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# AN EMPIRICAL ANALYSIS OF MONETARY POLICY REACTION FUNCTION: EVIDENCE FROM NIGERIA

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## ABSTRACT

*The changing and unpredictable nature of the money demand function has led many Central Banks authorities around the world to shift from exchange rate and monetary policy targeting to inflation targeting framework. The gradual shift to inflation targeting has reawakened interest in the Taylor's Rule which states that nominal anchor interest rate must be raised by more than a proportionate change in inflation to achieve price stability. The objective of this study is to examine the Central Bank of Nigeria monetary policy reaction function and how the CBN responds to the dynamic and evolving macroeconomic environment. The monetary policy response function developed for this study is derived following the basic structure of the Taylor's rule. Using secondary time series data sourced from the Central Bank of Nigeria Statistical Bulletin covering the periods 1998:Q1-2014:Q2, the study builds on the Taylor rule to formulate a model that track the Central Bank of Nigeria monetary policy reaction function. The method adopted in carrying out the study is the Auto Regressive Distributed Lag Modeling technique and the Error Correction modeling framework. The stylized fact of the study shows that monetary policy variables are moving along same path accompanied by declining inflation and improved productivity. Results obtained from the study will be used to track stability and dynamics of the Central Bank reaction function and to predict the future direction for monetary policy in Nigeria.*

**JEL:** C11, E52, E58

**KEYWORD:** Monetary Policy, Central Bank, Reaction Function, Taylor's Rule

## INTRODUCTION

The philosophy of achieving internal balance and external viability has remained the strategic anchor of monetary authorities in Nigeria. Conventionally, the goal of maintaining price stability and a stable macroeconomic growth has remained the focus of monetary authorities' all over the world. In Nigeria, the success of monetary policy in the last 5 year is evident in the management of inflation which has been brought down and kept low at a single digit level between 2013 and year end 2014. As at end 2013 inflation in Nigeria at 8.5% was amongst the countries in Sub-Saharan Africa with a single digit inflation level, and an inflation level lower than 10 years average of 11.49% (see exhibit 1). Despite the success recorded by the Central Bank of Nigeria in managing inflation to a single digit level in 2013 and up to Q2:2014, there is now a reawakening of the relevance of Taylor's rule following the 2007 US mortgage crisis. Taylor's rule which was first proposed by Taylor (1993) and Henderson and Mckibbin (1993), relates to how much Central bank should vary nominal interest rate in response to changes in inflation and other notable macroeconomic aggregates. The rule popularly known as the Taylors principle stipulates that for every one percent increase in inflation, the monetary authorities should raise nominal interest rate by one percentage point (Dvig, Leeper and Eric 2007; Anthanasios 2001).

The policy reaction function estimated by Taylor concludes that an interest rate setting rule can be approximated empirically for monetary policy operation. The Taylor's response function points to a rigorous altering of Central Bank's nominal interest rate to impact market rates and influence monetary policy short term and long term decisions. Overtime, the Central Bank of Nigeria has adopted various instruments at their disposal to meet their short term and long term goals. These instruments affect the intermediate and ultimate targets variables through different channels of Monetary Transmission Mechanism. Tools used in recent times include; Open Market Operation (OMO), Reserve money, Exchange rate, and Cash Reserve Ratio (CRR) and the deliberate fixing of the anchor rate at 12% since the fourth quarter of 2011. The paper extends the study of the monetary policy reaction function by focusing on the efficacy of the current CBN monetary policy with the aim of predicting the optimum certainty monetary policy action and the relevance of the Taylor's rule in the management of interest rate and inflation for Nigeria. Following the broad objective of the paper, the rest of the study consists of four sections; Section 2 provides an overview of monetary policy in Nigeria and the review of literature, Section 3 prescribes the theoretical framework and model Section 4 presents the data, methodology and analyses the empirical results. Section 5 summarizes the main findings and draws some policy implications.

## LITERATURE REVIEW

Monetary policy rule focuses on the choice of policy instruments which are transmitted through the interest rate and monetary base. The concept of Monetary Policy Reaction Function (MPRF) motivated by the pioneer work of Taylor 1993 emphasis the inverse coefficient of the Philips equation while explaining how central banks reacts to macroeconomic conditions by altering interest rate. In the foundational work of Taylor's Monetary Policy Response function, a linear real GDP trend was used to measure potential output and expected inflation was taken to be 2 percent (Taylor, 1993). The rationale behind this was to show that this rule can stimulate short-term nominal interest rate of the United States. The policy rule obtained therefore is that Central Bank's policy rate rises if inflation increases above the target inflation rate or if GDP rises above potential GDP. On the contrary, the Central Bank policy rates decreases if inflation is below the target rate or f real GDP decreases below potential GDP.

