Original Research Article

ESTIMATION OF THE INFLATION FUNCTION UNDER THE INFLUENCE OF MONEY SUPPLY AND THE MONETARY REACTION FUNCTION IN NIGERIA

Abstract

Nigeria's average price level of goods and services has been on the rise in the past decade, and this in part, has contributed to the low economic growth rates that have been witnessed in the country. Hence, the need to control inflation has become one of the dominant objectives of the monetary authority. The purpose of this paper is to evaluate the inflation function under the influence of monetary variables and money supply; and also estimate the monetary reaction function with the policy anchor as the monetary policy rate. The scope of study is from 1996 to 2023 and annual time series data on inflation (proxied by *CPI*), monetary policy rate (*MPR*) money supply (proxied by *M3/GDP*), real gross domestic product (*RGDP*) and nominal exchange rate (*NOMEXR*) were obtained from the CBN annual statistical bulletin (2023). The ARDL approach was used in the estimation of the specified model. The findings from the inflation function revealed that in the long run, money supply (*M3/GDP*) and nominal exchange rate (*NOMEXR*) exerted significant influence on inflation, but the magnitude of impact of the former on inflation was higher. Moreover, the outcome show that the monetary policy rate (*MPR*) could significantly influence the rise of inflation in the short run. The findings on the monetary reaction function suggest that stabilizing effect in terms of output deviation, but the same cannot be said of inflation deviation. This suggest that sustaining economic growth in the long run was prioritized by the monetary authority during the period under review. The study therefore recommended that the monetary authority should be cautious of the growth of liquid liabilities in the economy and its influence on inflation; as well ensure that relevant information on informal financial market activities are taken cognizance in the setting of inflation targets.

KEYWORDS: Monetary Reaction Function, Inflation, MPR, M3_GDP, ARDL, Taylor Rule

1. Introduction

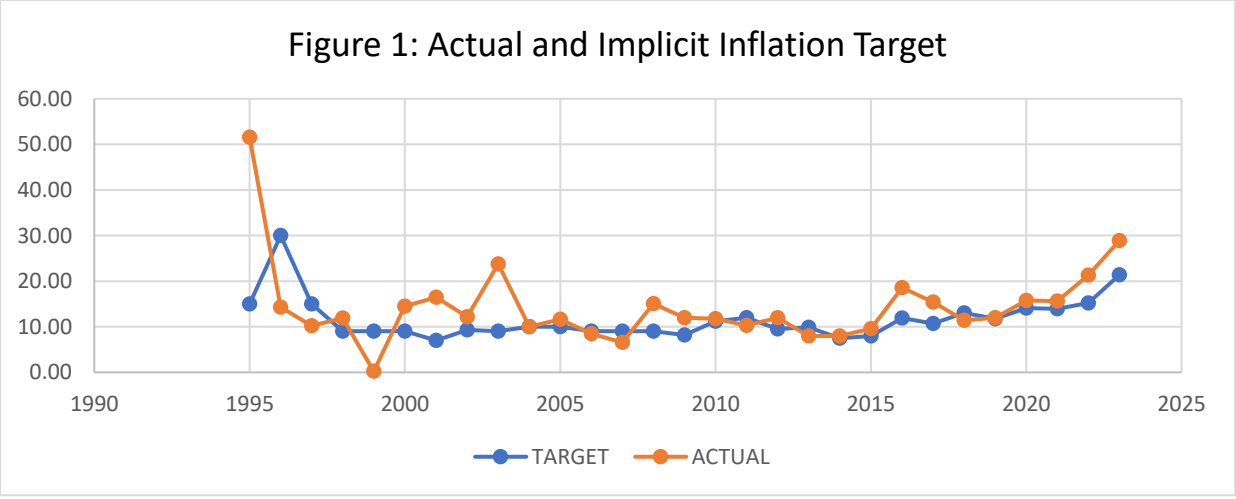
Economic globalization in international trade and financial transactions accentuated by innovative changes in communication and financial technologies would continue to impact on the behaviour of monetary policy for some time in the foreseeable future. Moreover, increased integration and the occurrence of external and internally induced inflation cycles - which are effectively bye-products of integration in outward-oriented developing economies - would mean that the propensity for salient changes in the monetary policy frameworks adopted by monetary authorities cannot be ruled-out, especially when consideration is given to the weak monetary policy frameworks and lack of independence of some monetary authorities in such climes (Gupta and Kashyap, 2015; Rishad et al., 2021; Rishad et al., 2018).

In developing countries, these changes may come in the form of constructive use of monetary policy instruments to ensure the availability of credit for investment purposes and stabilization of inflation. This is because ensuring price stability helps sustain the value of the domestic currency and engenders effective plan actualization, while availability of capital may contribute to the generation

of new capital stock, employment, income and economic growth. Thus, in practice, monetary policy requires the adoption of suitable policies on the cost of credit and money supply by monetary authorities within a policy framework oriented towards achieving specific monetary targets or inflation targets for the overall growth of the economy.

Tolulope and Ajilore (2013) opined that monetary targeting approach involves the use of open market operations to control money supply in the economy, while inflation targeting as a policy framework requires the manipulation of interest rate levels so as to control the movement of the average price level within a targeted band. While there is no unamity as to the superiority of one method over the other, substantial literature exists of economies that have employed either of these monetary frameworks in the control of inflation in the economy (See: Bernanke & Mishkin, 1997;

In Nigeria, since the 1990s, the central bank has sustained the policy of implicit inflation targeting regardless of the monetary policy framework it adopts. Implicit inflation targeting helps monetary policy formulators build consistent expectation formation mechanisms as well as understand the inflation dynamics of the country. Thus, for instance, in 1991 and 2010 the implicit inflation target was 13.00% and 11.20 whereas, actual inflation was 23.0% and 11.80%, respectively. Figure 1. Shows the trend of actual and implicit targets of inflation from 1995 to 2023. The chart highlights show the deviation of inflation performance from its target, which is indicative of the ineffectiveness of inflation forecasting in the time period. This is so because where deviations from the target become strengthened in a successive manner, it is suggestive that the central bank's control of inflation is not producing the desired outcome.



