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Assessing the Effectiveness of Monetary Policy Instruments on Bank Liquidity Management

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ABSTRACT

Recognising the importance of monetary and price stability for sustainable growth, many countries' Central Banks often set certain liquidity targets to be achieved using various monetary policy instruments. This study fills the gap in the literature by employing the ARDL Bounds test to examine the relative effectiveness of a combination of quantity- and price-based policy instruments used by the Central Bank of Nigeria (CBN) to regulate the level of bank liquidity. Also, the likelihood ratio test is used to determine whether monetary policy instruments work better as a complement (or substitute) concerning liquidity management. Using quarterly time series data covering 2008/Q1-2020/Q2, we found that, price-based instruments mostly impact liquidity level in the short- and long-run. The quantity-based instrument shows a significant impact at second lag. However, the impacts of some policy instruments were not consistent during the periods – this may be because they are often used as short-run measures. All the six monetary policy tools considered in this study were found to be complementary to each other concerning liquidity management. The policy implications from these findings are noteworthy

Keywords: Quantity-based policy instruments; Price-based policy instruments; Liquidity management; Central Bank of Nigeria; ARDL Boundstest

Disclaimer: This paper represents the views of the authors and does not necessarily reflect those of the Central Bank of Nigeria (CBN).

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1. INTRODUCTION

Monetary policy has over the years proven to be a vital component of macroeconomic policy and many countries of the world have, to an extent, structured their economies around a specific monetary policy framework administered by their monetary authorities. However, due to the globalization and continuous evolvement of domestic and world economies, it has become imperative for monetary authorities to re-establish specific objectives to pursue and focus on perfecting its monetary policy strategies in achieving the set objectives (Ojo, 2013).

The Central Bank of Nigeria (otherwise known as “CBN” and (or) the “Bank”), has the object of ensuring price and monetary stability. The strategy employed by the CBN in achieving this mandate is encompassed by effectively managing the short-term credit supply ability, which depends on the liquidity position in the money market. The liquidity position however is known to influence economic activities through aggregate demand and can be a threat to achieving the objective of price stability among others. Thus, the Bank needs to determine and ensure an optimal liquidity required to achieve a non-inflationary growth and sustain it overtime (Dogo, 2015). Consequently, it is imperative to understand the choice and effectiveness of monetary policy instruments in liquidity management.

Considering this, in the study carried out by Bernanke and Blinder (1992), it was observed that liquidity is impacted by the monetary policy through bank loans and bank deposits. i.e., the credit and money channels. While investigating whether monetary policy effects vary between financial crises and normal times, Berger and Bouwman (2017) showed that monetary policy impacts are significant. However, its effects in terms of liquidity creation by small banks is inconsequential. In the case of medium and large banks, the effects are seen to be varied, albeit weak. The causality, interrelatedness, impacts and even the determinants of monetary policy instruments and liquidity creation for various countries, have been analysed in several other extant studies (see e.g., Khemraj, 2007; Fernandez-Amador, Gachter, & Peter 2012); Lovin, 2014 and Nather, 2018).

However, given that the level of financial sector development varies among countries, the referred studies have tailored their analysis to capture relevant conditions as they relate to the dynamics of the economies under focus. The need to understand the peculiarity of the CBN’s monetary policy instruments in liquidity management was among others attempted by
Osakwe, Agbo and Okonkwo (2019), Augustine, Chinwe&Ukpere, 2018, Chuku (2009) and Olekah (2007). While this is a step forward, these studies do not show the exact link with liquidity management in the economy. More so where they do, only a few selected price- or quantity- based policy instruments are considered.

With this exposition, a study assessing the relative effectiveness of the monetary policy instruments used by CBN will be an important contribution to the literature. This study contributes to the literature by combining price and quantity-based monetary policy instruments in assessing the impact of Central Bank’s policy on liquidity management. We also offer a further clarification of whether the instruments work as a complement or substitute. To the best of our knowledge, there has not been study that considered both quantity and price-based policy instruments to determine their complementarity (or substitutability) in assessing the impact of monetary policy on bank liquidity. Therefore, this study seeks to bridge the gap in the literature.

Through the empirical assessment undertaken, thus, the three following sub-questions are addressed. Do monetary policy instruments significantly affect the liquidity position of the economy? What are the relative impacts of monetary policy instruments on liquidity position? Are monetary policy instruments complementary or substitutes? To achieve these, we

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employ the ARDL Bounds test by Pesaran, Shin, Smith & Smith, 2001) to analyse the relative long-run and short-run impacts of the monetary policy instruments on bank liquidity management in Nigeria. The study also adopts the likelihood ratio (LR) test to test for complementarity or substitutability of the instruments which is a novel and important contribution to extant studies on macroeconomic policy analysis.

Subsequent sections of this document are structured thus: The following section (i.e., Section 2) presents key stylised facts of monetary policy instruments in Nigeria. The theoretical framework and methodology are presented in section 3. Section 4 presents and discusses our data and empirical findings, and section 5 concludes with the policy implications.

1.1 Trends in Nigeria's Key Money Market Variables

Pursuant to the CBN act of 1958, the Bank uses various monetary policy instruments to influence a set of operational and intermediate activities to achieve the ultimate target (i.e., stability prices). The various quantity-based and price- based monetary policy instruments adopted by Central Bank of Nigeria range from Open Market Operations (OMO) to Cash Reserve Requirement (CRR). The trajectories of these instruments and their relationship with the intermediate and ultimate targets have varied over the years. To put this in context, we analyse the Bank's various monetary policy and money market indicators for the period between January 2018 - February 2021

1.1.1 Relationship between Treasury Bills Rates, Monetary Policy Rates, and Interbank Call Rates

The trends of interbank call rates (IBR), treasury bills rates (TBR) and the monetary policy rate (MPR) are represented in Figure 1. The MPR stood at 14% from January 2018 all through to February 2019 after which it dropped to 13.5% and was pegged at that rate till May 2020. Between May to August 2020, the MPR was kept at 12.5%. However, at the MPC meeting of September 2020, the Committee decided to reduce the rate by 100 basis points to 11.5% to date.