Subsequent studies on Monetary Policy Response function sine Taylor (1993), has continue to build with care on the Taylor's seminal article and has produced various reports regarding the Central Bank response function. In the study carried out by Clarida, Gali and Gertler (1998), they estimated the Central Bank reaction functions using Generalized Method of Moments. In their study, they found the Central Banks in United State, Japan, and Germany pursued an implicit forward-looking inflation targeting which reacts to the expected inflation rather than past inflation. A similar study by Judd and Rudebusch (1998), concluded that the Taylor's rule prescribe guide on the relationships that existed among variables when conducting monetary policy. However, the study by Gerlach and Smets (2000) produced a mixed result. By examining whether monetary policy would respond to shocks in exchange rate, the authors found a mixed result across countries. They found that Australia's Central Bank is insensitive to shocks emanating from exchange rate while the Central Banks in Canada and New Zealand responded significantly to a shock to the exchange rate. Assane and Malamud (2000) using the Vector Auto-regression (VAR) model, having studied the relationship between monetary policy and exchange rates found that a weak dollar causes the Fed to raise the federal funds rate thus a rise in the federal funds rate leads to appreciation of the U.S. dollar.

The study by Romer (2001), focused on estimating the value of the coefficients of output gap and price gap to explain the effectiveness of monetary policy. The result obtained from the study showed that the values the coefficients attains can change the effectiveness of monetary policy through its effects on the level of actual inflation actual output. Hsing (2004), used a Vector Auto Regression modeling technque to estimate the Bank of Canada's monetary policy reaction function. The result from the study, showed that the Taylor rule is extended to include exchange rate since the objectives of the Bank of Canada is to maintain currency stability to promote international trade. By applying the same methodology in estimating the Bank of Korea monetary policy reaction function, Hsing and Lee (2004) found that bank of Korea call rate react positively to shocks from inflation gap, output gap, exchange rate gap, stock price gap and lagged bank call rates. The result obtained from the study showed that, the most influential short run variables that explained variations in call rates in Korea was exchange rate gap variable and inflation gap variable. The variables that contributed to long run variation in Korea call rates is the output gap variable and stock price gap variable. In a similar study carried out for the European Union countries Galbraith, et al. (2007) found that the Federal Reserve does not react to inflation signals but to the unemployment. Estimating the monetary policy reaction function for European Union countries, Sutherland (2010) found that there exists disparity across countries as to determinants of policy response function. Specifically, the results showed monetary policy in developed economies significantly influenced monetary policy response function in the less developed countries. However, they found little evidence that output gap significantly influences monetary policy response function. Kaytanci (2008) applying vector error-correction model estimated monetary policy reaction function for Turkey based on an extended Taylor rule. He found that the policy rate responds positively to shock to the output gap, the inflation gap, or the lagged overnight rate while responding negatively to exchange rate.

In a much more recent study, Hamori (2009), employing dynamic ordinary least squares (OLS) method to the estimation of a Taylor-type monetary policy reaction function for India, concluded that output gap variable and exchange rate gap variable were statistically significant and having the right signs in explaining monetary policy response function. However, the price gap variable had the wrong sign and failed the test of significance. In Nigeria, there are very few studies that have attempted to explain the monetary policy response function. The study by Iklaga (2009) estimated a Taylor-type monetary policy response function. The result obtained from the study suggests that inflationary pressures played a significant role in influencing monetary policy decisions in Nigeria.

In a more recent study by Apanisile and Ajilore (2013), monetary policy response function was estimated under the Taylor's rule using Engle-Granger approach to co-integration. They authors reached a conclusion that the implementation of monetary policy function was carried out in effect to achieve price stability in Nigeria. The study by Agu (2007) confirm that inflation is the primary determinant of the central bank's reaction though policy targets usually differ from outcome while Doguwa and Essien (2013), found that the monetary policy response function for Nigeria fits the actual monetary policy performance of real monetary policy rate and reserve money. This work extends the body of knowledge on monetary policy response function for Nigeria by drawing extensively on the basic structure of Taylor's rule and the recent work of Doguwa and Essien (2013).

## DATA AND METHODOLOGY

### Overview of Monetary Policy in Nigeria – Stylized Facts

The monetary authority-the Central Bank of Nigeria (CBN) has the power to alter deliberately monetary instruments (direct and indirect) to achieve the intermediate and ultimate target of monetary policy. Unlike many Central Banks around that have shifted to inflation targeting (IT) framework to achieve macroeconomic goals and objectives, the Central Bank of Nigeria uses a mix of the monetary targeting strategy and inflation targeting strategy as the platform for achieving its policy objectives. The CBN under the monetary targeting platform uses nominal anchors (money supply, exchange rate and interest rate) to manage liquidity and cost, with the overall goal of maintaining a stable macroeconomic environment. The Central Bank of Nigeria explored the Exchange Rate Targeting option from 1959 to 1974. From 1975, the policy choice of target variable shifted to Monetary Targeting which lasted until 2001, when the Central Bank adopted a mix of Inflation Targeting and Monetary Targeting Strategies.

The fundemental distinction between the various types of policy option lies primarily with the set of instruments and variables that are used by the monetary authority to achieve their goals. These strategies are usually supported by interest rate and output targeting. Table 1 shows the evolution of monetary policy instrument in Nigeria as well as the various monetary policy instruments, the intermediate target variables and the ultimate target variables. New changes in monetary policy instruments which became active from October 2013 include the introduction of public deposit CRR and foreign exchange sales (Retail Dutch Action Sales. The ultimate target variable since 2006 include, exchange rate stability, price stability and a stable real GDP growth rate.

