Monetary Policy Transmission and Bank Interest Rates in Nigeria

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The paper examines the adjustment of retail and money market interest rates to changes in discount corridor of the monetary policy in Nigeria. A vector error correction model was adopted for this study, using monthly data from 2007:06 to 2019:12. We further accounted for structural breaks in the dataset to improve its policy reliability. The adjustment parameters were found to be significant but with slow speed of adjustment. This finding provides evidence of the weakness of the discount corridor in monetary policy transmission in Nigeria. Furthermore, the results showed no asymmetric adjustment of retail rates to long run equilibria. Lastly, the study found that the deposit rates respond inversely to changes in the standing lending facility. The results imply that the transmission of policy signals through the standing facility rates is not strong, and that raising the standing lending facility will not induce a rise in banks' deposit rates.

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1. Introduction

Monetary policy involves the management of money supply and interest rates, depending on the specific framework chosen by a central bank. This is demand side policy targeted at curtailing the demand for money, to achieve a desired price level. The objectives of monetary policy include low and stable inflation, low unemployment, and higher economic growth. Monetary policy is often conducted through the adjustment of interest rates, managing the exchange rate, and adjusting money supply through a change in the cash reserve requirement (CRR).

Monetary policy in Nigeria has evolved over the years with direct control at inception and during the earlier decades of central banking in the country, to eventual migration

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to indirect system (Ikhide, 1998). With the adoption of a market-based monetary policy mechanism in 1993, these policy objectives have been largely pursued using the open market operations supported by several indirect instruments including the discount operations and the CRR.

The discount window is an important monetary policy instrument for reserve adjustment and monetary control procedures. Through the window, the central bank allows counterparties – commercial banks and other qualified depository institutions – to deposit and borrow funds to ameliorate temporary liquidity surpluses and shortages, respectively. Deposits and lending at the window are implemented through the reserve accounts that banks maintain at the central bank. The discount window operating framework functions as a safety valve in relieving pressures in the reserves market. By extending credit, the central bank relieves liquidity stress on a bank and in the banking system, while accepting deposits helps to firm up the system in times of liquidity overhang.

In Nigeria (and many climes such as the eurozone), the discount window is known as the Standing Facilities. The counterparties utilize the facilities to increase the amount of reserves for overnight settlements using the standing lending facility (SLF). Conversely, excess funds can be deposited with the central bank using the standing deposit facility (SDF). The rates for these two facilities signal the monetary authority's outlook for commercial interest rates and set the upper and lower limits for interest rates on the short end of the domestic money market, thereby helping to ensure stability in the market.

There are, however, concerns about the nature of the transmission of monetary policy to the money market and retail markets rates, leading to several changes over the years by the Central Bank of Nigeria to improve the transmission mechanism of monetary policy. One of such changes was the migration from minimum rediscount rate (MRR) to monetary policy rate (MPR) framework in 2006, and the subsequent adaptation of discount window corridor. The migration became necessary as the effectiveness of the MRR was called to question. Liquidity overhang, oligopolistic banking sector that created volatility in bank interest rates, and fiscal dominance, which crowded out private sector borrowing, shielded interest rates from receiving the nudge in the direction envisaged by changes in MRR. The new framework was operated as an anchor against which movements of market interest rates are benchmarked and controlled and was meant to calm the interest rate volatility and drive credit towards the private sector. Apprehensions concerning transmission are not peculiar to Nigeria, as the efficacy of monetary policy pass-through is a matter of concern across several developing countries (Mishra, *et al.* 2014; Mishra & Montiel, 2012).

Furthermore, the rationale for the discount window operations has come under scrutiny as some analysts wonder if it is necessary for the apex bank to provide banks with liquidity through discount window corridor. They allude to possible shortcomings that include the possibility of undermining the central bank's control over the monetary base, the risk of possible abuse of the policy tool, and the belief that its effectiveness is diminished by stigma – unwillingness of banks to access the window because they may be perceived as being in precarious financial condition (Carlson & Rose, 2017; Ennis & Price, 2020; Kaufman, 1992; Schwartz, 1992). Others, on the other hand, believe that the discount window is useful as it helps to dampen excessive seasonal fluctuations in interest rates and encourage the buoyancy of bank lending by offering a flexible source of liquidity. Additionally, they argue that discount window operations can sufficiently reduce panic that may arise in the banking system by limiting a surge in portfolio risk and drying up of bank liquidity that characterize periods of high lending, or in times when unpredictable upsurge in deposit withdrawals pose a threat to banking system liquidity (Carlson & Rose, 2017; Ennis & Klee, 2021; Diamond & Dybvig, 1983).

Most studies on monetary policy transmission make use of minimum rediscount rate (MRR) and/or monetary policy rate (MPR), money supply, and credit to the economy in the analysis of interest rate pass-through in Nigeria (Kelilume, 2014; Mordi, Adebiyi & Omotosho, 2019; Okaro, 2011; Sanusi, 2010). Yet, an important complementary monetary policy tool that has grossly been under-studied, is the role of the discount window operations in the analysis of the transmission of monetary policy to bank interest rates. Motivated by the need to fill this gap, this paper intends to re-examine the evidence on monetary policy transmission to bank interest rates in

Nigeria using the discount window corridor. In other words, the paper seeks to provide further evidence on monetary policy transmission in Nigeria by investigating how the SDF and SLF transmit to retail interest rates in the economy.

The rest of the paper is organized as follows: Section 2 follows the introduction and discusses the literature review; Section 3 outlines the data sources and methodology; Section 4 presents and discusses the results; while section 5 concludes and presents policy recommendations.

2. Literature Review

2.1 Theoretical Literature

Monetary policy is a demand side policy intended to impact aggregate demand. Various theories in the monetary economics literature highlight the transmission mechanism of monetary policy to the real economy. These include the interest rate pass-through theory, the credit channel mechanism as well as other theories that highlight other asset price channels.