In essence, persistent deviation of the implicit inflation targets from the real outcome suggests that there is the need for a coordinated approach to respond to the problem of inflation in the economy. This, as the paper argues, is because high inflation is bad for development, but is neither an accidental index and may not necessarily be a short-lived phenomenon in outward-oriented developing economies, and therefore, should be given serious consideration. In this context, it is imperative that its underlying sources are keenly identified and its interaction with monetary policy instrument properly understood if the goal of the monetary authority to insulate its effect on savings, investment and economic growth must be achieved.

Consequently, it is on this basis that the present study empirically investigates the inflation function and monetary reaction function in Nigeria. Evidence from previous studies on the impact of monetary variables on inflation the country has generally been mixed. For instance, the studies of Ezeanyeji, et al (2021) and Amassoma, et al., (2018) observed that monetary policy has no influence on inflation in the short run and long run time period in Nigeria; while Okeke (2023) and Okotori (2019) concluded that monetary policy instruments significantly influence inflation movements in the country. The present study departs from these other studies as its purpose is in two folds; first, to test the impact of liquid liabilities and output on the inflation function in Nigeria, and this is done by taking in to cognizance the effect of money supply, interest rate and real sector factors on inflation in the country. The second specific objective is to estimate the monetary reaction function from 1996 to 2023 using the Taylor rule.

This study is significant because it identifies the influence of monetary policy variables on the average price level and further reveals the long run interaction of the monetary policy anchor with inflation, national output and exchange rate.

The rest of the paper is laid out as follows. Section 2 is an exposition on previous scholarly literature on the subject-matter and in Section 3, the methodology of the study is discussed. Section 4 is result and discussion of findings, while Section 5 concludes the study as well as makes policy recommendations.

2. Literature Review

Nigeria's Inflation Problem and Inflation Targeting

The problem of rising average price level has for long been a deep-rooted problem in Nigeria, and the return to democracy since 1999 has not been able to abort nor engender an abatement of its effect on the welfare of the populace in the country. For instance, the national bureau of statistics (NBS) annual report shows that at the beginning of 1999, monthly statistic of the consumer price index (CPI) for headline, core and food inflation was 26.36%, but rose to 34.56% (an upward rise of 8.20%) after one year. Moreover, by the first month of 2015 to the same time in 2023, it has risen from 165.77% to 508.69%, respectively (NBS, 2023). Consequently, it could be argued that the persistence in the rise of inflation over the years, effectively makes it a fundamental problem for the central bank and Nigerian government.

A core problem of high inflation is in its ability to slow down the wheels of production and economic activities. Mishkin (2008) opined that there is some sort of relations between high inflation, slow economic growth and financial crisis. This is because, with rising average price levels, the incentive to invest and save on the part of the private sector is severely weakened; while on the part of the government, discrepancies may emerge between planning objectives and actualization; and the combined effects of this may produce imbalances in private and public sector accounts. Moreover, for countries with labour markets and inflexible fixed monthly income payment systems for workers in both public and private sectors, high inflation levels may cause repercussions on the welfare of workers and the poor who have little access to interest bearing accounts of financial holdings or real assets (Ha, Kose & Ohnsorge, 2019).

Moreover, high inflation is also associated with economic development issues such as inequalities in income and wealth, imbalances in the allocation of scarce resource and poverty. In particular, the unanticipated "policy changes" which inflation may trigger in government fiscal actions, could exacerbate the trade-off costs of government policies and cause less rational distribution of scarce resources. In addition, since high inflation reduces the incentive for private investment, unemployment will also rise, thus, making it hard for poor people to find work and earn income.

Inflation is however not a one-off occurrence and, in this vein, should be effectively monitored by monetary authority and the government since it is fundamental to the achievement of the macroeconomic objectives of sustained economic growth and balance of payment equilibrium. For monetary authorities, the approach adopted in the control of inflation is either based on the use of monetary policy framework that combine the pursuit of other fundamental objectives (example, the

control of money supply, stabilization of exchange rate, etc.) with the goal of stabilizing inflation as defined by an implicitly stated inflation target; or one that combine these other objectives with the unambiguous goal of inflation control using explicitly defined inflation targets.

Inflation targeting basically refers to the public announcement of medium-term numerical targets for inflation with an institutional commitment by the monetary authorities to achieve these targets (Mishkin, 2001). The attractiveness of the new policy with effect from the late 1990s has seen an increasing number of emerging market economies, especially from developing countries embracing the inflation targeting policy framework. In the African continent, early adopters of the new policy framework were South Africa in 2000 and Ghana in 2007. In fact, in South Africa, it is noted that the adoption of the inflation targeting framework by the monetary authority since 2000 has helped in the management of the inflationary trend in the economy with significant declines as compared to levels obtained in former monetary frameworks.

Theoretical Literature

Structuralist Theory

The structuralist theory was first propounded by Prof. Gardner Ackley and gained prominence among Latin America scholars in the 1950s. This theory alludes to the presence of rigidities in the structure of developing countries as the cause of inflation in those economies. The theory argues that rigidities such as the forms of property ownership as well as the established structure of wealth, power and product-specilisation in developing countries engender an environment of growth accompanied with inflation. Hence, attempts to control or suppress inflation by monetary policies alone may not be effective. Consequently, they proffer both the use of monetary and fiscal measures for sorting out this economic problem.

Taylor Rule

There are a number of theoretical expositions that have been carried out overtime to explain the behaviour of monetary policy in reaction to macroeconomic aggregates such as output, inflation and total employment. These theories (Taylor rule; Freidman and Schwartz monetary hypothesis; etc.) try to portray specific formulation and use of monetary instruments by monetary authorities, as well as how they may influence economic activities in the country. In this context, the Taylor rule is one of such specifications of the monetary reaction function that have gained prominence overtime.

Taylor (1993) in line with the propositions of proponents of the New Keynesian Policy Model argued that the salient objectives of monetary policy should be the pursuit of stable inflation and full employment. The Taylor rule basically posits that the central bank's policy rate reacts to the difference between actual and potential inflation rate, as well as to the difference between actual and potential GDP (output gap). In this way, the Taylor rule is essentially a reduced form approximation of the rection function of the policy interest rate adopted by the monetary authority to deviations in inflation, output, and any other economic variable of interest.