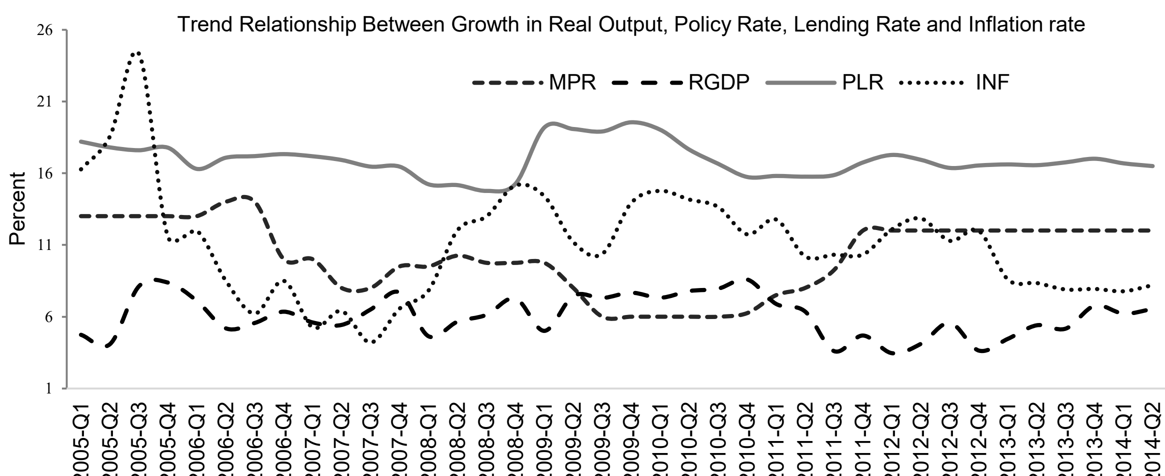
Table 1: Instruments of Monetary Policy in Nigeria

| **Monetary Policy Instruments** | **Intermediate Target** | **Ultimate Target** |
|---|---|---|
| Nominal Anchor rates(MRR/MPR; SLF, SDF) | Money Market | Inflation Stability |
| Liquidity Management-OMO; LR; CRR | Exchange rate market | Exchange rate stability |
| Fixed Exchange Rate or Exchange Rate Band(Floating Exchange Rate Regime) | Equity Market | GDP Growth |
| | Bonds Market | |
| FOREX Sales (WDAS) | Deposit Money Banks (DMBs) | |
| Sectoral Allocation of Credit | | |
| Credit Facilities | | |
| Stabilization Securitization | | |
| **Became Effective 11th December 2006** | | |
| Nominal Anchor Rate (MPR, SLF, SDF) | Stability in short term interest rates | Stable value of domestic currency |
| Liquidity Management-OMO, LR and CRR | | Single digit inflation |
| **Became Effective 7th August and 2nd Oct. 2013 Respectively** | | |
| Public Deposit CRR, FOREX Sales (RDAS) | | |

*Note: MRR=Minimum Rediscount Rate; MPR=Monetary Policy Rate; SLF=Standing Lending Facility Rate; SDF=Standing Deposit Facility Rates; OMO=Open Market Operation; LR=Lending Rate; CRR=Cash Reserve Ratio; WDAS=Wholesale Dutch Auction Sales; RDAS=Retail Dutch Auction Sales;*

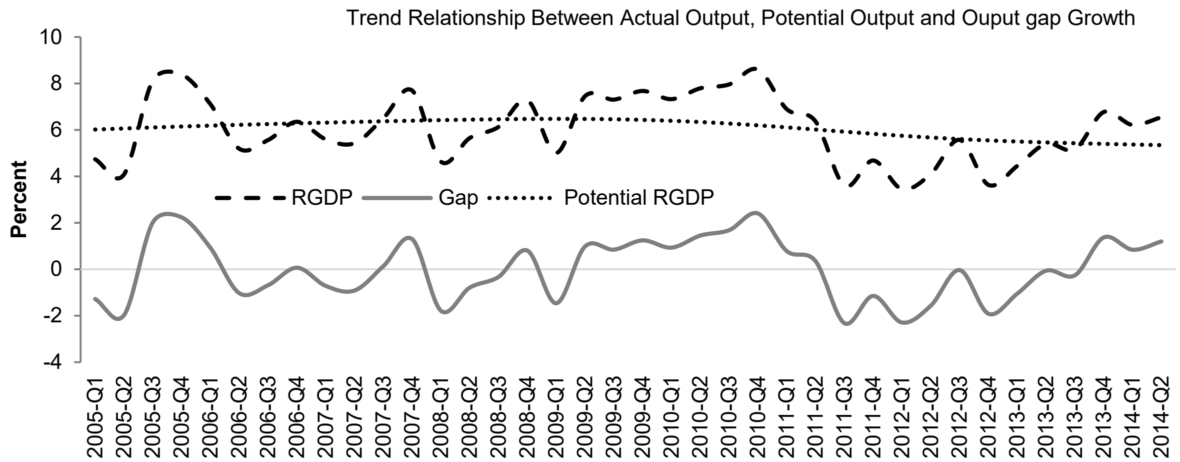
Figure 1, shows trend relationship between Real GDP growth rates, monetary policy rates, prime lending rates and inflation. The pattern shows real GDP growth rate is negatively correlated with inflation and positively correlated with prime lending rates and monetary policy rates. However, output gap in figure 2 suggest that more monetary stimulus is needed to drive economic growth in the positive direction