An interesting starting point for the review of the transmission mechanism of monetary policy is the interest rate theory. This gained more importance with the Keynesian ISLM model (Mishkin, 1996) wherein the impact of monetary expansion on aggregate demand and output is seen to work through a low interest rate channel, which raises investment levels of firms and in turn results in higher aggregate demand and output. Monetary policy anchored on this theory holds that interest rate is the link between money supply and output growth. However, such a view exposes monetary policy to certain limitations such as the liquidity trap, which negates monetary policy. This limitation became obvious even to Keynes himself as well as the modern monetary economists who subsequently rejected it (Jhingan, 2003). Their alternate view became known as the portfolio adjustment process.

The modern portfolio adjustment view of monetary policy transmission contends that central bank actions such as open market operations, will ultimately increase aggregate demand and expand output through the substitution and wealth effects. Regarding the substitution effect, if a central bank's purchase of securities result in excess cash balances in the hands of the public, they will progressively re-adjust the proportions of their asset portfolio by substituting the excess balances for other assets whose prices are yet to rise due to increased demand. This chain of portfolio readjustments will ultimately impact economic activities by bringing about increases in the output of capital goods (Jhingan, 2003).

The agency cost or the credit rationing theory by Stiglitz & Weiss (1981) implies that interest rates may not always function as efficient allocator of credits. This obtains in the face of information asymmetries in financial markets and leads to credit rationing even if interest rates were liberalized by policy. In essence, banks would rather ration credit to borrowers instead of pricing them strictly against the signals of monetary policy when it is too costly to get information about borrowers for loan administration or monitoring. When this happens, it is implied that the transmission of monetary policy impulse will be truncated. For a developing financial market like Nigeria, where identity management is in its infancy, such a theory may come close to predicting the prudential behavior of banks in lending to scarcely identifiable borrowers.

In the same class of price stickiness theories of bank loan market, the switching cost theory juxtaposes rational behavior of lenders and borrowers, to explain why interest rates respond to policy rate changes in an inelastic manner. In summary, the theory holds that a rational lender will, in order to cover the cost of acquiring less risky borrowers, impose an up-front fee devised to keep the borrowers from switching to the competitor. This fee, which is a cost to borrowers, is added to other 'search' costs to make the option of switching to alternative loan suppliers less attractive to borrowers. Therefore, to the extent that switching costs make loan demand less elastic to interest rate changes, monetary policy will be less direct in influencing aggregate variables (Klemperer, 1987, cited in Lowe & Rohling, 1992).

The risk sharing theory further explores price stickiness by considering the often realistic and observable risk aversion of some borrowers. This risk aversion influences their preference for more stable interest rate regimes and, to accommodate this preference, banks price loans less than the marginal cost of funds while making up with a higher average rate than obtainable with risk neutral borrowers.

All the above interest rate transmission theories based on the price stickiness hypothesis hold varying degrees of usefulness in explaining the transmission inertia documented in literature. Yet, each must be judged alongside the prevailing economic structure of the specific monetary authority. Such aspects as the level of competition in the banking sector, level of financial system development or even the extent of the central bank's pursuit of secondary objectives such as economic development and promotion of protected sectors as in Nigeria could influence the transmission mechanism of monetary policy.

2.2 Empirical Literature

Bassey, *et al.* (2018), established the existence of long-run relationship of the monetary policy instruments (open market operations (OMO) and CRR) with the MPR, and argued that the MPR could serve as a veritable instrument for the control of money supply and effective monetary policy management in the economy. Okaro (2011) also showed the important role of the interest rate policy in Nigeria by demonstrating that credit is an important part of the transmission process of Nigerian monetary policy.

Asaleye *et al.* (2018) in a study spanning 1981 to 2016 explained how shifts in the central bank's monetary policy influence economic growth as well as the level of employment in Nigeria. The study which made use of autoregressive distributed lag and structural vector autoregressive models showed that during the initial periods, changes to monetary policy had a greater impact on GDP than they had on unemployment, but this trend was reversed at later periods when the impact on unemployment became larger. The findings did not give any indication of a long run relationship when output is explained by other variables while a long run association is found when unemployment is explained. The indicator of monetary policy was seen to be very important in explaining unemployment both in the near term and in the long term.

Anwar and Nguyen (2018) examined the transmission mechanism of monetary policy in Vietnam using quarterly data from 1995 to 2010 in a structural vector autoregression (SVAR) method. They reviewed the economy's response to shocks in domestic and foreign monetary policy and found that the credit channel is important because, among other channels, it stands out in the propagation of monetary policy in the country. However, this role, seen via the impact of money supply on the growth of real output, is not as strong as expected, implying a weak or muted transmission channel.

Sanusi (2010) estimated the magnitude and speed of the interest rate pass-through for Nigeria using monthly data (2002:01-2010:04) and SVAR model and found that interest rate pass-through in Nigeria is incomplete and slow. He also analyzed the 2007-2010 sub-sample with a view to verifying if the pass-through of interest rate changes to both retail and market rates remained the same after the banking sector consolidation of 2005 and the introduction of the monetary policy rate in 2006. Although incomplete, the pass-through of monetary policy rate to the money market is substantially larger and faster than to the retail market. There is some evidence of signaling effects of policy rate changes on money market rates, but not to retail rates. While the pass-through to the money market increased substantially in the post-consolidation period (2006-2010), transmission to the retail market declined relative to the pre-consolidation period of 2002-2005.