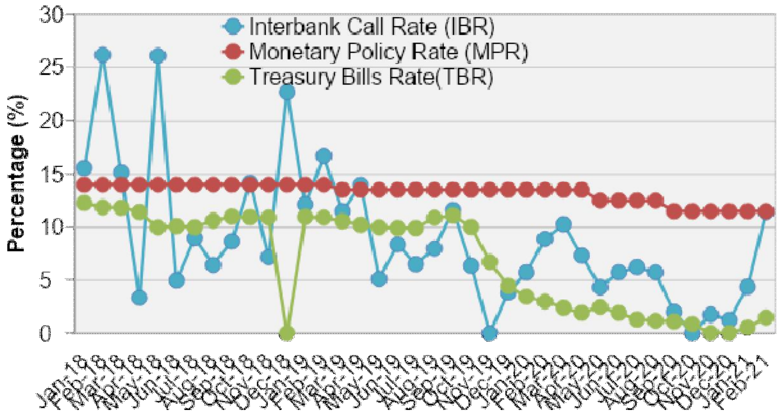

Figure 1: Trends in Monetary Policy Instruments Rates in Nigeria

Source: computed by authors based on data from CBN

There is a strong positive correlation coefficient of 0.841 between MPR and TBR. The MPR and IBR also show a positive but lesser degree of a correlation coefficient[1]of 0.524. Although the IBR peaked at 26.19% in February 2018, it has been on an average of 9.41% while the TBR also average at 6.98% during the period under review.

1.1.2 Relationship between Interest Rates and Money Supply

The trends and observed relationship between broad money supply and interbank call rates (IBR) in Nigeria from January 2018 to February 2021 are represented in Figure 2. In the context of economy-wide liquidity, a decline in interest rate is expected to increase loans, trade credits and other forms of domestic credits available to individual and companies (i.e., private sector), and boost aggregate demand. On the other hand, a fall in money supply is expected to reduce lending and ultimately moderate inflation. On the flipside, a decline in interest rate is expected to cause a fall in bank liquidity as savings/investments will no longer be attractive to the private sector.

[1] The correlation coefficients are computed using Microsoft Excel. Similar data for plotting the graphs are employed

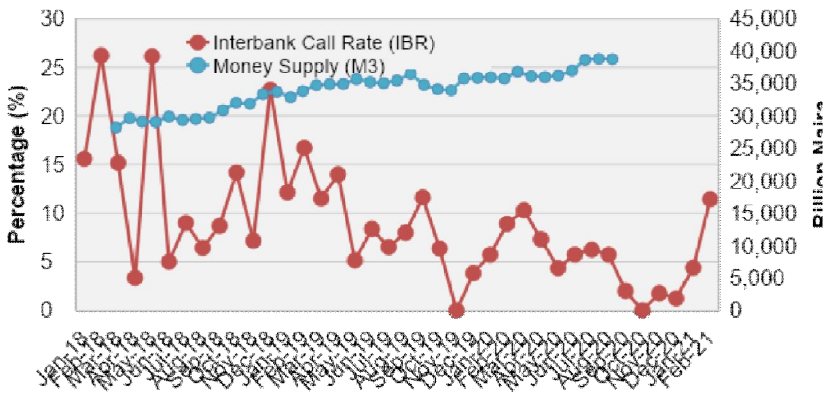

Figure 2: Trends in Broad Money Supply and Inter-bank Call Rates in Nigeria

Source: computed by authors based on data from CBN

1.1.3 Relationship between Open Market Operations, Base Money, and Bank Reserves

The trends in the monthly balances of the base money (monetary base), bank reserves and the total sales in Open market Operations (OMO) which is a quantity-based direct monetary policy activity are represented in Figure 3. It was noted that the base money and bank reserves peaked in February 2020 at ₦7.445trillion and ₦9.632trillion respectively. The averages however stood at ₦9.172billion and ₦6.759billion respectively. Both bank reserves and based money are inversely linked to OMO bills sale with estimated correlation coefficients of -0.629 and -0.632 respectively, indicating that an increase in the sale of OMO bills will reduce bank reserves, i.e., mop up liquidity.

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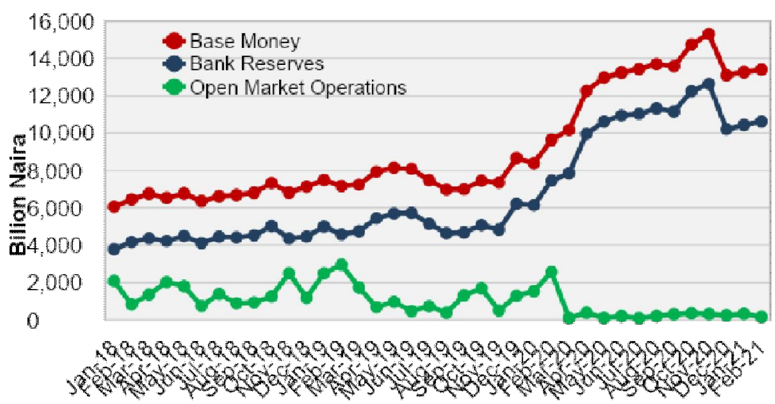

Figure 3: Base Money, Bank Reserves and OMO Sales in Nigeria

Source: computed by authors based on data from CBN

1.1.4 Deposits Money Banks Liquidity Indicators

The trends in the DMBs closing balances and monthly SLF and SDF during January 2018 February 2021 are represented in Figure 4. During this period, the SDF and SLF values fluctuated within averages of ₦1.05 trillion and ₦966.04billion, respectively. Although SLF and DMBs show similar spikes in certain periods, a negative correlation coefficient of -0.017 was noted between both in the period under review. This underpins banks' unwavering preference for collateralised interbank OBB rates in the Nigerian financial system. However, consistent with economic resonance, the correlation coefficient between the DMBs closing balances and SLF is negative (-0.102) which indicates banks' recourse to the discount window in periods of liquidity strain. The DMBs balances averaged at ₦375.76 billion with closing balances of ₦255.54 billion in February 2021.