Figure 1: Trend Relationship between Macroeconomic Aggregates in Nigeria




*This figure shows the trend in monetary policy from 2005-2014. The sample include monetary policy rate (MPR), real GDP growth rate (RGDP), prime lending rate (PLR) and inflation. The trend shows all the variables moving along the same path tending downwards since Q1: 2000.*

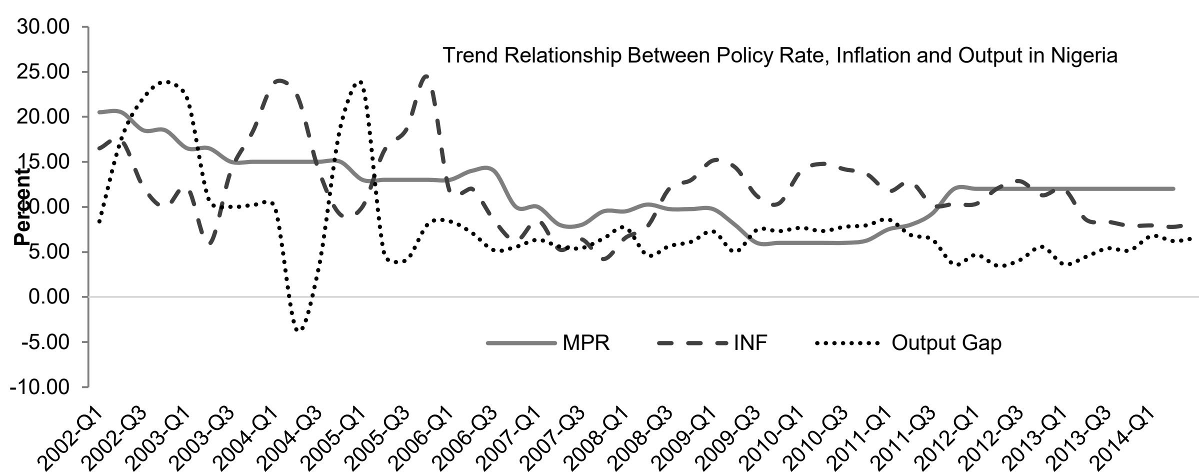
Figure 2: Trend Relationship in Nigeria




*This figure shows the trend relationship between actual output, potential output and the output gap from 2005-2014. The trend shows a wide gap potential output and the output gap.*

In the conventional Taylor's rule, with the equation-($r^* + \pi^* + \beta(\pi_t - \pi^*) + \gamma(y_t - y_N)$), the beta ($\beta$) and gamma ($\gamma$) values are estimated at 1.5 and 0.5 respectively. This suggests how Central Bank should set short-term interest rates to achieve both its short-run goal for economic stability and long-run goal for price stability. This rule further suggest that real Fed funds rate (MPR in the case of Nigeria) should be raised 1.5 percentage points for every percentage point increase in inflation above target values, and should also be raised 0.5 percentage points for every percentage point increase in actual output above potential output. Figure 3 shows the trend relationship between policy rate, inflation and output gap. The trend shows a negative relationship between the real policy rate, inflation and output gap. The nominal policy rate is significantly above inflation rate and actual output growth which goes contrary to the specification in Taylor's rule.

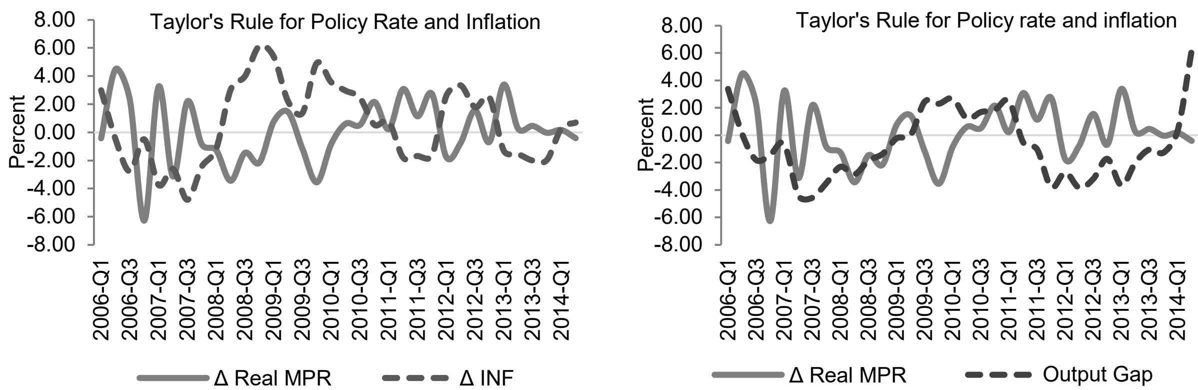
Figure 3: Trend Relationship between Monetary Policy Rate, Inflation and Output Gap in Nigeria