Ogundipe and Alege (2013) employed the maximum likelihood and Engel-Granger's two–step procedures, as well as VAR-based error correction model (ECM) and the mean adjustment lag (MAL) to determine the short-run estimates and asymmetric behavior respectively. They find evidence of downward stickiness both in the short-run and long-run policy pass-through to the retail market. Similarly, Kelilume (2014) identified a sticky pass-through of monetary policy to short and long term retail interest rates in Nigeria, and that the evidence of the effectiveness of monetary policy is seen only in the relationship between monetary policy rate and interbank rates. Abayomi and Sheriffdeen (2015) also found dissimilar outcomes of interest rate pass-through (IRPT) to financial products of commercial banks. In particular, deposit rates pass-through is near complete in the short run for all products except the 12-month deposit rate. In the case of lending rates, the prime lending rate pass-through was complete while the maximum lending rate was incomplete. Further enquiries using the bounds test indicated the existence of a long-run relationship between the retail rates such that the speed of adjustment takes an average of 16 months for deposit rates and 7 months for prime lending rate to return to their equilibrium positions. Based on the findings that pass-through of wholesale rate to banks' retail rates is sufficiently high, the authors concluded that monetary policy is reasonably effective in determining changes to the intermediate target in the short-run in Nigeria.

Mordi, *et al.* (2019) documented some robust evidence on interest rate pass-through in Nigeria. Their work confirms, among others, that a long-run relationship exists between the MPR and each of prime lending and savings deposit rates, in spite of significant structural breaks occurring in the co-integrating vectors at different periods. The study further shows that the transmission of changes in MPR to the retail market is not complete and that bank retail rates (except the savings rate) adjust symmetrically to changes in the policy rate. This, they argued, suggests that changes to the savings rate depends on the nature of the shock to the policy rate. Positive shocks in the policy rate get transmitted wholly to the savings rate in two months in contrast to eight months for negative shocks. They further find that it takes about fourteen months for shocks to the policy rate to be passed fully to the prime lending rate, while the full impact on the 6-month deposit rate takes place in about eleven months.

Matousek and Solomon (2018) employed the generalized method of moments (GMM) two-step estimator, to investigate the impact of the Central Bank of Nigeria's (CBN) bank restructuring policies of 2002 - 2008 on bank lending channel of transmission and found that larger and more capitalized banks are less sensitive to changes in monetary policy. Osadume (2018) examined how monetary policy rate and other discount rates affect development in Nigeria. The study documented an indication that discount rates – represented by interest and monetary policy rates – have a significant short-run impact, and positive and significant long-run impact on economic development with substantial speed of adjustments.

Mangwengwende, *et al.* (2011) applied an asymmetric error correction model, mean adjustment lag (MAL) model and autoregressive distributed lag model on monthly data (1994-2007) to determine the link between banking sector concentration and interest rate pass-through (IRPT) in Botswana, Nigeria, South Africa, and Zambia. The study also sought to investigate if there was asymmetry in the IRPT, and whether such asymmetry was related to changes in bank concentration. The study found that, for Nigeria, there was a cointegration of the deposit with lending rates, though, supported by only two of the testing techniques. It noted that Nigeria had the lowest banking sector concentration among the set of countries, and that the symmetric error correction for deposit and lending rates was significant, with the latter adjusting faster than the former. It also found that the adjustment of lending rates did not indicate a relationship with bank concentration level, however, lending rates had the smallest asymmetric long-run adjustment similar to the other countries.

Mishra *et al.* (2014) made use of quarterly data spanning 1978-2013 and panel structural VAR model to examine the transmission of monetary policy to bank lending rates across a large number of advanced economies, emerging market economies and low-income countries. They found that the response of lending rates of commercial banks to changes in monetary policy vary very widely across countries. Additionally, they noted that the pass through of monetary policy among developing countries is generally weaker compared to the rest. They attributed this to weak institution and non-competitive banking environment that characterize the low-income countries. This corroborates earlier finding by Mishra and Montiel (2012) that the transmission of monetary policy is particularly weak among developing countries.

From the reviewed literature, it could be seen that whereas the incompleteness of the interest rates pass-through of monetary policy in Nigeria has been variously established in the literature using the MPR. Many of the studies located the sources of these limitations either in the nature/level of financial markets or the natural downward stickiness of retail interest rates.

3. Data and Methodology

3.1 Data

The study makes use of monthly data on nine retail interest rates of commercial banks and the policy corridor rates of the CBN discount window operations, namely, the rates applied in the standing lending facility and the standing deposit facility. Net liquidity injection was derived by differencing the monthly series of the CBN claims on deposit money banks. The two standing facility corridor rates are then adjusted to reflect the applicable or effective policy rates during periods of shortages and surpluses of liquidity. The adjustment was achieved by taking the product of the corridor rates and the associated liquidity condition dummy as explained under equation (1). By this adjustment, the model will be switching between the corridor lending and deposit rates according to the prevailing liquidity condition. The nine rates of commercial banks are: prime lending rate (plr), maximum lending rate (mlr), savings rate (svr), 7-day time deposit (td7d), rate on one-month tenor deposit (td1m), rate on three-month tenor deposit (td3m), rate on six-month tenor deposit (td6m), rate on twelve-month tenor deposit (td12m) and time deposit with tenor above 12 months (tda12m). The data are gotten from the CBN's statistics database with series spanning from 2007:06 to 2019:12. The choice of this series range is guided by data availability for all the variables.

3.2 Analytical Framework

In discount window systems operated by some central banks, there is usually an established lending window through which the central bank offers any quantity of reserves requested for by banks. The rate at the lending window is usually kept at a rate of interest that is higher than the anchor rate to serve as a punitive measure on banks that seek to source from the monetary authority instead of from the interbank market. In the same vein, there is a deposit window in the corridor system which is the standing deposit facility for banks with excess liquidity to lodge such surpluses with the central bank overnight at a fixed rate of interest. Similar to typical discount rate, the deposit rate is normally set lower than the anchor rate to induce the depository corporations to place any surplus funds not with the apex bank but in the interbank market. With the upper and lower bounds in place, the corridor system is meant to deflate the magnitude of oscillations in the short-term rate. When banks are in need of funds to square up their statutory reserve balances, they will be discouraged to pay a rate that is more than the upper bound rate, and when in surplus position, they will most likely not agree to take a rate below the standing deposit rate of the discount window. Besides, within the corridor defined by the bounds, banks with surpluses and shortages of funds will be motivated to lend to and borrow from one another resulting in a vibrant interbank market. In this way, the monetary authority may be able to exercise firm control over the interest rate on short-term funds. For the banking system seen as one, the applicable rate at any point in time will depend on the liquidity situation in the system.

