run cointegration with asymmetry, requiring an asymmetric error correction representation of equation 16 for the long-run relationship:

$$\Delta y_t = \alpha_5 + \sum_{i=1}^{n} \phi_{4y} \Delta y_{t-i} + \sum_{j=0}^{m} \phi_{5x}^+ \Delta x_{t=j}^+ + \sum_{k=0}^{m} \phi_{6x}^- \Delta x_{t=k}^- + \varphi ect_{t-1} + \eta_t \tag{20}$$

where φ the error correction coefficient determines the speed of adjustment to long-run asymmetric equilibrium. However, making a conclusive judgment on the long-run asymmetric response of the dependent variable requires testing the statistical significance of the long-run asymmetric effects ($Lx_+ = \frac{-\varpi_{2xt}^+}{\varpi_{2yt}}$ and $Lx_- = \frac{-\varpi_{3xt}^-}{\varpi_{2yt}}$), and short-run effects ($Sx_+ = \sum_{i=0}^{m} \phi^+$ and $Sx_- = \sum_{i=0}^{m} \phi^-$), equivalent to testing the null hypotheses:

$H_0 : \frac{-\varpi_{2xt}^+}{\varpi_{2yt}} = \frac{-\varpi_{3xt}^-}{\varpi_{2yt}}$ against the alternative $H_A : \frac{-\varpi^+_{2xt}}{\varpi_{2yt}} \neq \frac{-\varpi^+_{3xt}}{\varpi_{2yt}}$ for long-run asymmetry and $H_0 : \sum_{i=0}^{m} \phi^+ = \sum_{i=0}^{m} \phi^-$ against the alternative $H_A : \sum_{i=0}^{m} \phi^+ \neq \sum_{i=0}^{m} \phi^-$ for short-run asymmetric effects.

Rejecting the null hypotheses implies the presence of long-run and short-run asymmetry, respectively, validating dissimilarities in the response of the endogenous variable to positive and negative shocks. Similarly, the cumulative dynamic multipliers are obtained from $m_h^+ = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^+}$ and $m_h^- = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial x_t^-}$, for $h = 1, 2, 3, ...,$. It shows the response path of the target variable to long-run equilibrium following negative or positive shocks in the explanatory variables.

IV.1 The Data.

We used monthly data from 2007M12 to 2020M12, obtained from the statistical database of the CBN. The period of the study is important as it marked significant events that had implications for the Bank's liquidity management, including the change in the monetary policy implementation framework; the global financial and economic crises of 2007 to 2009; the 2016 economic recession, and the active utilisation of balance sheet policies for monetary policy. The new monetary policy implementation framework introduced an interest rate corridor for the standing facilities that would shape the evolution of the interbank rate. Also, the GFC-induced liquidity crunch led to volatility in banks' liquidity and the inter-bank rate, causing specific changes in monetary policy implementation. These included: a reduction in the monetary policy rate and guarantees for inter-bank transactions; liquidity support for banks and expanded utilisation of balance sheet policies by the CBN to encourage interbank transactions and economic activities. The economic recession caused substantial disruptions to money market liquidity, and volatility in the interbank rate, during which period, traditional monetary policy instruments clearly failed to keep the target rate within the corridor. The evolving volatility of the key variables in the model required appropriate dummy variables to account for the developments. The relationship between the inter-bank rate and liquidity factors is specified in the following non-linear form:

$$ibr = f(mpr^+, mpr^-, dl^+, dl^-, er^+ er^-, al^+, al^-) \quad (21)$$

The inter-bank rate (IBR) is the target rate for liquidity management, achieved through the Bank's influence on the interbank and collateralised discount markets. Activities at the two markets influence the interbank rates, which are intrinsically linked with the monetary policy rate. It is observed that open market operations, discount lending and the currency reserve ratio collectively induce discretionary liquidity dl and bank reserves. One shortcoming of this assumption, however, is that the possible asymmetric responses of the policy-target rate to open market operation and standing facilities are subsumed. Although Bhattacharyya and Sahoo (2011) is of the view that unconventional monetary policy can also be a source of discretionary liquidity under financial stress, we, however, considered liquidity flow from unconventional policy measures to be majorly encapsulated in the autonomous liquidity, al component. The currency reserve ratio (*crr*) is discussed in the model, but only in the context of its influence on excess reserves,

er, or liquidity in banks. The monetary policy rate, mpr, indicates the central bank's stance on interest rates movement. It sets the corridor width for the standing facilities and the inter-bank rate and sets the benchmark for all other rates in the market.