*This figure shows the trend relationship between Monetary Policy Rate (MPR), Inflation and Output Gap in Nigeria. The trend shows significant volatility in the variables between 2002-2006 with inflation trending higher over Monetary Policy Rate and Output Gap. Between the periods 2011-2014, Monetary Policy rate variable trended higher than inflation and Output Gap variable.*

Figure 4 shows trend analysis of the Taylor's rule estimate for Nigeria. The result shows real policy rate rise by more than 0.5% for every percentage point increase in inflation above target or output gap. This result gives credence to the fact that the Taylor estimate differ significantly with economic structure.

Figure 4: Analysis of Taylor Estimate and Rule in Nigeria




*This figure shows the trend analysis of Taylor's rule estimate for Nigeria. The trend shows the relationship between change in real monetary policy rate and change in inflation as well as the relationship between change in real monetary policy rate and output gap.*

The theoretical foundation of the monetary policy reaction function is derived from three structural equation, namely the Phillips curve relationship, the aggregate demand model (IS equation) and the uncovered interest rate parity model which formed the bedrock Taylor (1993) monetary policy reaction function. The derivation of the MPRF begins with the first equation-the Phillips curve relationship. The Phillips curve emphasizes a trade-off between inflation and unemployment by relating inflation directly to output gap. This relationship is expressed in equation (1) as follows;

$$\pi_t = \alpha + \beta\pi_{t-1} + \theta Y_t + \varepsilon_t \qquad (1)$$

Where π is inflation, $\pi_{t-1}$ is inflation lagged by one period and Y is the output gap. α, β and θ are the unknown parameters while $\varepsilon_t$ is the error term.

The aggregate demand model (the IS equation) relates output gap to interest rate and inflation and the model is expressed as follows in equation (2);

$$Y_t = \alpha + \beta i + \gamma\pi_t + \varphi R_t + \varepsilon_t \qquad (2)$$

Where Y is the output gap, í is the policy anchor rate, π is inflation and R is the nominal interest rate.
The third model-the uncovered interest rate parity model emphasizes exchange rate premium and interest rate differential between domestic and foreign interest rate. The model is expressed in equation (3) as follows;

$$R_t = \alpha + \beta R_t^* + \gamma(\chi_t - \chi_{t-1}) + u_t \qquad (3)$$

Where R is the nominal interest rate, $R^*$ is anticipated interest rate, χ is exchange rate and ($\chi_t$ - $\chi_{t-1}$) is exchange rate premium. The original version of Taylor's rule however, relates nominal interest rate to assumed equilibrium real interest rate and the divergence between actual inflation rate and target inflation rate as well as the divergence between actual output and potential output. The equation in its original version is expressed in equation (4) as follows;

$$i_t = \alpha + r_t^* + \beta(\pi_t - \pi^*) + \gamma(Y_t - Y_N) \quad (4)$$

The calibration of the three structural equation above yield the simple model for the MPRF which relates policy to output gap and the deviation of inflation from target as shown by the equation below

$$i_t = \alpha + \delta(r^* + \pi^*) + \beta(\pi_t - \pi^*) + \gamma(Y_t - Y_N) + \mu_t \quad (5)$$

Where r* is the average (long-run) real interest rate, (r*+π*) is the nominal interest rate, ($Y_t$ - $Y_N$) is the output gap. Thus the model can be expressed in a simplified form as;

$$i_t = \alpha + \delta R_t^* + \beta\pi_t + \gamma Y_t + \mu_t \quad (6)$$

The model links the policy instrument (short-term interest rate) and the nexus of output, inflation, and the exchange rate in a small-open economy. Following the basic structure of the Taylor's rule (1993) and Doguwa and Essien (2013), we estimate the model for tracking the performance of CBN monetary policy response function as expressed in equation

$$i_t = \alpha + \delta(r^* + \pi^*) + \beta(\pi_t - \pi^*) + \gamma(Y_t - Y_N) + \theta X_t + \mu_t \quad (7)$$