The Taylor rule is algebraically stated as:

$$i_t = \theta i_{t-1} + \alpha(\pi_t - \pi^*) + \beta(\gamma_t - \gamma^*) \quad . \quad . \quad 2.1$$

Where i_t is the policy interest rate of the monetary authority, $(\pi_t - \pi^*)$ $is\ inflation\ deviation$ and $(\gamma_t - \gamma^*)$ is output deviation. Equation 2.1 show that the Taylor rule is composed of three variables and is mearnt to ascertain the reaction inflation and output to adjustments in the policy anchor employed by the monetary authority. Froyen and Guender (2018) opined that the Taylor rule is now practically applied in central banking operations in the setting of targets for inflation control and stabilization of the economy.

Empirical Literature

Empirical studies exist on monetary policy and inflation targeting from scholars across the globe. For instance, Vincent (2020) examined the behaviour of the monetary framework of inflation targeting in South Africa and Nigeria from 1970 to 2016. The study which was based on a modified model of the Taylor rule observed significant reaction of inflation and squared inflation, as well as the output gap to the interest rate anchor for South Africa, whereas, in Nigeria, they were not significant. Moreover, the findings of the study revealed that trade openness, exchange and international reserves were critical to central policy decisions in both countries. The authors therefore suggested that there is need for central banks in the two countries to adopt an eclectic approach, setting the monetary policy rule to adjust to any observed disequilibrium between output gap, inflation, exchange rate, foreign reserves and openness to trade. Evans (2018) examined the implications of the Freidman and Schwartz monetary hypothesis in Nigeria and South Frica. The outcome revealed evidence of the existence of non-linear relationship between money, inflation and output in the countries. Ozili (2024) examined factors required for successful operationalization of

the monetary policy of inflation targeting in Nigeria. The author noted that precipitating factors such as the size or number of economic agents monitoring the inflation target, the credibility of the central bank, the degree of central bank independence, reduction in budget deficit, limited dollarization of the Nigerian economy, effective central bank communication, avoidance of fiscal dominance, financial development, greater financial inclusion and financial stability are necessary for the achieving the goal of inflation targeting in the country.

Salisu (2018) investigated the monetary policy reaction function of the Central Bank of Nigeria. The study utilised a non-linear quadratic model with quarterly data from 2007Q1 to 2016Q2. The Non linear two stage econometric method was utilised for the estimation of the specified model. The findings indicated that the policy rate reacts to inflation and exchange rate volatilities significantly, and the reaction is quite aggressive when inflation exceeds the 10% threshold. Moreover, the author observed that only the current lead of inflation was significant, and therefore opined that it was suggestive of the monetary authority's inability to correctly forecast inflation beyond the first quarter in Nigeria.

Okwori and Abu (2017) also investigated monetary policy and inflation targeting in Nigeria using the Vector Error Correction Model. The study employed time sequences on variables from 1986 to 2015. The findings revealed that monetary policy is significant in curbing inflation threshold in Nigeria, however, due to the large proportion of informal sector activities in the economy which are outside formal banking channels, monetary variables are weak in controlling inflation in the country. The study suggested that the monetary authority should narrow the asymmetric corridor around the MPR to check commercial banks excess reserves. Moreover, they argued that required cash ratio and liquidity ratios should be adjusted regularly to curtail banks excess reserves so as to control inflation.

Okeke (2022) evaluated the impact of money supply on inflation in Nigeria from 1981 to 2021. The method of estimation was based on the autoregressive distributed lag model (ARDL). The findings show a long run positive and negative relationship between inflation and money supply. The study recommended that monetary and fiscal authorities should control the growth in money supply in such ways as not curb high inflation in the country. Ibrahim and David (2022) examined the effectiveness of monetary policy instruments in the control of inflation in Nigeria from 1981-2019. The autoregressive distributed lag (ARDL) method was employed in the estimation of the specified

model. The outcome showed that in the long run, monetary policy instruments showed signs of ineffectiveness in controlling inflation levels in the country. Lagged treasury bills showed a significant negative influence on inflation in the short run, while liquidity ratio was effective in the management of inflation in the long-run but not in the short run. The authors emphasized the need to reduce the leaks from informal financial systems to strengthen the effectiveness of monetary policy in the country.

Elias (2020) examined the monetary policy reaction function for Nigeria using quarterly data from 2000Q1 to 2018Q4. The study employed SVAR-X estimation approach in the analysis of the specified model. The findings showed that it was imperative that the response of monetary policy to output gap and inflation is distinguished so as to allow for evaluation of the response function in periods of economic turbulence and prosperity. Moreover, the findings suggest that the effectiveness of monetary policy in Nigeria should be evaluated in cognizance with the prices of oil and gas at the international market, since it depends heavily on the oil and gas sector.

Ofori-Frimpon, et al. (2017) studied the effect of money supply on inflation rate in Ghana using annual data from 1967 to 2015 to test the model. The research was restricted to using money supply as an independent variable on the dependent variable, which was an inflation rate. The results showed that there was a long-run positive link between money supply and inflation rate based on an Ordinary Least Square (OLS) method.

Ezeanyeji, et al., (2021) investigated monetary policy and inflation control in Nigeria. The study utilised time series data on exchange rate, inflation rate, money supply (% of GDP), treasury bill and monetary policy rate from 1980 to 2019. The findings indicated that monetary policy had no significant impact on inflation control in the country in both the short run and long run time periods. Moreover, treasury bill has negative but significant effect in the short run, while in the long-run, the effect is positive but insignificant. The author's recommended that the government should ensure a conducive market environment which is a necessary condition for effectiveness of monetary policies, so as to attract investment, create job opportunities and economic growth in the country.

3. Methodology

The broad objective of the study is to estimate the inflation function and the monetary reaction function in Nigeria. Consequently, the research employed annual time series sequences from 1996 to 2023. The choice of this period was informed by the need to identify the effect on inflation and

the monetary policy anchor of macroeconomic indicators. Accordingly, historical sequences on the monetary policy rate (MPR-proxy for the policy anchor), year-on year consumer price index (proxy for inflation), real gross domestic product (RGDP), nominal exchange rate, and ratio of M3 to GDP (proxy for liquid liabilities) were obtained from the Central Bank of Nigeria Annual Statistical Bullentin (2023). Moreover, preliminary investigation of the stationarity properties of the variables was conducted with the help of the Augmented Dickey- Fuller (ADF) test for stationarity.