In Nigeria, the standing facility (SF) was introduced as a discount window framework in liquidity management. It comprises two rates: the SDF rate which is a fixed point below the MPR, and the SLF rate which is a fixed point above the MPR. In a deficit liquidity situation, the CBN would be injecting liquidity at the SLF rate (i.e. upper bound of the policy corridor), and in periods of excess liquidity, the Bank will be draining liquidity from the system at the SDF rate (i.e. lower bound of the policy corridor).[2] In view of this, two sets of effective policy rates are considered: the SDF rate during liquidity surplus (i.e. net liquidity injection $<$ 0); and SLF rate during liquidity deficit (i.e. net liquidity injection $>$ 0). To determine the proxy for liquidity conditions (surplus or deficit), we utilized the changes in CBN claims on deposit money banks. Increase in these claims plausibly indicates injection of liquidity into the system while a contraction of the claims points to the opposite. We apply a modified version of the framework used by Das (2015) in the case of India, and incorporate into the long run model, the two bounds of the policy corridor that are adjusted by a liquidity condition dummy as follows:

$$BIR_{it} = \beta_{it} + \beta_{1it} SDF_t * LiqCon_t^d + \beta_{2it} SLF_t * LiqCon_t^l + \varepsilon_{it} \tag{1}$$

where: BIR_{it} is commercial banks' retail rate i at time t, SDF_t and SLF_t are standing deposit facility rate and standing lending facility rate at time t, respectively. $LiqCon_t^d$ is the liquidity condition in times of surplus, defined as:

$$LiqCon_t^d = \begin{cases} 1 & if\ net\ injection < 0 \\ 0 & otherwise \end{cases} \qquad \text{during liquidity surplus}$$

[2] The Bank also provides temporary liquidity accommodation to the banks using the repo rate, and withdraws liquidity during surplus conditions using the reverse repo rate. However, this study does not cover the repo and reverse repo as the focus is on monetary policy operations via the standing facilities.

$LiqCon_t^l$ is the liquidity condition in times of shortage, defines as:

$$LiqCon_t^l = \begin{cases} 1 & if\ net\ injection > 0 \\ 0 & otherwise \end{cases} \quad \text{during liquidity shortage}$$

β_{it} is a mark-up for the different interest rates, while β_{1it} and β_{2it} capture the transmission effects of liquidity expansion and contraction through the standing facilities of the discount corridor, respectively, for every specification of retail rates, and ε_{it} is the residuals obtained from the various equations of bank interest rate.

This specification ensures the capturing of the effects of policy switches between liquidity contraction and expansion all through the entire period of the sample, and not being restricted solely to the anchor rate that does not change at every slight shift in policy.

3.3 Model Specification

The error correction model (ECM) was chosen over other modeling approaches since the data indicated that the underlying variables have a long-run common stochastic trend. All the variables are integrated of order one I(1), and can be differenced once to achieve stationarity. For each of the interest rates, an ECM is estimated thus:

$$\Delta BIR_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \Delta BIR_{t-i} + \sum_{i=0}^{q} \beta_i \Delta SDF_{t-1}^d + \sum_{i=0}^{q} \delta_i \Delta SLF_{t-1}^l + \varphi ECT_{t-1} + \mu_t \quad (2)$$

where SDF^d is SDF modified by the surplus liquidity condition, SLF^l is SLF modified by the deficit liquidity condition, and φ is a measure of the speed of adjusting back to long run equilibrium after a deviation occurred, ECT_{t-1} is one-period lag of the residuals from the selected Gregory-Hansen long-run equation for each of the bank interest rates.

As the usefulness of applied time series is, based on the assumption of parameter constancy, it becomes imperative to adopt a procedure that explicitly checks if structural breaks are present in the series. This informs the choice of Gregory-Hansen cointegration method. The cointegration test with unknown break date involves estimating the augmented Dickey-Fuller and Philips-Perron test statistics for each of the break points and then picking out the one with minimum value obtained across all possible break points, since this will provide ample grounds for the rejection of the null hypothesis of no cointegration. Gregory & Hansen (1996) came up with four models for the test, namely: (i) standard model with no structural change:

$$y_{1t} = \mu + \alpha^T y_{2t} + e_t \qquad t = 1, \ldots, n \tag{3}$$

where y_{it} is $I(1)$ and e_t is $I(0)$, μ and α are the intercept and slope, respectively.
To specify models with structural shifts, a dummy variable is introduced:

$$D_{t\tau} = \begin{cases} 1 & if\ t \leq [n\ \tau], \\ 0 & if\ t > [n\ \tau]. \end{cases}$$

where the unknown parameter $\tau \in (0,1)$ is the timing of the point of break.
(ii) model with level shift in which only the intercept shifts:

$$y_{1t} = \mu_1 + \mu_2 D_{t\tau} + \alpha^T y_{2t} + e_t \qquad t = 1, \ldots, n \tag{4}$$

where μ_1 is the intercept prior to the break and μ_2 is the change in intercept when the shift occurs.
(iii) model in which level shifts with trend;

$$y_{1t} = \mu_1 + \mu_2 D_{t\tau} + \beta t + \alpha^T y_{2t} + e_t \qquad t = 1, \ldots, n \tag{5}$$

(iv) one with regime shift in which the slope also shifts.

$$y_{1t} = \mu_1 + \mu_2 D_{t\tau} + \alpha_1^T y_{2t} + \alpha_2^T y_{2t} D_{t\tau} + e_t \qquad t = 1, \ldots, n \tag{6}$$

where μ_1 and μ_2 are as defined in equation (3), α_1 and α_2 are the slopes before and after the regime shift respectively.
The best performing model in terms of fit is chosen, in this case, relying on Akaike information criterion. To account for possible bias from misspecification due to struc-

tural breaks, the vector of residuals from the selected Gregory-Hansen equation is incorporated into equations (2) and (7) as the error correction term (ECT).