V. Empirical Results

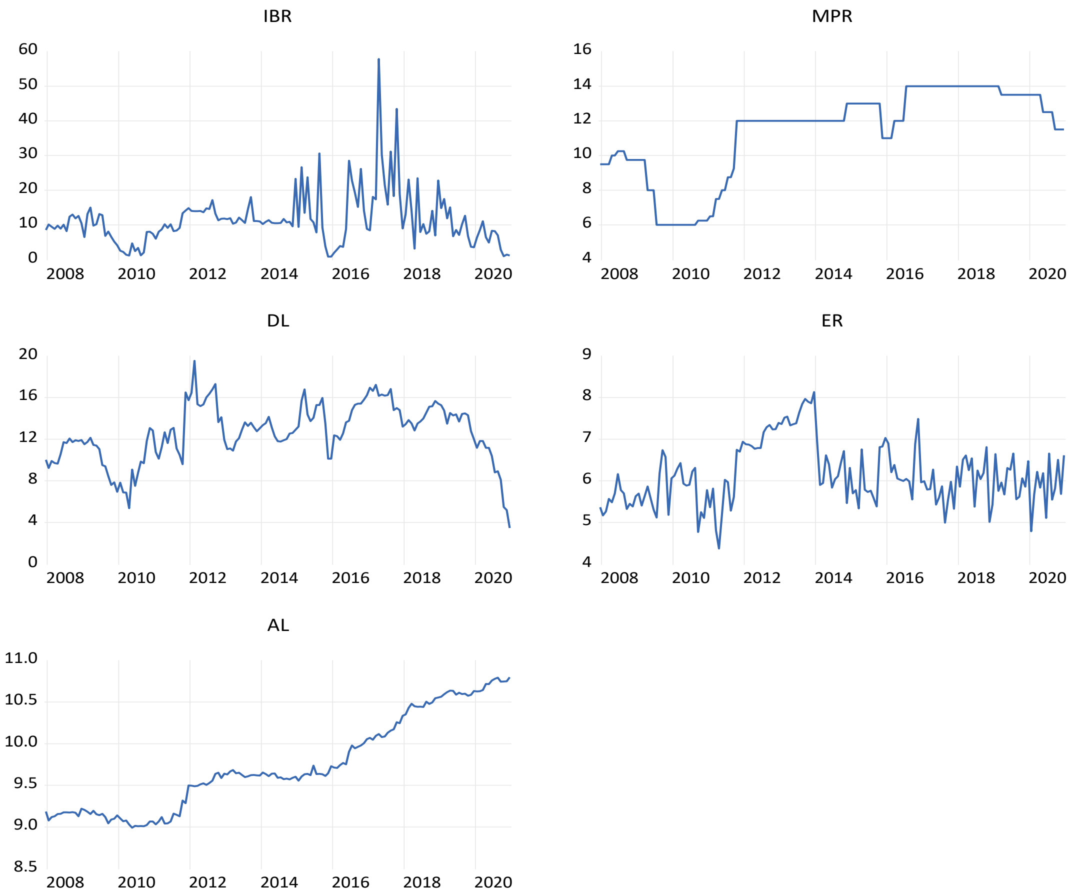
The results of the study are presented in this section. Table 2 provides the summary statistics for the variables and Figure 7 contains the graphical view. From inspection, the variables generally appear to be stable around their means, with no outliers observed. However, the average inter-bank rate, of 11.4 per cent ranged between 0.87 and 57.81 per cent and exhibited significant volatility during the period of the study, with kurtosis exceeding 3, same for the other two variables, while two are mesokurtic. Excess reserves, discretionary and autonomous liquidity averaged ₦627.3 billion, ₦20,150.8 billion and ₦2,324.9 billion, respectively. The graphs of the variables in the model showed that one variable, al, exhibits a significant trend, while others such as er exhibit some breaks that needed to be accounted for. The graphical view also showed relative stability but some breaks, oscillation, and trends, are observed and factored in the test for stationarity of the variables.