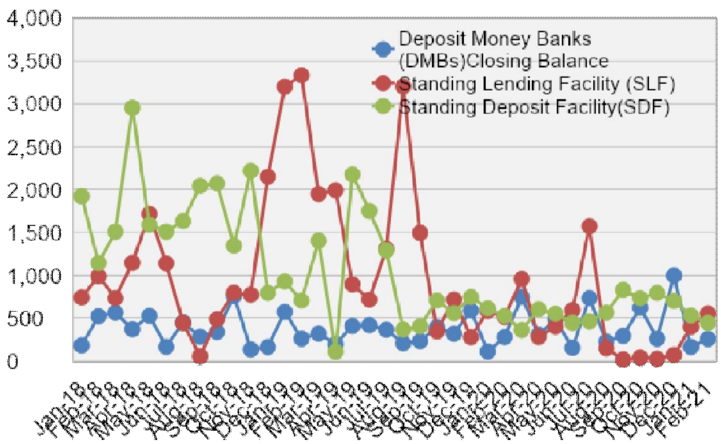

Figure 4: Deposits Money Banks Liquidity Indicators in Nigeria

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Source: computed by authors based on data from CBN

1.2 Concise Theoretical Framework

There have not been definite theories that capture the effectiveness of monetary policy vis-à-vis liquidity. Available theoretical models focus on monetary policy and interest rates, and (or) prices and growth in output, but with an undertone of liquidity. For instance, Friedman's (1970) Quantity Theory of Money, in its basic form represented by Irving Fisher's Eqn., shows that money supply directly affects

$$MV = PT \quad (1)$$

prices as follows: Alternatively,

$$= PT \quad)$$

where M represents money supply, while $MV + nMd'VT'$ V, P a represent velocity of circulation, p (2 rice level and volume of transactions respectively. Although this theory has come under a lot of criticisms, it has an established relevance on the basis for explaining monetary policy transmission in many developing economies including Nigeria.

In recent times, researchers have proposed interesting modifications to the extant theories to incorporate the dynamics of the liquidity effect vis-à-vis interest rates and prices, and to analyse and/or explain how such liquidity effect is captured. A relevant and more precise of these studies is the liquidity effect of the traditional sticky prices model by Ohanian and Stockman (1995) where liquidity effect is seen as the statistical relationship between bank reserves and short-term interest rates such that a specific policy action of the Central Bank has the same impact on the bank reserves and the short-term interest rates.

2. METHODOLOGY

2.1 Data Description, Sources and Summary Statistics

The study considers six key variables namely deposit money banks balances (DMBs), monetary policy rate (MPR), cash reserve ratio (CRR), OMO sales (OMOs), standing lending facility rate (SLF) and standing deposit facility rate (SDF). These variables are quarterly time series data for 2008Q1-2020Q2. MPR, CRR, SLF and SDF are proxies for price-based monetary policy instruments, OMOs represents the quantity-based monetary policy instrument, while DMBs is used as a proxy for liquidity.

We source all variables excluding OMOs from the CBN statistical department. We compute three-month averages of OMOs (extracted from the CBN database) to have quarterly series data as it is a daily volume. We use all variables in their form. Summary statistics and graphical illustrations of the variables are represented in Table 1 and Figure 5 respectively.

Table 1: Variables Definition and Summary Statistics

Variable	Label	Obs.	Mean	SD	Min.	Max.
Monetary Policy Rate (%)	*MPR*	51	11.387	2.577	6.000	14.000
Cash Reserve Ratio (%)	*CRR*	51	14.304	9.519	1.000	31.000
Standing Lending Facility (%)	*SLF*	51	13.132	2.824	8.000	16.000
Standing Discount Facility (%)	*SDF*	51	7.721	2.671	1.000	11.000
Open Market Operations Sales (₦'Trillion)	*OMOs*	51	1.428	1.592	0.000	7180.61
Deposit Money Banks Closing Balances (₦' Billion)	*DMBs*	51	358.002	239.472	25.210	1133.670

Source: Authors' compilation based on data from the Central Bank of Nigeria (CBN) Statistics

Figure 5: Trends of the Variables Used for Empirical Analysis

Source: Computed by authors based on data sourced from CBN Statistical Database & Statistics Department

2.2 Methodology

2.2.1 Model Specification

Drawing from Eqs. (1) and (2), the link between liquidity and Central Bank's monetary policy instruments is represented as follows:

$y_t = \alpha + \phi' x_t$

Where $yt$is liquidity level at time tε;x_t is the vector o+fεb^{t}oth quantity- and price-bas (e3d)
monetary policy instruments at time t; is the error term.

2.2.2 Estimation Procedure

To determine the appropriate method to estimate Eq. (3), it is necessary to properly consider the underlying time-series properties of the variables to avert spuriousness. Our estimation procedure is inclined to the study by Shrestha and Bhatta (2018) which indicates that, firstly, the stationarity of the variables must be tested. If all the variables are stationary at level, an Ordinary Least Square (OLS) or a Vector Autoregressive (VAR) method will suffice to assess the link among the variables of interest in Eq. (3). Conversely, if they are non-stationary at levels, the relationship in Eq. (3) may be estimated with alternative methods that require co-integration among the variables. In this case, Johansen test and Autoregressive Distributed Lag (ARDL) Cointegration test (ARDL bounds test) by Pesaran et al (2001) are suitable methods to adapt.

- *Unit Root Tests*

Following the above exposition, to check if the variables are stationary, we adopt the Augmented Dickey-Fuller (ADF) test complemented by the Phillips-Perron (PP). The standard ADF model is presented below as:

$$\Delta Y_t = \alpha + \lambda t + \rho Y_{t-1} + \sum_{p=1}^{n} \delta_p \Delta Y_{t-p} + \varepsilon_t \qquad (4)$$

Where Yt is a time series variable, Δ is the first difference operator, α and λ are constant and time trend coefficient respectively. Finally, p represents the lag order.