Where $i_t$ represents monetary policy instrument (MPR), (r* + π*) is the nominal interest rate proxy by the Prime Lending Rate (PLR), $\pi_t - \pi^*$ is the divergence between actual inflation rate and target inflation while $Y_t$ - $Y_N$ is the divergence between actual output and potential output. $X_t$ represents other control variables of each model to be estimated, especially the Naira- Dollar exchange rate premium between interbank rate and the official exchange. We introduce the control variable to capture business transactions which are usually carried out using the interbank rate. Specifically, the model formulated to access and track the CBN monetary policy reaction function is specified as follows;

$$MPR_t = f(R, \pi^*, Y^*, \chi^*) \quad (8)$$

Where MPR is the target short term nominal interest rate (monetary policy rate), R is prime Lending rate, π* is the divergence between actual inflation rate measured by GDP deflator and the desired inflation rate, Y* is the divergence between the log of real GDP and the log of potential output while χ* is the exchange rate premium between bureau de Change and official exchange rate. The model is expressed in linear estimation form as;

$$MPR_t = \alpha + \beta R_t + \theta\pi_t^* + \delta Y_t^* + \gamma\chi_t + \mu_t \quad (9)$$

Where on a *priori*, β, δ, γ < 0, θ > 0,

The Auto-Regressive Distributed Lag (ARDL) Bound Testing Methodology

Several methods have been applied in the empirical literature to conduct cointegration test and estimate the short run and long run relationships between macroeconomic variables. These methods ranges from the residual based Engle-Granger (1987), the maximum likelihood based Johansen (1991; 1995) test, the Johansen-Juslius (1990) test and the ARDL testing methodology of Pesaran, Shin and Smith (2001). Of the several methods used in conducting cointegration test, the ARDL testing methodology stands out because of its simplicity and use in situations where variables in the model exhibits a mixture of I(0) and I(1) data series. The uniqueness of the ARDL modeling technique motivates the preference for the ARDL (p,q) modeling technique in place of other cointegration testing procedures to examine the CBN monetary policy reaction function for Nigeria. Drawing from equation (9), the ARDL (p, q) model is defined as follows;

$$\begin{aligned} MPR_t = {} & \phi_1 MPR_{t-1} + \ldots + \phi_p MPR_{t-p} + \beta_0 R_t + \theta_0 \pi^* + \delta_0 Y^* + \gamma_0 \chi_t + \beta_1 R_{t-1} \\ & + \ldots + \beta_q R_{t-p} + \theta_1 \pi^*_{t-1} + \ldots + \theta_q \pi^*_{t-p} + \delta_1 Y^*_{t-1} + \ldots + \delta_q Y^*_{t-p} \\ & + \gamma_1 \chi_{t-1} + \ldots + \gamma_q \chi_{t-p} + \mu_t \end{aligned} \tag{10}$$

Where, $\mu_t \sim iid\ (0, \tilde{O}^2)$

Equation (10) is the unrestricted ECM model. From this model, we obtain the ECM regression of the model as follows;

$$\begin{aligned} \Delta MPR_t = {} & \alpha \, \widehat{\in}_{t-1} + \sum_{j=1}^{p-1} \phi_j \Delta MPR_{t-1} + \sum_{j=0}^{q-1} \beta_j \Delta R_{t-j} + \sum_{j=0}^{q-1} \theta_j \Delta \Pi^*{}_{t-j} + \sum_{j=0}^{q-1} \delta_j \Delta Y^*{}_{t-j} + \sum_{j=0}^{q-1} \gamma_j \Delta \chi_{t-j} \\ & + \psi_1 MPR_{t-1} + \psi_2 R_{t-1} + \psi_3 \Pi^*{}_{t-1} + \psi_4 Y^*{}_{t-1} + \psi_5 \chi_{t-1} + u_t \end{aligned} \tag{11}$$

Equation (11) is the ARDL cointegration model. In the model, the symbol $\Delta$ represents the first difference operator. The summation signs in the equation represent the error correction dynamics while the variable with the coefficients $\psi's$ corresponds to the long run relationship. To obtain the optimal lag length of the model, we make use of the Schwartz-Bayesian Criteria (SBC) and the Akaike Information Criteria (AIC). To ascertain the appropriateness of the ARDL model, the residual diagnostics, serial correlation LM test is applied for the study.

## EMPIRICAL ANALYSIS

### Data and Method

The data used to fit the model consists of quarterly time series data with sample period covering 1998:Q1-2014:Q2. All date were sourced from the Central bank of Nigeria Statistical bulletin and the National Bureau of Statistics, Nigeria. Specific data used include changes in real GDP, changes in monetary aggregate (Monetary Policy Rate inflation rate measured by real GDP deflator, real interest rate proxy by the summation of nominal interest rate and inflation and exchange rate premium measured as the difference between interbank rate and the Wholesale Dutch Auction sales. rest rates (Prime lending rate, interbank and Treasury bill rate). With the exception of monetary policy rate, real interest rate and exchange rates, all the other variables are analyzed in quarterly changes of their logarithms.

The uniqueness of the ARDL modeling approach makes it easy for estimation of models with a mix of I(0) and I(1) series but not in the presence of I(2) series. Other co integration test method such as Johansen-Juselius (1990) and Johansen (1991;1995) requires that all the variables used in testing for short run and long run relationship among the variables in a model must be integrated of order one or an I(1) series. Given the limitation of the ARDL modeling approach which is that the model collapses in the presence of I(2) series, we proceeded to testing for the unit root properties of the variables at their levels and first difference with the aid of the Augmented Dickey Fuller (ADF) unit root testing procedure. The result of the unit root test reported in Table 2 shows that we have no concern for I (2) variables in the model. All the variables were either stationary at levels or at their respective first difference. This presupposes that the ARDL Bound Testing procedure can be carried out by first testing the existence of cointegrating relationship among the variables in the model.