Model Specification

Following the famous Taylor (1993) rule, the study estimates a modified version of the monetary policy reaction function of the central to highlight how the former reacts to inflation deviation and output from a target rate. Taylor (2001) monetary policy reaction function assumed that central banks reacts to output deviations from a potential level of output. However, estimating potential output levels are difficult in practice, hence, the study follows the difference rule of Orphanides and Williams (2007). Accordingly, the functional form of the Taylor interest rule is stated as:

$$mpr_t = \propto_0 + \propto_1 \widehat{\Delta cpi_{t-1}} + \propto_2 \widehat{\Delta y_{t-1}} + \propto_3 \widehat{\Delta exr_{t-1}} + \in_t \quad . \quad . \quad 3.1$$

Equation 3.1 is the functional form of the Taylor rule. The dependent variable (mpr) is the policy interest rate, while the explanatory variables are the inflation deviation term ($\Delta cpi_{t-1},$), output deviation inflation deviation term ($\widehat{\Delta y_{t-1}}$), and nominal exchange deviation term ($\widehat{\Delta exr_{t-1}}$). The deviation for each explanatory variable is calculated by removing the Hodrick-Prescott (HP) trend from the annual series. In line with theoretical expectations, the study asserts that for the policy anchor rate to be countercyclical, the parameters should show the following $\propto_1 > 0$; $\propto_2 > 0$; $\propto_3 > 0$ signs after empirical analysis.

Furthermore, the functional form of the inflation model is specified as:

Icpi = f (rgdp, mpr, Im3_gdp, Inomexr) . . . 3.2

Where:

cpi = year-on-year consumer price index (proxy for inflation)

rgdp = real gross domestic product (proxy for economic growth)

mpr = monetary policy rate

m3_gdp = ratio of money supply to output

nomexr = nominal exchange rate

The theoretical expectations for the coefficients of equation 3.2 are $\propto_1 < 0;\ \propto_2 < 0;\ \propto_3 > 0\ \propto_4 > 0$

To decide the appropriate econometric procedure for the estimation of the inflation function and the monetary policy reaction function, the ADF unit root test was used to determine the order of integration of the variables in the two models. The results shown a mixed order of integration for the inflation model (See: Table 3) and the monetary reaction model (See: Table 11). Accordingly, since the Autoregressive Distributed Lag approach (ARDL) permits estimation of variables with mixed order of integration, it was employed in the econometric analysis of the specified models. Pesaran and Shin (1999) developed the ARDL for the cointegration analysis of models with variables having mixed unit root properties. (Pesaran and Shin, 1999). Improvements in the ARDL method ensures the estimation of the dependent and explanatory variables with different lags as well as the use of fixed regressors, which is impossible in other conventional methods used for the test of cointegration. Moreover, the ARDL gives robust estimates even for small data sets, and is therefore suitable for the present study that spans from 1996 to 2023, a period of 27 years.

The general specification of the ARDL(p,q) is as follows:

$$\Delta y_t = a_0 + \sum_{i=1}^{p} a_{1i}\Delta\gamma_{t-1} + \sum_{j=1}^{q} \gamma_j X_{t-j} + \varepsilon_t \quad . \quad . \quad 3.3$$

where y_t is the dependent variable, X_t is a vector of the dynamic explanatory variables which and ε_t is the error term that should be normally distributed with zero mean and constant variance $\varepsilon_t \sim N(0, \sigma^2)$, p and q are the number of lags for dependent and explanatory variables; respectively.

To test for whether there is long-run relationship (cointegration) between y_t and X_t, the bound test equation is specified as follows:

$$\Delta y_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i}\Delta\gamma_{t-1} + \sum_{j=1}^{q} \varphi_{1i}\Delta X_{t-j} + \omega_0\gamma_{t-1} + \omega_1 X_{t-1} + \vartheta_t \quad . \quad . \quad 3.3$$

where β_1, and φ_1 are the parameters of the short-run relationship; ω_0 and ω_1 are the parameters of long-run relationship. Accordingly, cointegration between y_t and X_t exists if the null hypothesis, H_0: $\omega_0 = \omega_1 = 0$ is rejected against the alternative H_1: $\omega_0 \neq \omega_1 \neq 0$.

In addition, the existence of cointegration relationship in the models, also necessitates an evaluation of the error correction model (ECM). The equation of the ECM is specified as follows:

$$\Delta y_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \Delta \gamma_{t-1} + \sum_{j=1}^{q} \varphi_{1i} \Delta X_{t-j} + \emptyset_0 ECM_{t-1} + \vartheta_t \quad . \quad . \quad 3.4$$

In actual fact, the term of the ECM_{t-1} is derived from the lagged value of the error term (μ_{t-1}) of the following long-run relationships:

$$y_t = a_0 + \sum_{j=1}^{q} \gamma_j X_t + \mu_t \quad . \quad . \quad . \quad . \quad . \quad 3.5$$

$$ECM_{t-1} = \mu_{t-1} = y_{t-1} - \sum_{j=1}^{q} \gamma_j X_{t-1} \quad . \quad . \quad . \quad . \quad . \quad 3.6$$

and $\emptyset_0 < 0$ is the parameter of the error correction model ECMt-1 that measures the speed of adjustment from any shocks in the short-run back towards the long-run.

Continuing, post-diagnostic tests on the outcome of the specified models, such as the normality test, stability test as well as test for serial correlation and heteroscedasticity were also carried out.

4. Data Analysis

a. Empirical Results of the ARDL Inflation Model

In the ARDL approach, the first step is to evaluate the appropriate lag using different criteria. Table 1 shows the Table 1 shows that the ARDL specification with the minimum value in the set the lag criteria is the ARDL (3,0,3,1). Specifically on the basis of the Akaike Information Criteria (AIC), the ARDL lag model (3, 0, 3, 1) is selected. This specification also has the lowest value among the values of the BIC and Hannan-Quinn (HQ) information criteria.