The PP test on the other hand corrects for the problem of lag selection which may have occurred using the ADF. It achieves this by combining the standard Dickey-Fuller test with non-parametrically modified test statistics (Aritova and Fedorova, 2016). A significant advantage of the PP test over the ADF is the fact that it corrects for heteroscedasticity and autocorrelation issues. Following, Shrestha and Bhatta (2018), we specify the PP unit root test equation as follow:

$$\Delta Yt = \delta Yt{-}1 + \beta i Dt{-}1 + et \quad (5)$$

Where Dt_1 is a determinδis=tic0trend component and et is an (0) with a mean of 0.

The null hypothesis is tested for . Despite the similarities in the hypothesis testing technique, the procedure to calculate the t-ratio to get δ is different from the ADF.

- *The ARDL Bounds Test (Cointegration Test)*

Where the time series data has mixed stationarity results, we will adopt the ARDL bounds test by Pesaran et al (2001) to test for cointegration. This has been widely employed by extant studies that assessed the effectiveness of monetary policy (see e.g., Zgambo and Chileshe, 2014; Adekunle, Baba, Stephene, Ogbuehi, Idris, &Zivoshiya, 2018); Hatmanu, Cautisanu&Ifrim, 2020). As applicable, the ARDL bounds test, will subsequently be employed in evaluating the relative impacts (long-run and short-run) of the monetary policy instruments on liquidity management.

The ARDL (p, q, . . ., q) modelling approach is illustrated as follow,

$$yt = \alpha 0 + \alpha 0t + {}_i\sum_{=}^{\rho}{}_1 \beta i yt{-}i + {}_j\sum_{=}{}^{k}{}_{1i}\sum_{=}{}^{q}{}_0 \phi j, xj, t{-}i + et \quad (6)$$

Where yt and xjt represent dependent and explanatory variables respectively;[2] and et is the error term. Thro,ugh a simple linear transformation of Eq. (6), a dynamic error correction model (ECM) that allows to test for long run cointegration can be derived as follows:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{\rho-1} \beta_i \Delta y_{t-i} + \sum_{j=1}^{k} \sum_{i=1}^{q-1} \phi_{j,i} \Delta x_{j,t-i} + \pi_1 y_{t-1} + \sum_{j=1}^{k} \lambda_j x_{j,t-1} + e_t \quad (7)$$

[2] The definitions of the variables and identities are presented in sub-section 5.1 on data.

where α_0, β_i and $\phi_{j,i}$ represent measurements of short-run dynamics; $\pi 1$ measures the
ment and λ_j re
adjust presents measurements of long-run relationship. The optimal lag order for the dependent variable (q) and regressors (q), which may be different across regressors, can be obtained based on information criterion. The variables in (y_t,xj,) are allowed to be purely I(0), purely I(1) or co-integrated (Kripfganz and Schneider, 2016).

The bounds test entails the test for non-existence of long-run relationship among the variables under review. In other words, the bounds test is used to test the null hypothesis which states that no cointegration (i.e.,$H0$: $\pi 1 = 0$; $\lambda j = 0$ $\forall j$) using the Fisher test. Pesaran
et al. (2001) provides the critical values for the F-statistics and defines lower and upper bounds, derived from the hypothesis that all variables are I(0) and I(1) respectively. This addresses the non-standard and asymptotic nature of the test statistics. The decision rule is as follows:

Calculated value of *F*-statistics (or *t*-statistics as applicable) >Upper bound: Variables are cointegrated.

Calculated value of *F*-statistics (or *t*-statistics as applicable) <Lower bound: No long-run relationships exist between variables. (Therefore, a short-run ARDL model will be appropriate).

To test for complementarity and/or substitutability of the monetary policy instruments, different versions of Eq. (7) with regards to the number of policy instruments included will be estimated and subjected to Likelihood Ratio (LR) test to arrive at the preferred parsimonious model that passes a range of diagnostics tests.

- *Test for Endogeneity: Toda and Yamamoto Augmented VAR Model.*

In addition to the ARDL model, which may be restricted to a unidirectional analysis, we consider an augmented VAR non-Granger causality procedure related to Toda and Yamamoto (1995) to allow for bi-directional interaction of the variables. The bi-directional interactions are very crucial in informing Central Banks' policy directions (Dritsaki, 2017). The Toda-Yamamoto procedure has the ability to analyse time-series that have different stationarity order. It augments the standard VAR by applying asymptotic theory to correct for mixed integrated order so far, the highest integration order does not exceed the VAR lag length order. The key parameters of use in the model to capture any integration order misalignment amid the time-series interactions are the VAR optimal lag length and the maximum integrated order i.e

VAR (k + $dmax$). The VAR variant of Toda-Yamamoto model is presented as follows:

$$\left[y_t\, x_{1t} \cdots x_{nt}\right] = \left[\alpha_0\, \alpha_1 \cdots \alpha_n\right] + \sum_{i=1}^{k}\left[\beta_{01}\, \beta_{11} \cdots \beta_{n1} \quad \beta_{02}\, \beta_{12} \cdots \beta_{n2} \quad \cdots\cdots \quad \cdots\cdots \quad \cdots\cdots \quad \beta_{0n}\, \beta_{16} \cdots \beta_{6}\right.$$

(8)

Where $yt$and xn,are the dependent and explanatory variadbmleaxs respectively.k denotes the optimal lag length determined by Information Criteria. is the maximum order of integration. From Eq. (8), Toda-Yamamoto uses modified Wald to test for restrictions on the parameters of lag k VAR and estimate the VAR (k + $dmax$) with an asymptotic chi-square distribution and k degree of freedoms in the limit. (Manapa, Abduhb, Omar, 2012). Thus, the (k + $dmax$) becomes the optimal lag used for estimating the model.