Table 2: Augmented Dickey Fuller Unit Root Test

| Variables: | In Levels | Order of Integration | In First Difference | Order of Integration |
|---|---|---|---|---|
| MPR (r) | 1.90 | I (0) | -6.37*** | I (1) |
| Real Interest Rate (Re) | -1.98 | I (0) | -6.38*** | I (1) |
| Price Gap (INFGAP) | -3.40 | I (0) | -9.00*** | I (1) |
| Output Gap (RYGAP) | -2.95 | I (0) | -5.99*** | I (1) |
| Exchange Rate Premium (XD) | -8.33*** | I (1) | -9.64*** | I (1) |

*Note: The table is the result of the Augmented Dickey-Fuller (ADF). The model includes an intercept and a linear trend. The null hypothesis (t-statistics values) states that the variables have a unit root and the notation (*) suggest a 1 percent level of significance. The test shows that none of the variables are I (2) series.*

After ascertaining the order of integration of the variables, we proceed to testing the existence of long run cointegration relationship between the dependent variables (MPR) and the regressors-output gap, price gap real interest rate and the exchange rate variable. This is done with the aid of the Wald (F-Statistic). The test for the long run cointegrating relationship is carried out by imposing restrictions on the estimated long run coefficients of the nominal interest rate variable (MPR). The imposition of restriction in the long run coefficients is made possible by first determining the lag length of the model through the Akaike criteria and the Schwarz Bayesian criteria. The calculated F-statistics for the cointegration test is reported in Table 3. The null and alternative hypotheses are as follows;

$H_0 = \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$ / There exists no long run cointegrating relationship among the variables in the model.

$H_0 \neq \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq 0$ /There exists a long run cointegrating relationship among the variables in the model.

The computed F-value from the Wald statistic will be evaluated based on the critical values of tabulated in Table CI of Pesaran et al (2001).

Table 3: F-Statistic of Co Integrating Relationship among the Variables

| Test Statistic | Value | Significance Level | Bound Criteria Values | |
|---|---|---|---|---|
| F-Statistic | 4.61 | 5% | I (0) | I (1) |
| | | | 3.18 | 4.32 |

*Note: The table is the result of the cointegrating relationship among the variables in the model. The null hypothesis states that there is no long run cointegrating relationship among the variables in the model.*

The value of our F-Statistics is 4.621 and we have (k + 1) = 6 variables in our model. From the critical values of the Bound test reported in Table 3 as provided in Table Ci (iii) of Pesaran et al (2001), the lower and upper bounds for the F-test statistic at 5% level of significance is 3.189 and 4.329 respectively. Given that the F-statistic value of 4.6129 > the upper bound at 5% level, we reject the null hypothesis of no cointegrating relationship among the time series variables. Having established the existence of long run relationship, between the variables in the model, we used the Schwarz Bayesian criteria to select the appropriate ARDL specification. The result of the Long run persimmons ARDL specification is reported in Table 4.

Table 4: Long Run Parsimonious ARDL Regression Estimate: Dependent Variable Is ΔMPR

| Variables | Coefficients | Standard Error | T-Values |
|---|---|---|---|
| MPR(-1) | -0.29*** | 0.08 | -3.72 |
| INFGAP (-1) | 13.13*** | 4.66 | 2.81 |
| EXRD (-1) | 0.03*** | 0.01 | 3.18 |
| D(MPR (-1)) | -1,155.68*** | 350.89 | -3.29 |
| D(MPR(-2)) | 1,064.96*** | 334.12 | 3.18 |
| D(MPR(-4)) | 5.73** | 2.26 | 2.53 |
| D(RINT (-1)) | 1,155.90*** | 350.90 | 3.29 |
| D(RINT(-2)) | -1,064.69*** | 334.10 | -3.18 |
| D(RINT(-4)) | -5.65*** | 2.23 | -2.52 |
| D(INFGAP (-1)) | -1,168.81* | 353.59 | -3.30 |
| D(INFGAP(-2)) | 1,052.20* | 332.27 | 3.16 |
| D(INFGAP(-3)) | -8.49*** | 2.71 | -3.13 |
| D(EXRD(-1)) | -0.01*** | 0.01 | 0.01 |
| Constant | 1.98*** | 0.51 | 3.83 |

R2 = 0.46; R-Bar Squared=0.31; F-statistic =3.11****Note: The table shows the result of the long run ARDL model of monetary policy reaction function for Nigeria. The dependent variable is ΔMPR while the explanatory variables are Price GAP variable (INFGAP), Exchange rate premium (EXRD) and real interest rate variable. (RINT). The lag length are selected based on SIC criteria which ranges from lag zero to lag four. The symbol *** and ** indicates significant at 1% level and at 5% levels respectively.*

The empirical result reported in Table 4, is obtained by simply normalizing the result of the ARDL model. The optimal model was selected using the Hendry "General to Specific Approach" and the SBC lag length selection criteria. This approach necessitated the dropping off of the variables that were not statistically significant on the basis of the individual test of significance-the student t-test.