To check for asymmetric adjustment, we estimate the following dynamic equation:

$$\Delta BIR_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \Delta BIR_{t-i} + \sum_{i=0}^{q} \beta_i \Delta SDF_{t-1}^{d} + \sum_{i=0}^{q} \delta_i \Delta SLF_{t-1}^{l} + \varphi_1 ECT_{t-1}^{pos} + \varphi_2 ECT_{t-1}^{neg} + \mu_t \quad (7)$$

which yields the error correction coefficients φ_1 and φ_2 for testing whether the effects are the same for monetary loosening and tightening. The test for ascertaining whether the adjustment process is asymmetric or not is executed by checking the restriction that the adjustment parameters in equation (7) are equal (Ho: $\varphi_1 = \varphi_2$). If the Wald test fails to reject the null, then, we can rule out any suggestion of asymmetry in the adjustment of bank interest rates to positive and negative shocks to the discount window rates.

3.4 Estimation Procedure

First, the variables were checked for stationarity. Thereafter, single equation tests for cointegration using the Gregory and Hansen (1996) algorithm was carried out.

Following the cointegration test, an error correction model is estimated for each of the bank interest rates as specified in equation (2). Test for the existence of asymmetric adjustment follows the approach used by Scholnick (1996), which was also applied by Das (2015) and Mordi *et al* (2019). The equilibrium condition between the bank interest rate and policy rates is defined as the mean of the residual series from the cointegrating equation. The estimation consists of a switching model of partial adjustment, which allows adjustment speeds to vary according to whether the residuals are above or below its long-run equilibrium, and estimates both the long-run relationship and the upward and downward adjustment speeds. The approach involves splitting the residuals from long-run specifications (equation (1)) into their positive (ECT^{pos}) and negative (ECT^{neg}) values which correspond to when the residuals are above and below its long run average, respectively (Neumark & Sharpe, 1992; Scholnick, 1996; Mordi *et al.,* 2019). This is specified in equation (7). All the estimation processes are carried out using Eviews 9 software.

A note on the implications of changes in SLF and SDF may be apt at this point. An increase in SLF implies an increase in cost of funds from the CBN source. This can have positive or negative impact on banks' interest rates. When there is an increase in cost of funds from CBN, banks may try to save cost by reducing interest rates paid on different tenures of their deposit products. In this case we expect the effect of an increase in SLF on deposit rate to be negative. If, however, an increase in SLF drives banks to resort to the alternative of aggressive deposit mobilization by offering high interest rates to depositors, the effect of an increase in SLF on deposit rates as well as on lending rates will be positive. Therefore, while the long run effect of an increase in SLF on banks' lending rates is expected to be positive, the effect on deposit rates will depend on which one dominates: the desire for cost reduction versus the desire for aggressive deposit mobilization.

Furthermore, an increase in SDF implies a heightened desire to mop up liquidity. In other words, an increase in SDF is an incentive for banks to deposit at the central bank, thereby reducing the amount of liquidity in the system. This happens mostly during persistent liquidity overhang. During this period, bank interest rates, especially on deposits, tend to fall naturally. Since the cost of funds sourced from CBN and cost of funds sourced by deposit mobilization both fall in periods of excess liquidity, we expect the effect of an increase in SDF on banks' interest rates to be negative in the long run.

4. Results and Discussion

We first present the summary statistics of the data used in Table 1.

Table 1: Summary statistics

	td7d	td1m	td3m	td6m	td12m	tda12m	plr	mlr	slf^l	sdf^d	net injection
Mean	4.23	8.46	9.02	9.09	8.56	8.57	16.79	25.23	12.90	6.88	23.36
Std Error	0.11	0.19	0.18	0.21	0.23	0.20	0.09	0.33	0.24	0.31	13.57
Median	4.34	8.47	9.14	9.73	9.29	8.70	16.72	24.90	14.00	9.00	1.37
Mode	4.45	8.09	9.48	12.98	4.90	8.95	16.50	31.39	14.00	10.00	N/A
Std Dev	1.30	2.30	2.17	2.53	2.85	2.49	1.08	4.01	2.91	3.80	166.78
Variance	1.69	5.29	4.70	6.40	8.13	6.19	1.17	16.05	8.47	14.41	27814.18
Kurtosis	-0.19	0.55	-0.02	-0.51	-0.89	-0.39	0.45	-0.87	-1.25	-0.88	98.89
Skewness	-0.04	0.11	-0.02	-0.25	0.01	0.17	0.58	-0.02	-0.57	-0.81	9.42
Range	6.05	11.52	10.52	12.34	12.94	11.96	5.08	13.98	8.00	11.00	1946.24
Min.	1.27	3.49	4.13	3.50	3.53	2.17	14.58	17.58	8.00	0.00	-96.84
Max	7.32	15.01	14.65	15.84	16.47	14.13	19.66	31.56	16.00	11.00	1849.40
Count	151	151	151	151	151	151	151	151	151	151	151

Source: Authors' compilation

Table 1 reveals that the minimum value across the deposit rates of banks are all below 5%, while the maximum values hover around 15% across the rates. This implies somewhat wide margin in the rates between the minimum and maximum values across the products. This is further seen in the variance ranging from 1.69 (7-day time deposit rate) to 8.13 (12-month time deposit rate). Meanwhile, the mean, minimum and maximum values of prime lending rate are in the double-digit range at 16.79%, 14.58% and 19.66%, respectively. At the same time, the SDF and SLF rates also exhibit wide margins in their mean, minimum and maximum values.