Sample: 1996 2023

Included observations: 24

Model	LogL	AIC*	BIC	HQ	Adj. R-sq	Specification
234	9.659778	0.203498	0.795929	0.352492	0.493401	ARDL(3, 0, 3, 1)

109	10.229671	0.240898	0.882699	0.402309	0.469683	ARDL(4, 0, 3, 1)
229	9.836205	0.275113	0.916914	0.436524	0.451225	ARDL(3, 0, 4, 1)
209	9.824230	0.276154	0.917955	0.437565	0.450653	ARDL(3, 1, 3, 1)
233	9.687243	0.288066	0.929867	0.449477	0.444070	ARDL(3, 0, 3, 2)

Table 1 Lag Criteria Selection

Source: Author's Computation, 2024.

The empirical estimates of the selected ARDL lag model (3,0,3,1) is shown in Table 2 below. The table shows that on the basis of the Akaike information criteria (AIC), a maximum of four (4) lags were selected for the variables *IYOYCPI*, *RGDP*, *INOMEXR*, *IM3_GDP,* respectively, while MPR is a fixed regressor. The value (0.95) of the coefficient of determination (i.e., R^2) shows the high explanatory power of the model. Moreover, the Durbin Watson (D.B) and F. statistic values gives a preliminary idea of the absence of serial correlation as well as the fitness of the model for empirical analysis. Table 2 is the preliminary evaluation of the covariance and correlation properties of the variables in the model.

Table 2 Covariance and Correlation Matrix

Covariance Correlation	YOYCPI	RGDP	MPR	NOMEXR	M3_GDP
YOYCPI	21.26971 1.000000				
RGDP	14865.27 0.173425	3.45E+08 1.000000			
MPR	1.375892 0.096797	-16973.55 -0.296313	9.499143 1.000000		
NOMINALEXR	105.2413 0.403789	859332.8 0.818145	-26.16621 -0.150227	3193.751 1.000000	
M3_GDP	5.351128 0.208722	97897.09 0.947530	-4.801365 -0.280237	248.3370 0.790487	30.90244 1.000000

Source: Author's Computation, 2024.

In addition, the Augmented Dickey Fuller (ADF) unit root test was used to examine the unit root properties of the model variables both at levels as well as intercept and trend. The output of the ADF unit root test is shown in Table 3. The result reveals a mixed order of integration in the variables as MPR, RGDP, M3_GDP, and NOMEXR are integrated at order I(1), but CPI is integrated at order

I(0). The identification of a mixed order of integration is a pre-requisite for evaluating evidence of cointegration in the model variables.

ADF UNIT ROOT TEST

Table 3: ADF Unit Root Test

	ADF(Prob.) @ Level		ADF (Prob.) @ First Difference	
Variables	Intercept	Trend and Intercept	Intercept	Trend and Intercept
CPI	-2.976263 (0.0555)**	-3.587527 (0.0682)	-2.981038 (0.0000)*	-3.595026 (0.0000)*
RGDP	-2.976263 (0.9020)	-3.622033 (0.2968)	-2.981038 (0.0361)**	-3.595026 (0.1277)
NOMEXR	-2.981038 (0.6625)	-3.595026 (0.5706)	-2.986225 (0.0006)*	-3.603202 (0.0039)*
M3_GDP	-2976263 (0.6890)	-3.587525 (0.4374)	-2.981038 (0.0010*	-3.23345 (0.0051)
MPR	-2.976263 (0.2749)	-3.587527 (0.6468)	-2.981038 (0.0000)*	-3.595026 (0.0001)*

*&** indicates significance levels (i.e. 1% and 5% level, respectively).

Source: Author's Computation, (2024).

Accordingly, the ARDL bound test approach was used to determine the existence of cointegration between the dependent and explanatory variables in the model. The outcome is highlighted in Table 3. The result shows that the F. statistic value (22.27224) is higher than the lower and upper bound values at all the significant levels, which therefore suggest that there is a long run cointegration relationship between inflation and the dynamic regressors in the specified model.

Table 4 ARDL Estimates of the Inflation Model

Dependent Variable: LOG(YOYCPI)
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): RGDP (LOG(NOMINALEXR))
(LOG(M3_GDP))
Fixed regressors: MPR C
Selected Model: ARDL(3, 0, 3, 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LOG(YOYCPI(-1))	-0.214772	0.250825	-0.856263	0.4086
LOG(YOYCPI(-2))	-0.393639	0.255305	-1.541837	0.1491
LOG(YOYCPI(-3))	-0.383750	0.231467	-1.657904	0.1232
RGDP	-4.09E-05	1.54E-05	-2.657323	0.0209
LOG(NOMINALEXR)	0.538970	0.134730	4.000361	0.0018
LOG(NOMINALEXR(-1))	-0.149832	0.230968	-0.648716	0.5287
LOG(NOMINALEXR(-2))	0.078956	0.205195	0.384785	0.7071
LOG(NOMINALEXR(-3))	0.320631	0.169687	1.889545	0.0832
LOG(M3_GDP)	0.237997	0.979721	0.242924	0.8122

LOG(M3_GDP(-1))	1.426176	0.781851	1.824104	0.0931
MPR	0.059621	0.034575	1.724407	0.1103
C	-1.980587	1.756915	-1.127310	0.2816

R-squared	0.950823	Mean dependent var	2.363957
Adjusted R-squared	0.905744	S.D. dependent var	0.881138
S.E. of regression	0.270520	Akaike info criterion	0.529908
Sum squared resid	0.878170	Schwarz criterion	1.118935
Log likelihood	5.641101	Hannan-Quinn criter.	0.686177
F-statistic	21.09239	Durbin-Watson stat	1.796386
Prob(F-statistic)	0.000004		

Source: Author's Computation, 2024.

Table 5 ARDL Bound Test Output

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	22.27224	10%	2.37	3.2
k	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66

Source: Author's Computation, 2024.

Table 5 reveals the values of the coefficients of the estimated parameters. The results show that all the parameters are significant at 1% and 5%, respectively. Moreover, the signs of the parameters are in accordance with theoretical postulations as inflation is found to be positively related to nominal exchange rate (NOMEXR) and broad money(M3_GDP), but negatively related to output growth in the long run.