Table 2: Summary Statistics

	Mean	Med	Max	Min	S.D.	Skew	Kurt	Obs
IBR	11.44	10.50	57.81	0.87	7.63	2.30	12.55	157.00
MPR	11.37	12.00	14.00	6.00	2.58	-0.97	2.73	157.00
ER	627.28	412.69	3,409.52	79.36	576.68	2.30	8.89	157.00
AL	20,150.8	15,249.64	48,865.51	8,028.44	12,204.11	0.97	2.55	157.00
DL	2,324.90	1,640.88	7,408.26	719.27	1,901.90	1.56	3.90	157.00

Source: Central Bank of Nigeria.

Figure 7: Variables in the Model



Source: Central Bank of Nigeria.

V.1 The linear estimates

Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) are commonly used tests for a unit root in time series analysis. Their reliability is, however, limited in the case of variables exhibiting structural breaks, as ignoring such can lead to false acceptance/ rejection of the null of unit root (Perron, 1989). Thus, it became necessary to account for structural breaks in the unit root tests by using a Zivot-Andrews unit root test on the variables. The unit root test results are presented in Table 3, and indicates that two variables are stationary at levels, while three are stationary at first difference. Thus, to account for the impact of such breaks in the series, we included dummy variables that took values of zero for the periods before the break dates and 1 after the dates. But the empirical estimates produced insignificant coefficients for the variables, and they were subsequently dropped from the model.

Table 3. Break Point Unit Root test

	Level			First Difference			
	ADF	PV	Break date	ADF	PV	Break Date	Order of Integration
DL	-3.05	0.654	2020M06	-14.57	< 0.01	2011M11	I (1)
IBR	-7.18	< 0.01	2009M01				I (0)
Al	-1.75	> 0.99	2015M11	-15.91	< 0.01	2011M10	I (1)
Mpr	-3.96	0.169	2011M02	-14.16	< 0.01	2011M10	I (1)
Er	-5.82	< 0.01	2009M02				1(0)

Source: Authors' compilation.

We started with a linear ARDL, with the knowledge that the NARDL is an asymmetric restatement of the unrestricted ARDL model. Accordingly, equation (16) was estimated as an ARDL (4, 0, 0, 1, 1) as suggested by the Akaike Information Criteria. The bounds test for cointegration rejected the null, with an F-statistic of 20.86 and t-statistics of -10.16, both of which exceeded the critical values of Pesaran et al. (2001) at a 1.0 per cent level of significance (Appendix 1). Both the Breusch-Pagan test for changing variances and the LM test for serial correlation rejected the null, based on the statistical significance of their F-statistics, and the stability of the model assured by both the cumulative sum (CUSUM) and the cumulative sums of squares (CUSUMQ) within the 5.0 per cent range.

Table 4. Conditional Symmetric Error Correction Regression

Variable	Coef.	S. E	t-Stat	Prob.
C	28.32	15.33	1.85	0.07
IBR (-1)	0.78	0.08	10.16	0.00
MPR	0.98	0.47	2.08	0.04
DL	0.86	0.28	3.1	0.00
ER (-1)	-1.62	0.76	-2.13	0.03
AL (-1)	-3.23	1.65	-1.96	0.05
D(ER)	0.74	0.89	0.83	0.41
D(AL)	15.51	11.16	1.39	0.17
ECM	-0.78	0.08	-10.35	0.00
Symmetric Long-Run Levels Equation				
Variable	Coef.	S. E	t-Stat	Prob.
MPR	1.24	0.58	2.13	0.03
DL	1.09	0.34	3.2	0.00
ER	-2.07	0.96	-2.16	0.03
AL	-4.12	2.07	-1.99	0.05

Source: Central Bank of Nigeria.