3. RESULTS AND DISCUSSION

3.1 Discussion of Results: Time Series Properties

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Following the exposition in subsection 3.2.2, we conduct the unit root tests using ADF and PP tests with and without trend. The results presented in Table 2 indicate that *OMOs* and *DMBs* are stationary at levels. However, all the variables (*DMBs*, *MPR*, *CRR*, *OMOs*, *SLF* and *SDF) are* stationary at first difference under all methods at 1% significance level. With these results, we conclude that *OMOs* and *DMBs are I (0)* variables while *MPR*, *CRR*, *SLF* and *SDF* are *I (1)* variables.

Table 2: Results of Unit Root Tests of the Variables

Variables	ADF				PP				*Decision*
	Without Trend		With Trend		Without Trend		With Trend		
	Level	1st Diff	Level	1st Diff	Level	1st Diff	Level	1st Diff	
$mcssodrldmmfprforbs$	-1.200	-5.397***	-1.248	-5.352***	-1.435	-5.487***	-1.801	-5.444***	*IIIIII*((((((111100))))))
	-0.731	-8.545***	-2.595	-8.468***	-0.550	-8.666***	-2.547	-8.582***	
	-1.391	-5.434***	-0.402	-5.529***	-1.496	-5.585***	-0.935	-5.664***	
	-1.791	-6.891***	-1.480	-6.943***	-1.888	-6.903***	-1.623	-6.949***	
	2.856*	-8.475***	-3.307*	-8.447***	-2.730*	-9.009***	-3.319*	-9.029***	
	-5.848***	-10.540***	-6.161***	-10.444***	-5.822***	-13.141***	-6.123***	-13.068***	

Notes of the table:

1. The null (H_0) hypothesis for the tests is non-stationary (i.e., unit root) and the alternative hypothesis is level stationary;
2. *, **, *** and indicate 10%, 5% and 1%

significance levels respectively;

3. ADF is Augmented Dickey and Fuller; PP is Phillips and Perron;
4. We allowed maximum lengths for both ADF and PP and conducted the test with and without trend

Since our variables have mixed stationarity, we test for co-integration using ARDL Bounds test by Pesaran et al (2001). At this stage, five (5) models of eq. 7 (Models A, B, C, D and E) are tested for cointegration and subsequently estimated. These models are estimated to determine which best explains Nigerian Banks' liquidity management. This is with the view to addressing the research question on whether the selected CBN's monetary policy instruments are substitutes or complements for effective management of bank liquidity. We arrived at the five (5) Models by including the regressors cumulatively into each model.

Thus, Models A, B, C, D and E contain respectively, 1, 2, 3, 4 and 5 regressors.[3]

The cointegration test outcomes reported in Table 3 show evidence of cointegration among the variables in the Models at all significance levels (i.e., at 1, 2.5, 5 and 10 percent levels). The calculated F-statistics and t-statistics in all cases are respectively higher and lower than the applicable upper-bounds critical values. Therefore, we reject the null hypothesis and conclude that there is a long run relationship between the variables in the respective models. Such long-run relationship can be estimated.

Table 3: Results of ARDL Bounds Test for Cointegration

Model A (with K=1)							
		Critical Values				Critical Values	
F-Statistic	Significance	I(0)	I(1)	*t-Statistic*	Significance	I(0)	I(1)
15.017	10%	4.04	4.78	-5.627	10%	-2.57	-2.91
	5%	4.94	5.73		5%	-2.86	-3.22
	2.5%	5.77	6.68		2.5%	-3.13	-3.50
	1%	6.84	7.84		1%	-3.43	-3.82
Model B (with k=2)							
		Critical Values				Critical Values	
F-Statistic	Significance	I(0)	I(1)	*t-Statistic*		I(0)	I(1)

[3]Specifically, besides *DMBs (i.e., dependent variable)*, Model A, the restrictive model, contains only *MPR*, Model B contains *MPR and CRR regressors,* Model C contains *MPR, CRR and OMOs regressors, Model D contains MPR, CRR, OMOs and SDF regressors, and* finally, Model E is the most unrestricted model that contains all the regressors in the study – *MPR, CRR, OMOs, SLF and SDF.*

Significancc ec e

15.986	10%	3.17	4.14	-6.925	10%	-2.57	-3.21
	5%	3.79	4.85		5%	-2.86	-3.53
	2.5%	4.41	5.52		2.5%	-3.13	-3.80
	1%	5.15	6.36		1%	-3.43	-4.10

Model C (with k=3)

F-Statistic	Significance	Critical Values I(0)	Critical Values I(1)	*t-Statistic*	Significance	Critical Values I(0)	Critical Values I(1)
11.792	10%	2.72	3.77	-6.864	10%	-2.57	-3.46
	5%	3.23	4.35		5%	-2.86	-3.78
	2.5%	3.69	4.89		2.5%	-3.13	-4.05
	1%	4.29	5.61		1%	-3.43	-4.37

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Model D (with k=4)

F-Statistic	Significance	Critical Values I(0)	Critical Values I(1)	*t-Statistic*	Significance	Critical Values I(0)	Critical Values I(1)
9.972	10%	2.45	3.52	-6.784	10%	-2.57	-3.66
	5%	2.86	4.01		5%	-2.86	-3.99
	2.5%	3.25	4.49		2.5%	-3.13	-4.26
	1%	3.74	5.06		1%	-3.43	-4.60

Model E (with k=5)

F-Statistic	Significance	Critical Values I(0)	Critical Values I(1)	*t-Statistic*	Significance	Critical Values I(0)	Critical Values I(1)
6.750	10%	2.26	3.35	-6.060	10%	-2.57	-3.86

						I(0)	I(1)
5%	2.62	3.79	5%	-2.86	-4.19		
2.5%	2.96	4.18	2.5%	-3.13	-4.46		
			1%	3.41	4.68	1%	-3.43	-4.79

Notes of the table:

1. The null hypothesis (H_0) is no cointegration between the variables
2. K is the number of parameters
3. The decision rule using F-statistics is to reject the H_0if the calculated

F-statistics is greater than the critical values for I(1) regressors while the decision rule using t-statistics is to reject H_0if calculated t-statistics is less than the critical value for I(1) regressors (Pesaran*et al.*, 2001).