Table 6 Estimates of Long Run Coefficients

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
RGDP	-2.05E-05	7.22E-06	-2.840865	0.0149*
LOG(NOMEXR)	0.395914	0.067085	5.901705	0.0001*
LOG(M3_GDP)	0.835361	0.384470	2.172758	0.0505**
C	-0.994190	0.942781	-1.054529	0.3124

Source: Author's Computation, 2024.

Moreover, the result suggests that the highest impact on inflation is exerted by the ratio of M3 to gross domestic product, which is measure liquid liabilities to the national output. It shows that a 1% increase in liquid liabilities in the economy is expected to raise inflation by 0.40%; whereas a 1%

increase in the foreign exchange rate (i.e., devaluation of the naira), will raise inflation by 0.84%. In addition, the table shows that to decrease inflation by 1%, national output should increase by 2.0%.

The ECM and short run estimates of the ARDL model are shown in Table 5. The findings show that the parameters are statistically significant at various lags. The ECM is correctly signed and its value (-0.420249) indicates that about 42% of shock run shock is corrected will be corrected annually. Interestingly, the table shows the effect of the monetary policy rate (MPR) on inflation in the short run and suggest that a 1% increase in the policy rate will raise the inflation level by 6%. The highlight also show that the explanatory power of the model is high and the F. statistic value attest to the overall significance of the estimated model.

Table 7 ECM and Short-Run Estimates

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(YOYCPI(-1))	0.777389	0.149388	5.203826	0.0002
DLOG(YOYCPI(-2))	0.383750	0.127412	3.011891	0.0108
DLOG(NOMINALEXR)	0.538970	0.092797	5.808070	0.0001
DLOG(NOMINALEXR(-1))	-0.399587	0.116967	-3.416223	0.0051
DLOG(NOMINALEXR(-2))	-0.320631	0.102707	-3.121800	0.0088
DLOG(M3_GDP)	0.237997	0.509133	0.467456	0.6485
MPR	0.059621	0.007446	8.006823	0.0000
ECM(-1)*	-0.420249	0.126014	-3.334932	0.0059

R-squared	0.975895	Mean dependent var	0.024297
Adjusted R-squared	0.965350	S.D. dependent var	1.258563
S.E. of regression	0.234277	Akaike info criterion	0.196575
Sum squared resid	0.878170	Schwarz criterion	0.589259
Log likelihood	5.641101	Hannan-Quinn criter.	0.300754
Durbin-Watson stat	1.796386		

Source: Author's Computation, 2024.

Post-Diagnostic Tests

Furthermore, post-estimation tests of the output of the specified model were conducted. The result is shown in Table 6 below. The table highlights the result of the Breusch Godfrey (BG) Serial correlation LM test, Breusch-Pagan-Godfrey heteroscedasticity test and the Jarque Bera test for normality. The output suggests that the BG and BPG tests with the null hypothesis of no serial correlation in the residuals and no heteroscedacity cannot be rejected as their p-values are greater than the adopted 5% level of significance in both the F test and Obs.*R-Square statistic. Moreover,

figure 2 shows that the Jarque Bera test of Normality is in conformity with expectations as the J.B probability value of 0.64 is above the 5% significance level.

Table 8. Post Estimation Diagnostic Tests Output

Breusch-Godfrey (LM) Test for Serial Correlation			
F-statistic	0.055509	Prob. F(2,10)	0.9463
Obs*R-squared	0.263516	Prob. Chi-Square(2)	0.8766
Breusch -Pagan-Godfrey Test for Heteroscedasticity			
F-statistic	1.388497	Prob. F(11,12)	0.2902
Obs*R-squared	13.44029	Prob. Chi-Square(11)	0.2655

Source: Author's Computation, 2024.

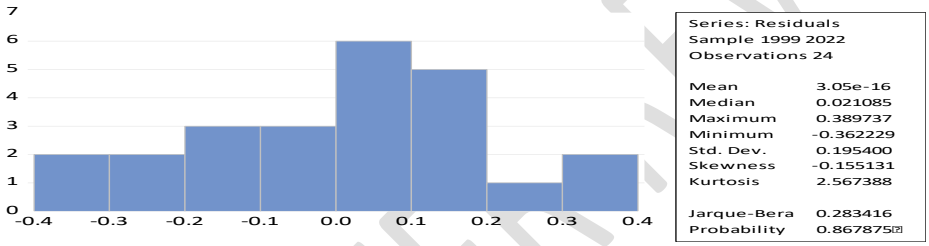


Figure 2. Normality Test

Source: Author's Computation, 2024.

Figure 3 shows the output of the CUSUM and CUSUM Square tests for parameter stability. The output indicates that the cumulative sum and cumulative sum of squares are located between the 5% critical values which means no structure breaks in the regression model and the parameters of the model are stable over time.

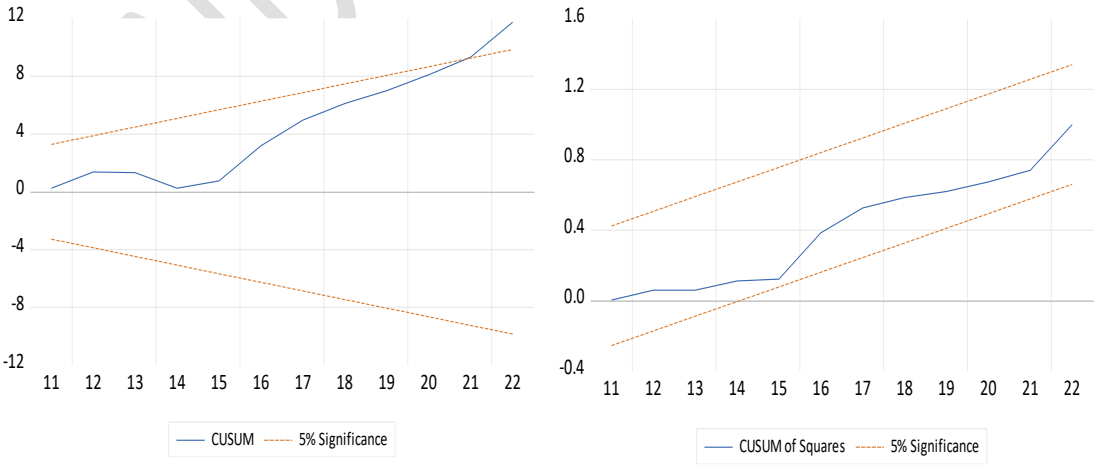


Figure 3. Normality Test

Source: Author's Computation, 2024.