The conditional symmetric long-run symmetric point estimates of the policy target rate and liquidity factors are presented in Table 4. Generally, the results showed significant long-run effects, but statistically insignificant short-run effects of liquidity factors on the policy variable. It is evident that the monetary policy rate influences the inter-bank rate positively, 1.2 per cent following a unit positive shock in the long-run. This result reinforces the point estimates in Bulus (2010), Tule (2014) and Nwosu et al. (2018). The estimate confirms the importance of the monetary policy rate as an important determinant of the target interbank rate and can be used to influence its behaviour as well as the behaviour of other rates in the market.

Similarly, a unit increase in discretionary liquidity flow, for instance, an increase in the sale of bills to banks, raises the interbank target rate by 1.1 per cent. Again, this validates the positive effects of open market operations in moderating banks' liquidity and the inter-bank rate. This result, however, is to be interpreted with caution as it is silent on the specific impact of the components of discretionary liquidity. Also, excess reserves and autonomous liquidity exert significant depressing effects on the inter-bank rate. The error correction term suggests a fast adjustment to long-run equilibrium from a shock as 78.0 per cent of the deviation from long-run equilibrium is corrected within a month. These points (symmetric) estimates show how important it is to use policy instruments to influence policy target rates.

Table 5. Asymmetric Conditional Error Correction Regression

Variable	Coef.	S. E	t-Stat	Prob.
C	9.66	2.19	4.41	0.00
IBR (-1)	-0.89	0.08	-11.12	0.00
MPR_POS	2.1	0.86	2.43	0.02
MPR_NEG	0.72	0.28	2.57	0.04
DL_POS	0.64	0.38	1.69	0.09
ER_POS (-1)	-4.75	1.21	-3.94	0.00
ER_NEG (-1)	-3.19	0.97	-3.29	0.00
AL_POS	9.82	5.45	1.8	0.07
AL_NEG	10.31	12.14	0.85	0.40
D(ER_POS)	-0.19	1.72	-0.11	0.91
D(ER_NEG)	-0.39	1.39	-0.28	0.78
ECM	-0.89	0.08	-11.52	0.00
Asymmetric Long-Run levels equation				
Variable	Coef.	S. E	t-Stat	Prob.
MPR_POS	2.35	0.93	2.52	0.01
MPR_NEG	0.64	0.17	3.76	0.08
DL_POS	0.71	0.42	1.69	0.09
DL_NEG	0.67	0.36	1.88	0.06
ER_POS	-5.32	1.31	-4.07	0.00
ER_NEG	-3.57	1.07	-3.3	0.00
LAL_POS	-10.99	6.04	-1.82	0.07
LAL_NEG	11.54	13.61	0.85	0.40

Source: Authors' compilation.

V.2 Asymmetric Estimates

The point estimates in Table 4 show the response of the policy target rate (or the interbank rate) to positive changes in liquidity factors only, which is partially restrictive with respect to the behaviour of the inter-bank rate. The inter-bank rate is likely to react differently to negative and positive shocks from liquidity factors. Accounting for such non-linearities identifies the *total* dynamic response of the policy target to asymmetric shocks. Thus, following Shin et al. (2014), we estimated equation (21) and tested it for long-run integration. The bounds test for cointegration is reported in Appendix 1.

Table 5 presents results for the asymmetric conditional error correction regression and asymmetric long-run levels results. It shows overall evidence of asymmetric response of the dependent variable to the specified liquidity factors, which is superior information from the point estimates presented in Table 4. The adjustment to long-run equilibrium following short-run deviation is also faster, as 89.0 per cent of the distortion is corrected each month. The evidence shows that the inter-bank rate is a positive function of both an increase and a decrease in the monetary policy rate. An increase in the monetary policy rate has a positive long-run impact of 2.4 per cent on the inter-bank rate but the decline has a lower impact (0.64%) on the target variable. This result is consistent with the point estimates but also validates the stickiness of interest rates in the downward direction. The low sensitivity of the inter-bank market rate to monetary easing may reflect the high counterparty risk perception in the money market. The implication of this is that the monetary policy rate will be an ineffective tool to stimulate economic activities in a recession.