3.2 Discussion of Results: Diagnostic Tests

Given the existence of cointegration, the ARDL model (Eq. 7) consequent on which the Bounds test is applied, is suitable to estimate both the short- and long-run coefficients and to generate the coefficient of adjustment of integrating the short and long-run dynamics and (or) relationships. Table 4 presents the results of the coefficients and the necessary diagnostics conducted.

First, optimal lag orders for each model as reported in Table 4 are selected based on Akaike Information Criteria (AIC). Secondly, the Durbin Watson and Breusch Godfrey LM tests are carried out to check for first-order autocorrelation and higher-order correlation, respectively. Thirdly, to ensure the validity of the model, Breusch Pagan and Ramsey's RESET tests were carried out to test for homoscedasticity and model specification error of the models. Lastly, the stability of coefficients is verified using graphs to illustrate the cumulative sum of recursive residuals (CUSUM) and cumulative sum of square recursive residuals (CUSUM-Squared).

The results, as presented in table 5 show that, generally, all models fit the data well, passing all diagnostic tests, that is, free from first and higher-order correlation problems, well-specified and free from heteroscedasticity problems. The models are stable as the CUSUM, and CUSUM-squared graphs reported in Appendix A show that all the sum of recursive residuals and recursive squared residuals fall within the 95% level confidence interval.

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Finally, to arrive at the preferred model, we conduct restriction tests whereby the five (5) models are tested against each other using the LR test[4]. For each LR test, the

[4] Given that the restriction is on the parameters and the ARDL bounds test reports both the R-squared and log-likelihood values for each of the models, an *LR* test is suitable to test the restrictions on

model with more regressors is treated as the unrestricted model while the model with fewer regressors is treated as the restricted model. Thus, the null hypothesis for each LR test is that the restriction of a fewer regressor is valid. As such, the policy instruments will be considered complementary if we reject the null hypothesis otherwise, it is taken as a substitute. The LR test results indicates that Model E, which contains all the policy instruments, is preferred to any form of restrictions represented by Models A-D.

Moreover, the adjusted-R2 is satisfactorily high for Model E implying strong evidence that the regressors in model E explain a larger part of banks' liquidity in Nigeria. Thus, we conclude that Model E is the most preferred to assess the effectiveness of monetary policy instruments on bank liquidity in Nigeria. In what follows, we focus our discussion on the estimated coefficients of Model E with some relevant policy and research implications.

Table 4: Results of ARDL Model of Liquidity Balances in Nigeria

	Dependent Variable: D(DMBs)				
Explanatory Variables:	Model A	Model B	Model C	Model D	Model E
	Part A: Short Run Effects:				
Constant	210.18	410.52**	446.05**	901.77***	998.57**
	(156.80)	(196.48)	(215.92)	(286.71)	(439.74)
D(DMBs (-1))	-		-	-	0.265
					(0.157)
DMPR	-91.17*		-	108.25	-96.266
	(43.23)			(65.86)	(105.911)
DMPR (-1)			-		161.57**
					(74.83)
DCRR		-23.243*	-22.62*	-33.837*	-38.60**
		(13.387)	(13.74)	(16.84)	(16.85)
DCRR (-1)		-47.7***	-47.75**	-72.367***	-67.74***
		(13.35)	(13.35)	(17.54)	(19.194)
DCRR (-2)	-	-	-	-36.862*	-28.290
				(20.00)	(24.13)
DCRR (-3)	-	-	-	-	-44.31**
					(20.55)
DOMOs	-	-			-0.044
					(0.032)
DOMOs (-1)	-	-			-0.022
					(0.027)

substitutability or complementarity of the variables. The *LR* test is expressed as . Where LLUis the log-likelihood value for the unrestricted model; LLR is the log-likelihoodLR(r)=-2LLRvalue-LLforU~r2the restricted model, and r is the number of restrictions on the parameters.

DOMOs (-2)	-	-			-0.058** (0.026)
DSDF	-	-		-130.521***	-147.66***

				(45.70)	(47.97)
DSDF (-1)	-	-	-		-129.36**
					(50.26)
DSDF (-2)	-	-	-		-41.81
					(29.08)
DSLF	-	-	-		262.61**
					(111.05)
Error Correction Adjustment (*DMBS (-1)*)	-0. 8.26***	- 0.945***	- 0.950***	-1.03***	- 1.407***
	(0.146)	(0.136)	(0.138)	(0.197)	(0.212)

Table 4 Cont'd: Results of ARDL Model of Liquidity Balances in Nigeria

	Part B: Long-Run Effects:				
MPR	14.293	-14.726	-19.675	-136.92***	-139.553**
	(17.824)	(26.458)	(27.257)	(40.069)	(59.39)
CRR	-	10.155	10.393	22.380**	19.09**
		(6.978)	(7.032)	(7.692)	(8.294)
OMOs	-	-	0.0111	0.018	0.025
			(0.0265)	(0.022)	(0.021)
SDF	-	-	-	98.79***	89.55***
				(73.209)	(24.44)
SLF	-	-	-	-	21.577
					(61.20)
	Models C haracteristics:				
Information Criteria	AIC	AIC	AIC	AIC	AIC
Lag Order	(1.1)	(1,0,2)	(1,0,2,0)	(1,1,3,0,1)	(2 ,2,4,3,3, 1)