4.1 Unit Root Tests

As part of the pre-estimation diagnostics, the time series properties of the variables were examined using standard statistical and econometric tests. The order of integration of each variable was checked with the Augmented Dickey Fuller (ADF) test. The results show that each of the eleven variables was integrated of order one, at either 1% or 5% level of significance (Table 2).

Table 2: Results of stationarity tests

Variable	Level	p-value	1st Difference	p-value	I(d)
sdf^d	-1.743463	0.4072	-21.62629	0.0000	I(1)
slf^l	-2.262155	0.1858	-21.60497	0.0000	I(1)
mlr	-1.443604	0.5592	-4.077640	0.0014	I(1)
plr	-2.091192	0.2486	-3.413829	0.0120	I(1)
Svr	-0.755810	0.8279	-6.132546	0.0000	I(1)
td7d	-1.791244	0.3837	-3.308107	0.0163	I(1)
td1m	-2.147397	0.2267	-3.106170	0.0283	I(1)
td3m	-2.188975	0.2112	-4.742910	0.0001	I(1)
td6m	-2.180099	0.2145	-3.546302	0.0081	I(1)
td12m	-2.308206	0.1708	-3.160517	0.0245	I(1)
tda12m	-2.037227	0.2708	-16.76165	0.0000	I(1)

ADF implies unit root test with intercept

The variables sdf^d and slf^l are the modified SDF and modified SLF, respectively, while others are as previously defined.

4.2 Cointegration Test

The Gregory-Hansen residual based cointegration test was applied to enable the investigation of not only the presence of long run association between the corridor rates and the individual retail interest rates, but also to take care of likely bias due to any structural break as explained in section 3.3. The test involves computing the Gregory-Hansen ADF t-statistics and Za-statistics for each break point and selecting the smallest value (the largest negative value) across all break points on the basis of Akaike information criterion.

The results of the tests which are presented in Table 3 indicate that at 5 per cent level of significance, the policy rates are cointegrated with 7-day time deposit, 1-month time deposit, 3-month time deposit, 12-month time deposit and time deposit above 12 months. This implies that the error correction approach can be applied to examine the long run relationships between the policy corridor rates and these interest rates. As further shown in the table, structural breaks occurred in February 2010 for 7-day time deposit in the model with intercept shift only, and March 2010 for the other four variables in the model with intercept shift with trend. The tests however did not find any long run relationship between the policy rates and maximum lending rate, prime lending rate, saving rate and 6-month time deposit as can be seen in Table 3, and therefore, these variables cannot be carried along in the error correction model estimations.

Table 3: Results of Gregory-Hansen cointegration tests

	Statistics	intercept shift	intercept shift with trend	intercept & slope shift
mlr	ADF t-stat	-3.557453	-3.872139	-3.681776
	Break date	2016M06	2011M04	2015M11
	AIC	-4.566523	-6.21864	-4.546727
plr	ADF t-stat	-3.515419	-3.411952	-3.39585
	Break date	2009M08	2009M07	2015M07
	AIC	-6.218095	-6.212207	-6.242201
svr	ADF t-stat	-4.010619	-3.912805	-4.507788
	Break date	2013M10	2010M08	2013M10
	AIC	-6.725381	-7.005925	-6.7056
td7d	Za-stat	-51.20868**	-52.17658	-54.54624
	Break date	2010M02	2010M03	2010M02
	AIC	-5.859161	-5.988142	-5.836561
td1m	Za-stat	-56.05271	-65.6814**	-62.60071
	Break date	2010M03	2010M03	2010M03
	AIC	-4.723161	-4.751063	-4.701479
td3m	Za-stat	-52.8912	-56.34552**	-57.52493
	Break date	2010M03	2010M03	2010M03
	AIC	-4.832387	-4.861392	-4.814729
td6m	ADF t-stat	-3.512944	-5.265278	-5.311011
	Break date	2010M06	2010M05	2010M05
	AIC	-4.531669	-4.525363	-4.509146
td12m	Za-stat	-39.8476	-54.50849**	-43.03647
	Break date	2010M03	2010M03	2010M03
	AIC	-4.325258	-4.31434	-4.301011
tda12m	Za-stat	-76.54178	-80.92498**	-84.01182
	Break date	2010M03	2010M03	2010M06
	AIC	-4.632225	-4.744413	-4.607116
5% crit.	ADF t-stat	-4.92	-5.29	-5.50
Values	Za-stat	-46.98	-53.92	-58.33

***, ** and * imply significant at 1%, 5% and 10% respectively

4.3 The Long Run Models

The estimated long run model (equation 1) in Table 4 revealed that the coefficients of 1-month time deposit, 3-month time deposit and time deposit above 12 months were negative and significant at either 5% or 1%. Furthermore, the 7-day time deposit adjustment to discount corridor was found to be negative and statistically significant at 10 per cent level, while the 12-month time deposit adjustment was also negative but statistically not significant. The consistent negative coefficients for the SDF for all the rates were in line with a priori expectation as bank interest rates tend to fall generally when the SDF rises in accord with CBN's intention to mop up during liquidity surplus. Furthermore, as shown by the all negative coefficients of the SLF, the results indicate that higher cost of CBN sourced funds is associated with a fall in deposit rates of banks. This finding appears novel since no existing empirical study has investigated the implication of a rise in SLF for interest rate on bank deposits. The implication, therefore, is that banks' desire to save costs by lowering deposit rates dominates over their desire for aggressive deposit mobilization in periods of tight liquidity. In other words, banks are more inclined to cutting cost during tight liquidity than offering higher interests to attract more deposits. This is a key finding of this study.