b. Empirical Results of the ARDL Monetary Policy Reaction Model

Table 9. Descriptive Statistics

	MPR	RGDP01	NOMEXR01	MPR01	CP101
Mean	12.92593	49820.58	104.9697	13.02455	12.85937
Median	13.50000	51202.67	105.5801	13.16606	11.96623
Maximum	20.50000	75892.32	201.6060	15.40591	20.49335
Minimum	6.000000	20106.24	-2.467557	10.39892	11.05687
Std. Dev.	3.140779	18805.33	52.58052	1.799018	2.422245
Skewness	-0.078900	-0.133701	-0.149173	-0.074585	1.960286
Kurtosis	3.672442	1.573619	2.586205	1.506698	5.880231
Jarque-Bera	0.536715	2.369325	0.292766	2.533727	26.62494
Probability	0.764634	0.305849	0.863827	0.281714	0.000002
Sum	349.0000	1345156.	2834.181	351.6628	347.2031
Sum Sq. Dev.	256.4769	9.19E+09	71882.50	84.14810	152.5491
Observations	27	27	27	27	27

Source: Author's Computation, 2024.

The descriptive statistics of the data series provides information about the sample series. The Statistical values for the mean, median, minimum, maximum value as well their pattern of distribution as measured by the Skewness, Kurtosis and Jarque-Bera statistic values are presented in Table 1 above. Highlights of Table 1 suggest that the average value and median of each of the variables are not too far apart, which is suggestive of the point that the distribution may be symmetrical. Furthermore, the table shows that total output gap (*RGDP01*) has the highest maximum value at 75892.32 followed by the value of nominal exchange rate deviation (*NOMEXR01*) which is 201.6060. Nominal exchange rate deviation (*NOMEXR01*) has the lowest minimum value (-2.467557) among the variables in the model. Moreover, the descriptive statistics show that monetary policy rate deviation (MPR01) has the lowest standard deviation of 1.799018 S.D points from the sample mean, while total output gap (*RGDP01*) has the farthest standard deviation of 18805.33 S.D points from the mean. In addition, Table 1 reveal that all the variables are negatively skewed, except the value for inflation deviation (*CPI01*) that is positively skewed. Lastly, the probability values of the Jarque Bera test for null hypothesis of normal distribution cannot be rejected at the 5% significance level, since they are not significant.

Covariance Correlation	MPR	CP101	RGDP01	NOMEXR01	MPR01
MPR	9.499143 1.000000				
CP101	1.497596 0.204423	5.649966 1.000000			
RGDP01	-15948.97 -0.280417	24822.83 0.565904	3.41E+08 1.000000		
NOMEXR01	-30.35107 -0.190854	87.03716 0.709663	904922.9 0.950378	2662.315 1.000000	
MPR01	3.820899 0.702236	1.854408 0.441918	-12519.29 -0.384285	-24.10803 -0.264662	3.116596 1.000000

Table 10 Covariance and Correlation Matrix

Source: Author's Computation, 2024.

Preliminary assessment of the correlation and covariance properties of the variables used in the specified econometric models were also conducted. The covariance and correlation matrix show the magnitude and direction of relationship existing between variables in a model. The result as highlighted in Table 2 above shows a weak correlation existing between the policy rate with the explanatory variables (output deviation, exchange rate deviation and inflation deviation). However, there is a strong correlation between the monetary policy rate and its deviation. Table 2 also suggests that the policy interest rate (MPR) is positive but insignificantly related to inflation devaition (CPI01); and negatively associated with nominal exchange rate deviation (NOMEX01) and output gap (RGDP01). Moreover, the covariance statistic which is indicative of the direction of movement of the variables in the model shows that the direction of movement is positive for MPR and CPI0. Moreover, there is positive movement between the CPI01 and NOMEXR01 and between CPI01 and output deviation (RGDP01). This outcome presuposses that the existence of direct relationship between these variables.

UNIT ROOT TEST

Table 11: ADF Unit Root Test

	ADF(Prob.) @ Level		**ADF (Prob.) @ First Difference**	
Variables	Intercept	Trend and Intercept	Intercept	Trend and Intercept
MPR	-2.976263 (0.2749)	-3.587527 (0.6468)	-2.981038 (0.0000)*	-3.595026 (0.0001)*

CPI01	-3.012363 (0.9907)	-3.632896 (0.0185) **	-3.012363 (0.0180)**	-3.644963 (0.0062)
RGDP01	-2.998064 (0.2476)	-3.612199 (0.6428)	-3.020686 (0.1227)	-3.658446 (0.0557)**
NOMEXR01	-3.004861 (0.9993)	-3.644963 (0.0006)*	-3.020685 (0.0262)**	-3.632896 (0.0828)

*&** indicates significance levels (i.e. 1% and 5% level, respectively).

Source: Author's Computation, (2024).

The ADF unit root test was employed to evaluate the properties of the variables in the monetary reaction model. The result as shown in Table 12. indicates that the probability values for the deviation of inflation (CPI01) and nominal exchange rate (NOMEXR01) at intercept and trend are significant at 1% and 5% respectively, suggesting that they are integrated at levels, while other variables were integrated at first difference. The identification of the mixed order of integration, therefore necessitates the use of the ARDL bound test approach to evaluate evidence of cointegration.

Table 12 ARDL Bound Test for Cointegration

F-Bounds Test:		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	9.776801	10%	2.2	3.09
K	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

Source: Author's Computation, 2024.

Continuing, after determining the stationarity properties of the variables and the lag length criteria, the ARDL bound test technique was employed in the estimation of the specified model. Table 5 reveals the result of the bound test. The results of the bound test for in Table 5 confirms that there is co-integration relationship among the variables included in the model. Specifically, the result shows that the F-statistic value of 9.776801 at four (4) degrees of freedom is greater than both the lower l(0) and upper I(I) bound levels. The outcome therefore suggests that the null hypothesis of no cointegration is rejected at all the critical values. The evidence of co-integration among the variables rules out spurious correlations and can also be viewed as an indirect test for the evidence of long run causality among the variables.