No of Obs.	47	49	47	47	47
R2	0.496	0.597	0.600	0.7142	0.827
Adjusted R^2	0.461	0.5482	0.5389	0.6348	0.700
Log-Likelihood	-320.43	-315.20	-315.100	-307.14	-295.29
	Models Diagnostics Tests:				
Breusch Godfrey LM test	0.877	0.632	0.697	0.6225	0.4363
DW-Test	1.673	1.803	1.841	1.812	1.749
Ramsey Reset Test	0.625	0.14	1.54	0.250	0.9167
Breusch-Pagan Test	0.538	0.274	0.1834	0.239	0.1043
Cusum& $Cusum^2$Tests	Within Limits	Within Limits	Within Limits	Within Limits	Within Limits
	***LR* test of Complementarity/Substitutability of Variables:**				
Model A vs. B		10.47***	-	-	-
Model B vs. C		-	0.200	-	-
Model A vs. C		-	10.68	-	-
Model C vs. D		-	-	15.91***	-
Model A vs. D		-	-	26.58***	-
Model B vs. D		-	-	16.11***	-
Model A vs. E		-	-	-	50.30***
Model C vs. E		-	-	-	39.62***
Model B vs. E		-	-	-	39.82***
Model D vs. E		-	-	-	23.71***

Notes of the table:

1. Standard errors, i.e., *, ** and *** are 10, 5 & 1% levels of significance respectively 2. DW-Test is Durbin-Watson d-statistics for 1st order autocorrelation (i.e., correlated residual)

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3. Breusch Godfrey LM test for higher-order autocorrelation (i.e., serial autocorrelation)
4. Ramsey Reset Test for omitted variables (i.e., model specification error)
5. Breusch-Pagan χ^2 Test for homoscedasticity (i.e., constant variance)

6. Cusum and Cusum^2 Test for the stability of the estimated parameters and the Model

Table 5: Results of T-Y Modified Multi-Variate Non-Granger Causality Test

Dependent Variable: ***DMBs***						
Independent Variable		**Lag K**	**Lag $K + d_{max}$**	**Chi-Sq.**	**Prob**	**Causality Outcome**
MPR		1	1+1	2.240093	0.3263	≠
OMOs		1	1+1	0.245799	0.8844	≠
CRR		1	1+1	2.548159	0.2797	≠
SDF		1	1+1	4.103381	0.1285	≠
SLF		1	1+1	3.462662	0.1770	≠

Notes of the table:
The Lag ($K + d_{max}$) represents augmented VAR lag order. The Lag (K) selection criterion is based on SIC which reveals optimal lag length to be 1. ≠ denotes no that the dependent does not cause the independent variables and vice versa.

3.3 Discussion of Results: Short-run Effects

For the preferred parsimonious Model E, many of the monetary policy instruments considered with their lagged values are statistically significant in the short run. Table 4 reveals that SLF has an estimated effect of ₦2.62 billion increase in DMBs stemming from a percentage increase in SLF. However, its positive impact on DMBs balances contrasts with economic resonance as an increase in SLF rate should discourage DMBs' recourse to the facility, hence a drop in bank liquidity. The result is closely related to the finding by Augustine et al. (2018) where the positive relationship is ascribed to banks' reserves being more than their operational needs.

Consistent with expectations, the SDF showed a negative relationship such that a percentage increase in the current, first lag and second lag rates will cause the DMBs balances to reduce by ₦1.47billion, ₦1.29billion and ₦0.41 billion respectively. The MPR was found to be statistically insignificant at both 10%, 5% and 1% levels. However, its first lag is found to be statistically significant with a ₦1.62 billion increase in bank liquidity balance. Nevertheless, the directions do not conform with expectations.

Although the magnitude of its impact on DMBs is not large, the CRR has a significant negative impact on DMBs in the short run which conforms to a-priori expectation. The estimations show that a percentage increase in CRR would cause about ₦0.39 billion decrease in DMBs balances. While its first lag is largely insignificant, the second lag of CRR accounts for a ₦0.44 billion change in DMBs balances at 5% level. Lastly, the current value, first and second lags of OMO sales have negative impacts on bank liquidity balances. This conforms to a-priori expectations albeit only its second lag is found to be statistically significant with a negligible impact of ₦0.6million. Similarly, the first lag of DMBs has a positive impact on the current level of DMBs balances albeit not statistically significant at the conventional levels.

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3.4 Discussion of Results: Long-run Effects

The long-run results also in Table 4 revealed that MPR has a negative impact on DMBs balances – a 1% increase in MPR leads to a ₦1.39 billion decrease in DMBs balances. While this trend may be contrary to expectations, our result corresponds with Chen, Wu, Jeon, & Wang, 2017 and Pham, Lee & Nguyen, 2021). Specifically, Pham et al. (2021) in their study on Vietnamese commercial banks, found that the effect of the base rate on creation of liquidity by Vietnamese commercial banks is significant, albeit negative. Their stance that expansionary monetary policy through low interest rates would stimulate a buoyant banking system liquidity corresponds with existing literature, and applicable within the Nigerian context which has a somewhat similar level of financial market development.

Both CRR and SDF indicated a positive impact on DMB balances with a 1% increase leading to a ₦0.19billion and ₦0.89 billion increase in DMBs balances, respectively. This directional relationship with DMBs balances does not conform to a-priori economic expectation seemingly, due to the long-term impact of persistent injection of interventions. In fact, the choice of policy tool may cause market distortions in some cases. For example, as indicated by IMF (2013), In a bid to control exchange rate pressures and inflation in 2011, the CBN increased MPR by 275 bps and CRR to 8%. The Bank further intervened by purchasing bonds totalling ₦2trillion to correct for impact of their initial policy actions. Thus, injecting liquidity in the banks.

Comment [H1]: in

Similar to the short run, the current value of our quantity-based instrument OMO sales as well as SLF rate are largely insignificant in the long-run. The reported value of the Error Correction Coefficient (-1.41) suggests speedy adjustment towards equilibrium. The magnitude of the coefficient of the error correction is similar to the values reported in acceptable extant studies like Persaran and Smith (1995), Narayan and Smyth (2006), Loayza and Ranciere (2005) suggesting oscillatory convergence which adjusts speedily beyond equilibrium at first, then subsequently falls back to equilibrium.