Table 4: Result of long run equations

Bank int. rates	Policy rates	Coefficients	Probability	F-stat	Prob. (F-stat)	Durbin-Watson	Adjusted R^2
td1m	sdf^d	-0.190718***	0.0061	2.345631	0.001226	1.920863	0.192628
	slf^l	-0.104806**	0.0133				
td3m	sdf^d	-0.155479**	0.0180	1.871509	0.054275	1.986980	0.056330
	slf^l	-0.083856**	0.0363				
td7d	sdf^d	-0.066430*	0.0927	2.095295	0.028785	2.032842	0.069785
	slf^l	-0.044042*	0.0681				
td12m	sdf^d	-0.093362	0.2840	2.957007	0.002150	2.011217	0.118198
	slf^l	-0.024640	0.6427				
tda12m	sdf^d	-0.258339***	0.0005	4.098241	0.000000	2.003665	0.175059
	slf^l	-0.134240***	0.0032				

***, ** and * imply significant at 1%, 5% and 10% respectively

In Table 4, the F and Durbin-Watson statistics seem good. Low adjusted R^2 values in Tables 4, 5 and 8 amidst low probability values still indicate some relationship between the significant predictors and the independent variable. In other words, the results indicate that the policy rates still provide evidence about banks' interest rates even though data points fall further from the regression line. Low values of adjusted R^2 are particularly problematic when the ultimate goal is forecast precision, which is not the focus of this paper.

4.4 Error Correction Models

The estimated coefficients of the error correction term (ECT) for the five interest rates were negative and highly significant at 5 per cent level, testifying to the presence of long run convergence between the lower and upper bounds of the policy corridor and each of the five variables. In Table 5, the magnitudes of the coefficients of the error correction term appear to be clearly suggestive of rather weak speed of returning the retail rates to their long run equilibria. At -0.0618 and -0.1765, the slowest and fastest speeds of adjustment were seen in the models for 3-month time deposit and time deposit above 12 months, respectively. These imply that about 6.18 per cent and 17.65 per cent of the deviations or errors are corrected within a period of one month for 3-month time deposit and time deposit above 12 months, respectively. The speeds of adjustment for other rates lie between these two meagre extremes.

Table 5: Speed of adjustment

Bank int. rates	ECT coefficients	Probability	F-stat	Probability (F-stat)	Adjusted R^2
td1m	-0.067111	0.0373	6.291722	0.000000	0.251156
td3m	-0.061760	0.0299	3.087754	0.007186	0.079018
td7d	-0.064326	0.0410	4.232979	0.001290	0.099682
td12m	-0.091703	0.0348	5.939159	0.000051	0.144677
tda12m	-0.176467	0.0111	6.757727	0.000003	0.191343

4.5 Asymmetric Adjustment

The results of the asymmetric error correction model indicate how bank interest rates respond to negative and positive shocks to the monetary policy of the central bank via the discount window corridor. The existence or absence of unequal adjustment of the interest rates to shifts in policy was tested using Wald test. The results presented in Table 6 show that all the five retails rates do not adjust differently whether they are low or high in relation to their equilibrium with the standing facility corridor rates. In other words, the null hypothesis that the parameters φ_1 and φ_2 are equal is not rejected for each of the five retail rates, meaning there is no asymmetry in the adjustment process of bank deposit rates to shifts in the SDF and SLF.

Table 6: Results of Ttests for asymmetric adjustment

Bank interest	Coefficients		Wald test: $\varphi_1 = \varphi_2$	
rate	φ_1	φ_2	χ^2	Probability
td1m	-0.096632*	-0.063950	0.192413	0.6609
td3m	-0.104529*	-0.030493	0.814296	0.3669
td7d	-0.130475**	-0.016086	1.598820	0.2061
td12m	-0.192243**	0.011918	2.077600	0.1495
tda12m	-0.158270	-0.229298*	0.111252	0.7387

***, **, * imply significant at 1%, 5% and 10% respectively

4.6 Post-Estimation Diagnostics

Some post-estimation diagnostics were carried out to determine the health of the models. Serial correlation, heteroscedasticity, residual normality, and parameter stability were checked using Breusch-Godfrey, White, Breusch-Pagan-Godfrey, and CUSUM tests, respectively. There were no serial correlations detected in the five models. Furthermore, all the models were dynamically stable as evidenced by the CUSUM test. However, heteroskedasticity was detected only in the equation for 1-month time deposit (which was corrected using the Huber-White covariance method), while residual normality concerns were seen in all the models.

In large samples, as in this study, the residual normality concern is not an issue since the least squares estimator of the parameter and variance are still consistent. They converge to their true values and are still useful for implementing tests and inferences. The test statistics had different but known asymptotic distributions. In particular, the t-statistic, which is normally T-distributed, will be asymptotically normally distributed when error normality does not take place (Wooldridge, 2016; Greene, 2012). Therefore, we can say our models are reasonably adequate for this study.

Table 7: Post-estimation diagnostics

Variable	Issue	Statistic	Probability	Remark
td7d	Serial Correlation	1.030704	0.5973	No Serial Correlation
	Heteroskedasticity	26.13158	0.1615	Not Heteroskedastic
	Normality	33.35756	0.0000	Non Normal Residuals
td1m	Serial Correlation	0.638771	0.7266	No Serial Correlation
	Heteroskedasticity	114.2048	0.0000	Heteroskedastic
	Normality	360.3113	0.0000	Non Normal Residuals
td3m	Serial Correlation	0.072064	0.9646	No Serial Correlation
	Heteroskedasticity	35.48127	0.1271	Not Heteroskedastic
	Normality	52.62421	0.0000	Non Normal Residuals
td12m	Serial Correlation	0.907849	0.6351	No Serial Correlation
	Heteroskedasticity	27.61572	0.1188	Not Heteroskedastic
	Normality	29.37539	0.00000	Non Normal Residuals
tda12m	Serial Correlation	2.364548	0.3066	No Serial Correlation
	Heteroskedasticity	38.99800	0.0634	Not Heteroskedastic
	Normality	301.4893	0.0000	Non Normal Residuals