There is also an asymmetric response of the policy target or interbank rate to discretionary liquidity factors. A unit increase in discretionary liquidity, such as an increase in the sale of bills to banks or an increase in the standing lending facility rate raises the policy target rate, consistent with theoretical expectation. The increase in the policy-target rate to such monetary contraction is 0.7 per cent, slightly lower than the point estimate of 1.1 per cent. However, a liquidity injection such as the purchase of bills reduces the policy target rate almost by the same magnitude, a likelihood of symmetric impact of discretionary liquidity on the policy target rate. This result is, however, to be interpreted with caution as it could be different where discretionary liquidity is disaggregated. Similarly, an increase in excess reserves of banks arising from an expansion of the Bank's balance sheet, for instance, pushes the inter-bank rate down by 5.3 per cent but a decline in excess reserves raises the target rate by a less than proportionate increase in the policy-target rate at 3.6 per cent. This implies that it is easier to lower the policy target rate by an increase in excess reserves than to raise the rate through a reduction in reserves. The evidence is consistent with a *priori* expectations and might be a response to the persistence of autonomous liquidity and the impact on excess reserves build-up, which is buttressed by the 11.0 per cent decline in the interbank rate from a positive shock to autonomous liquidity but a decline of 11.5 per cent following a negative shock. These results collectively show that non-linear models contain more information on the response of target macroeconomic variables, compared with the point estimates.

A definitive statement on the asymmetric effects of liquidity factors was confined by a test for the statistical significance of the asymmetric effects on the target variable, which was conducted with a Wald test (Table 6).

Table 6. Wald Test for Long-Run Asymmetric Effects

	MPR		ER		AL		DL	
t-statistic	2.79_a	0.01*	-3.07_a	0.00*	0.04_a	0.97	0.03_a	0.97
F-statistic	7.78_b	0.01*	9.44_b	0.00*	0.00_b	0.97	0.00_b	0.97
Chi-square	7.78_c	0.01*	9.44_c	0.00*	0.00_c	0.97	0.00_c	0.97

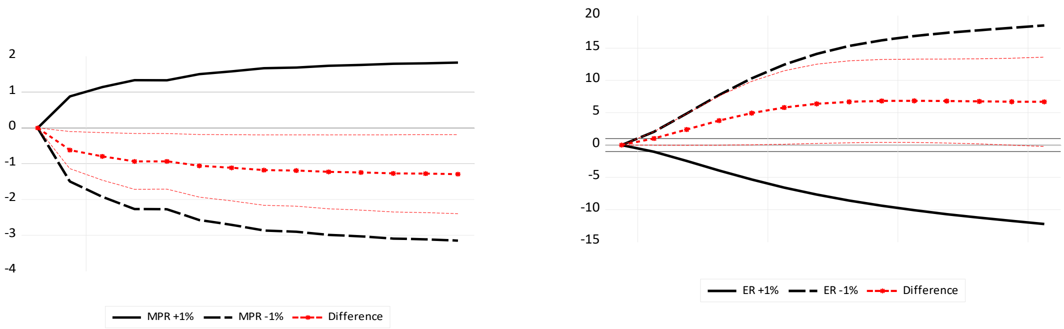
a=t-stat, b=F-stat, c=Chi-sq., * probability values, rejecting the null and confirming asymmetry
Source: Authors' compilation.

V.3 The Dynamic Multipliers

Observation of Figure 8 further confirms the long-run asymmetric effects of monetary policy rate and excess reserves on the target variable. Taking the monetary policy rate first, the positive (solid black line) and negative (broken black line) curves capture the adjustment of the policy target rate to positive and negative changes in the explanatory variables at the given forecast horizon. The evidence reaffirms that the target variable responds positively to an increase in the MPR and negatively to a decline and the response of the policy variable is more pronounced in the long-run. Also, the response of the policy variable is significantly greater with a monetary contraction than with a decrease in the monetary policy rate. This is reinforced by the position of the asymmetric plots $(m_h^+ - m_h^-)$ that is away from the zero line.