Notably, the long-run impact of MPR, CRR and SDF on bank liquidity level is significant, however, CRR and SDF contrast with a-priori expectations. While we note that some studies have shown interesting results contrary to a-prioiri expectations (see Abid&Lodhi, (2015), further research into this relationship will be welcomed.

3.5 Discussion of Results: Testing for Endogeneity

The result for the estimated Toda and Yamamoto augmented VAR model (Eq. 8), which deals with issues of possible endogeneity in the model is presented in Table 5 above. It shows that DMBs has independent causality with all the instruments (i.e., MPR, OMO, CRR, SDF and SLF implying that changes in liquidity do not induce a response from the bank's monetary polic)y stance. In other words, DMBs balance is statistically insignificant in affecting the monetary policy tools of CBN. This is plausible since the CBN monetary policy ultimate target is inflation suggesting why the Monetary Policy Committee's decisions are based on price level and recently, output.

Comment [H2]: have

Comment [H3]: policy

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4. CONCLUSION AND POLICY IMPLICATIONS

This research work examines the effectiveness of various quantity- and price-based monetary policy instruments of the Central Bank of Nigeria which are essential in achieving its statutory mandate. In addition, it assesses the combination of the instruments on bank liquidity, providing an intuition on whether they are complements or substitutes.

The study adopts time-series data approach with quarterly data sourced for the period 2008Q1-2020Q2. It employs ARDL Bounds test in carrying out analysis of the existence of a connection between the quantity- and price-based policy instruments, and liquidity level and examines the impact of the former on the latter. Deposit money banks' balance is used to proxy liquidity level. Monetary policy rate, cash reserve ratio, standing lending facility rate and standing deposit facility rate are disaggregated components used as price-based instruments while OMO sales are used as the quantity-based instrument.

The empirical results reveal that all the monetary policy instruments and bank liquidity level share similar movements that may be linked to form equilibrium long-run relationship. Also, both long-run and short-run impacts of the instruments on bank liquidity balances are found to be mostly significant. The LR test reveals that the unrestricted model that contains all the policy instruments are prefered to any form of restricted model. Thus, all the five monetary policy tools considered in this study are complementary. The results offer interesting responses to the first and second research questions as highlighted in the introduction – monetary policy instruments have significant effect on banks' liquidity position in the Nigerian economy and complement each other.

Comment [H4]: preferred

In terms of the relative impacts of monetary policy instruments on banks' liquidity position, the price-based instruments are relatively more effective in managing liquidity in Nigeria. Other than MPR and SLF which are found to be insignificant in short-run and long-run respectively, all other price-based tools impact liquidity in both time profiles. However, MPR,

Comment [H5]: of

Cash Reserve Ratio and Standing Deposit Facility rate demonstrated contradictory impacts in the long-run, defying a-priori expectations. Our quantity-based instrument, i.e., OMO sales show that its current value has insignificant impact in both periods but its lagged values have a negligible but statistically significant impact on bank liquidity. The inconsistent results between the short- and long-run impacts perhaps are because the policy instruments are often used as a short-run measure.

Several policy implications emerged from this study. First, for the short-run dynamics, though the current value of OMO sales is non-impacting, its previous values remain vital for liquidity management. Thus, CBN should continue to use these instruments as complements to other tools. Secondly, CBN should reassess the disbursement of interventions and their implications on liquidity. Lastly, while studies (including this study) have shown that MPR pass-through to other rates and macroeconomic variables is slow and incomplete, it remains crucial in determining liquidity. Thus, CBN should continue its use as a monetary policy instrument. Nonetheless, a continuous review of its operationality to identify and reduce possible distortions may be beneficial.

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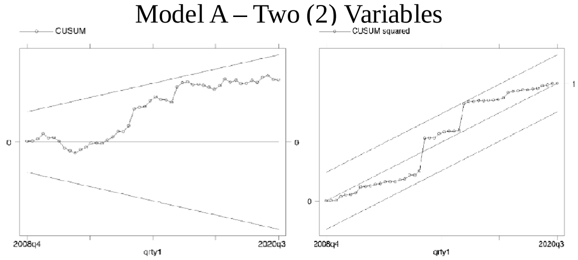
APPENDIX

A. Stability Test Results

Model A – Two (2) Variables



Model B – Three (3) Variables

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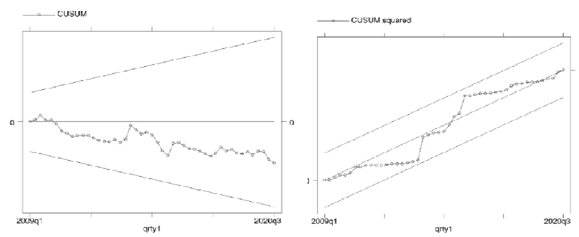
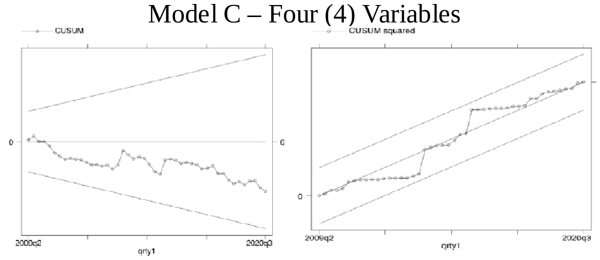
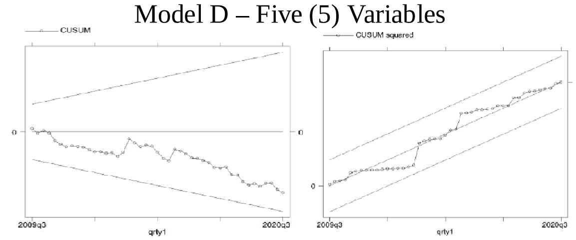


Model C – Four (4) Variables



Model D – Five (5) Variables



Model E – Six (6) variables