From the result, the F-statistic value of (3.11) easily passed the test of significance at the 1% level of significance which shows the overall model had a good fit. The $R^2$ value of 0.46 and $\overline{R}^2$ value of 0.31 are all indicative that the models have a fairly good fit. On the basis of the individual significance of the parameter estimates all the variables and their lag specifications passed the test of significance at the 1% and 5% level of significance respectively. From the ARDL specification reported in Table 3, the short run and long run effects of the model was obtained by normalized the equation with the coefficient of MPR(-1) which was well signed and significant at the 1% level of significance.

The normalization process generated the short run and elasticities which are reported in Table 5. The result produced interesting findings for monetary policy reaction function for Nigeria. The output gap variable proved to have no long term relationship with the CBN monetary policy rate hence the variable was dropped. Only two variables the exchange rate variable and the price gap variable appear to have a significant long run effect on monetary policy rate. The result showed that a 1% increase in Price GAP variable elicited an increase in monetary policy rate by over 44% while a 1% increase in the exchange rate variable raises monetary policy rate by 0.1%. These findings follow earlier conclusion by Agu (2007), Iklaga (2009) and Apanisile and Ajilore (2013). All these studies concluded that the price GAP (inflation targeting) plays a significant role in the Central Bank monetary policy reaction function.

In the short run, the coefficients of the explanatory variables shows that real interest rate and the price gap variable are the major variables that determines the monetary policy reaction function for Nigeria One interesting findings of this study is that the two most important variables that tracks monetary policy reaction function for Nigeria is exchange rate and the price Gap variable. This is quite reviling given the fact that the Taylor rule recommends MPR should be raised 1.5 percentage points for every percentage point increase in inflation above targeted inflation and a raise of MPR by 0.5% for every percentage point increase in actual output above potential output.

Table 5: Long Run Elasticity and Short Run Elasticity of the ARDL Model

| Variables | Long Run Coefficients | Short Run Effects | Long Run Effects |
|---|---|---|---|
| MPR(-1) | -0.29 | | |
| INFGAP (-1) | 13.13 | | 4.83 |
| EXRD (-1) | 0.03 | | 0.10 |
| D(MPR (-1)) | -1,155.68 | -3,857.97 | |
| D(MPR(-2)) | 1,064.96 | 3,555.09 | |
| D(MPR(-4)) | 5.73 | 19.15 | |
| D(RINT (-1)) | 1,155.90 | 3,858.68 | |
| D(RINT(-2)) | -1,064.69 | -3,554.21 | |
| D(RINT(-4)) | -5.65 | -18.87 | |
| D(INFGAP (-1)) | -1,168.81 | -3,901.80 | |
| D(INFGAP(-2)) | 1,052.20 | 3,512.51 | |
| D(INFGAP(-3)) | -8.49 | -28.36 | |
| D(EXRD(-1)) | -0.01 | -0.49 | |
| Constant | 1.98 | 6.61 | |

*Note: Table 5 shows the short run effects and long run effects of the ARDL model which is obtained directly from the long run coefficients of the result reported in Table 4. The output GAP variable was eliminated from the model because it had no short run or long run effect on nominal interest rate. The only variables that had long run effect on nominal interest rate are the price GAP variable and the exchange rate differential variable.*

## CONCLUSION

Several studies have attempted an explanation of the monetary policy reaction functions in both advanced economies and emerging economies drawing essentially from Taylor's rule. This article fills the existing gap in the literature by investigating the monetary policy reaction function for Nigeria and adding to the body of existing knowledge on monetary policy response function. We developed a monetary policy response function for Nigeria derived essentially from the basic structure of Taylor's rule and made use of secondary time series data sourced from the Central Bank of Nigeria Statistical Bulletin covering the periods 1998:Q1-2014:Q2. . The method used for this study is the autoregressive distributed lag framework and the frequency of the data used is quarterly time series data. The result provide a strong evidence that monetary policy reaction function for Nigeria is influenced greatly by the price Gap in both the short run and the long run period. The output Gap variable was found to be statistically insignificant in influencing the Central Bank monetary policy decisions. Exchange rate variable and real interest rate variables were also found to be major determinants of monetary policy reaction function.

The policy implication to be drawn from this study, is that in pursuing the goal of price stability in Nigeria the monetary authorities should track the divergence between actual inflation and expected inflation as well as the divergence in exchange rate differentials between the official exchange rate, bureau de change (BDC) and the interbank rates. This is important given that Nigeria is a major oil exporting country and volatility in the international oil price is transmitted directly to the economy through its impact on exchange rates. In drawing the conclusion for this study, we used the autoregressive distributed lag modeling technique (ARDL). Further studies might consider using the vector autoregressive model (VAR) to track the reaction time of the Central bank monetary policy to changes in macroeconomic variables.

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