With respect to the asymmetric response of the inter-bank rate to changes in the bank reserves, the strong long-run asymmetric effect is also evident from the dynamic multipliers graph. The evidence also suggests that an increase in excess reserves causes a decline in the inter-bank rate (the continuous thick black line), and a decline causes a long-run rise in the policy target rate (the dotted line). Furthermore, the evidence shows that the change in the policy target rate (the decline) is more pronounced with an increase in excess reserves than the increase in rate, attributable to reserves scarcity. These have policy implications.

Figure 8. Dynamic Multipliers



VI. Conclusion and Policy Implications

The paper considered the effectiveness of liquidity management instruments focusing on the average inter-bank market rate, the policy target variable. The short-term rate was specified to be sensitive to the Bank's monetary policy rate, discretionary and autonomous liquidity factors, and the stock of excess reserves. The objective was to determine the extent to which the central bank's policy target rate is sensitive to policy instruments relative to the non-policy influences. The policy factors considered were the monetary policy rate and policy or discretionary liquidity, and the non-policy variable(s) were the stock of banks' excess reserves and autonomous liquidity factors. The results show the asymmetric long-run response of the policy-target variable to changes in the MPR and excess reserves, while the response to discretionary and autonomous liquidity factors remains largely symmetric. In summary, the study found:

a) The presence of a long-run relationship between the inter-bank rate and liquidity factors, but an insignificant short-run relationship. The adjustment to long-run equilibrium is also fast;
b) The response of the policy rate to liquidity factors is both symmetric and asymmetric. However, more information is extracted with the non-linear estimates than from the point estimates;
c) Stronger long-run asymmetry with the monetary policy rate and excess reserves are observed while the response of discretionary and autonomous liquidity appears to be largely symmetric;
d) The policy-target rate is more sensitive to a monetary contraction than expansion using the MPR;
e) Also, there is a greater sensitivity of the policy-target rate to an increase in excess reserves than when reserves are scarce; and
f) Autonomous and discretionary liquidity factors exert significant influence on the interbank rate, but the relationship appears symmetric, which might be due to the compartments of the variables.

The policy implications of these findings are:

- The strong effect of the monetary policy rate on the inter-bank market rates implies that the MPR is a veritable instrument for liquidity management. The stronger sensitivity to a tightening cycle implies that the monetary policy rate is an effective tool in a contraction cycle;
- The policy - target rate is also more sensitive to excess reserves than when reserves are scarce. This implies that raising the interbank rate by curtailing excess reserves is less efficient; and
- Both discretionary and autonomous liquidity factors are also credible determinants of the Bank's policy-target rate.

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Appendices

Appendix 1: Bounds Testing

Symmetry Bounds Test					Asymmetric Bounds Test				
Test Stat	Value	Signif.	I (0)	I (1)	Test Stat	Value	Signif.	I(0)	I (1)
F-stat	20.86	10%	2.45	3.52	F-stat	14	0.1	1.95	3.06
K	4	5%	2.86	4.01	k	8	0.05	2.22	3.39
		2.50%	3.25	4.49			0.025	2.48	3.7
		1%	3.74	5.06			0.01	2.79	4.1
Test Stat	Value	Signif.	I(0)	I (1)	Test Stat	Value	Signif.	I(0)	I(1)
t-stat	-10.1602	10%	-2.57	-3.66	t-stat	-11.1	0.1	-2.57	-4.4
		5%	-2.86	-3.99			0.05	-2.86	-4.72
		2.50%	-3.13	-4.26			0.025	-3.13	-5.02
		1%	-3.43	-4.6			0.01	-3.43	-5.37

Appendix 2: Residual Diagnostics for NARDL

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.421809	Prob. F (11,143)	0.169
Obs*R-squared	15.28105	Prob. Chi-Square (11)	0.170
Scaled explained SS	104.3176	Prob. Chi-Square (11)	0.000

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.649874	Prob. F (2,141)	0.524
Obs*R-squared	1.41575	Prob. Chi-Square (2)	0.493

Appendix 3: Model stability (CUSUMS)