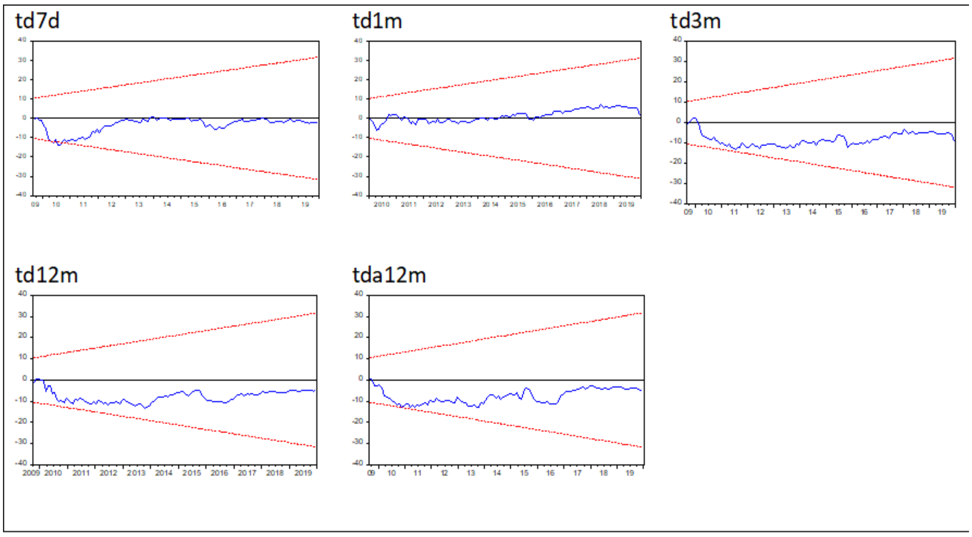

Figure 1: Stability Diagnostics

4.7 Robustness Checks

For robustness checks, three variables are included and estimated in equation 8 to control for other factors that influence commercial bank interest rates apart from the standing facility rates. Such factors may include regulatory thresholds and other elements that reflect activities in the interbank market. Hence, private sector cash reserve requirements (CRR), inter-bank call rate (IBC) and open buy-back rate (OBB) were selected as the control variables.

$$\Delta BIR_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \Delta BIR_{t-i} + \sum_{i=0}^{q} \beta_i \Delta SDF_{t-1}^{ADJ} + \sum_{i=0}^{q} \delta_i \Delta SLF_{t-1}^{ADJ} + \sum_{i=1}^{p} \rho_i \Delta CRR_{t-i} + \sum_{i=1}^{p} \omega_i \Delta IBC_{t-i} + \sum_{i=1}^{p} \xi_i \Delta OBB_{t-i} + \varphi ECT_{t-1} + \mu_t \quad (8)$$

The results of equation (8) are presented in Table 8 below.

Table 8: Speed of adjustment (model with control variables)

Bank int. rates	ECT coefficients	Probability	F-stat	Probability (F-stat)	Adjusted R^2
td1m	-0.033402	0.0279	1.997075	0.003944	0.193828
td3m	-0.072240	0.0147	1.525109	0.087439	0.063965
td7d	-0.073208	0.0302	1.295519	0.097576	0.037034
td12m	-0.094958	0.0308	2.637862	0.000695	0.175697
tda12m	-0.135618	0.0372	2.495352	0.001347	0.162900

The results largely confirm the validity of the earlier results. The estimated coefficients of the error correction term (ECT) for bank interest rates are negative and significant at 5 per cent level even when control variables are included in the model. This implies that long-run convergence exist between the standing facility rates and each of the retail rates. From a minimum of -0.0334 for one-month time deposit to -0.1356 for time deposit above 12 months, the speeds of adjustment range from 3.34 per cent to 13.56 per cent per month across the five retail rates, indicating slow speed of reverting to their long-run equilibria. The F-statistics and adjusted R^2 are reasonably in line with earlier results.

5. Conclusion and Recommendations

This paper extended the analysis of interest rate pass-through from the perspective of the discount window operations. The empirical study was conducted using monthly data ranging from 2007:06 to 2019:12. The cointegration tests based on Gregory and Hansen (1996) showed that five of the nine interest rates examined had long run relationships with the SDF and SLF rates, with structural breaks occurring around 2010:02 and 2010:03 in all the relationships.

The influence of the structural breaks was therefore built into the error correction model by fitting the vector of residuals from the Gregory-Hansen long-run equations into the dynamic equations estimated for each of the banks' retail rates. For each of the five variables which have long-run relationship with the SDF and SLF, we estimated the long-term interest rate pass-through and examined how they adjust to innovations in the policy corridor rates of the CBN, which we found to be significant but incomplete and with slow speed of adjustment. In addition to accommodating structural breaks in our modelling approach, we also checked for the existence of asymmetric adjustment of the retail rates to their long run equilibrium with the results showing no asymmetric pattern of adjustment. However, there was ample evidence of sluggish transmission of changes in the SDF and SLF rates to the five rates as well as slow process of returning to equilibrium.

The observed low and incomplete pass-through is a reconfirmation that monetary policy transmission through the interest rate channel is not very strong in Nigeria. It could be that factors other than the market have overwhelming influence on interest rates in Nigeria. Finally, we found that the adjustment of the deposit rates to changes in the SLF has an inverse relation. The implication of this is that when there is increased cost of funding resulting from the CBN raising the SLF, banks' desire to cut costs by reducing the amount of interest paid to depositors outweighs the desire for aggressive deposit mobilization via offering of higher interest rates to depositors.

While non-market factors may possibly be affecting the efficacy of monetary policy transmission, we recommend the need to intensify the development of the money market to enhance its sensitivity to monetary policy signals.

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