Table 13 Estimated Long run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
CP101	-0.122514	0.047247	-2.593045	0.0268**
LOG(RGDP01)	4.355999	0.683852	6.369799	0.0001*
NOMEXR01	-0.019334	0.004959	-3.899096	0.0030*
LOG(MPR01)	6.710241	1.024041	6.552708	0.0001*
C	-58.51564	8.319694	-7.033389	0.0000*

Source: Author's Computation, 2024. * @ 1%, **5% level of significance.

The Long run estimated coefficient is as follows:

MPR = -58.5156-0.1225*CP101 + 4.3560*LOG(RGDP01) -0.0193*NOMEXR01 + 6.7102*LOG(MPR01)

All explanatory variables except output deviation, do not possess the right signs. The policy rate is shown to be negatively related to inflation deviation and nominal exchange rate deviation but positively related to output gap. The policy reaction function to output deviation is generally in line with the theoretical expectations, as it shows stabilizing policy in terms of its reaction to output growth deviation. The reactions are also statistically significant.

The policy reactions to exchange rate and inflation are suggestive that the two variables may be interconnected in the context of the Nigerian economy. The policy rate reaction to inflation deviation and exchange rate deviation are statistically significant, but the sign of their coefficients is different from the apriori expectations. The finding is suggestive of the fact that the economy amongst others, may be affected by foreign induced inflation which is caused by the volatility in exchange rate movements on imported goods. In other words, for the policy reaction function to appropriate forecast inflation, it should take into cognizance the effect of volatility in exchange rate on the domestic price level.

The estimation output of the Error Correction Model (ECM) and the coefficients of the short-run dynamic relationship between the policy rate and its determinants are presented in Table (10). The output suggests that the error correction parameter is statistically significant at 1% level and is correctly signed and equals (-5.18). This is also a pointer to the adjustment rate and the amount of shock in the short run that will be corrected annually in the event of disequilibrium. With respect to short-run dynamic regressors, the results show that changes in output deviation and inflation deviation are the only explanatory variable to have a positive and statistically significant impact on the policy rate. The highest impact on the policy rate in the short run is brought about by changes in

the output deviation. This means that despite the monetary policy framework adopted, the monetary authority continues to ensure that the imperative of ensuring sustained economic growth is emphasized. Moreover, the outcome on inflation deviation in the short run is indicative that the influence of the policy rate is in line with apriori expectations, and further suggests the dynamic behaviour of the variable from the short run to the long run time periods. The outcome therefore alludes to the importance of controlling inflation for output growth in the Nigerian economy.

Table 14: Output of ECM and Short Run Regressors

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(MPR(-1))	3.095523	0.403906	7.663963	0.0000
DLOG(MPR(-2))	1.679157	0.256195	6.554211	0.0001
DLOG(MPR(-3))	0.718530	0.136463	5.265387	0.0004
D(CP101)	1.651205	0.228309	7.232329	0.0000
DLOG(RGDP01)	103.4612	11.15908	9.271480	0.0000
D(NOMEXR01)	-0.261951	0.031934	-8.202975	0.0000
DLOG(MPR01)	-27.45195	3.771810	-7.278192	0.0000
ECM(-1)*	-5.176326	0.551826	-9.380363	0.0000
R-squared	0.906924	Mean dependent var		-0.003783
Adjusted R-squared	0.863488	S.D. dependent var		0.240250
S.E. of regression	0.088766	Akaike info criterion		-1.737412
Sum squared resid	0.118192	Schwarz criterion		-1.342458
Log likelihood	27.98024	Hannan-Quinn criter.		-1.638082
Durbin-Watson stat	2.587829			

Source: Author's Computation, 2024.

Continuing, several post-estimation tests of the output of the specified model were conducted. The result is shown in Table 11 below. The table highlights the result of the Breusch Godfrey (BG) Serial correlation LM test, Breusch-Pagan-Godfrey heteroscedasticity test and the Jarque Bera test for normality. The output suggests that the BG and BPG tests with the null hypothesis of no serial correlation in the residuals and no heteroscedacity cannot be rejected as their p-values are greater than the adopted 5% level of significance in both the F test and Obs.*R-Square statistic. Moreover, figure 4 shows that the Jarque Bera test of Normality is in conformity with expectations as the J.B probability value of 0.64 is above the 5% significance level.

Table 15. Post Estimation Diagnostic Tests Output

Breusch-Godfrey (LM) Test for Serial Correlation			
F-statistic	7.528840	Prob. F(2,8)	0.1145
Obs*R-squared	15.02001	Prob. Chi-Square(2)	0.4205
Breusch -Pagan-Godfrey Test for Heteroscedasticity			
F-statistic	0.563394	Prob. F(12,10)	0.8281
Obs*R-squared	9.277444	Prob. Chi Square(12)	0.6791

Source: Author's Computation, 2024.

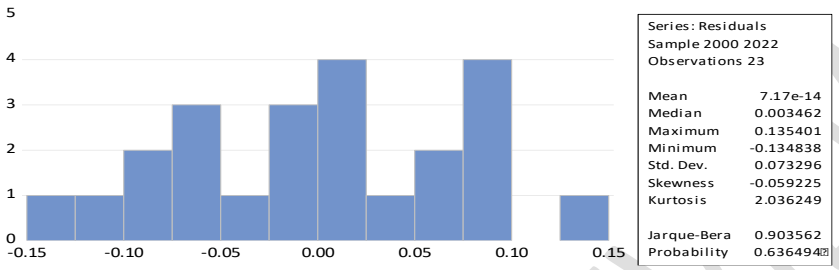


Figure 4. Normality Test
Source: Author's Computation, 2024.

Figure 5 shows the output of the CUSUM and CUSUM Square tests for parameter stability. The output indicates that the cumulative sum and cumulative sum of squares are located between the 5% critical values which means no structure breaks in the regression model and the parameters of the model are stable over time.

Figure 5 Output of the CUSUM and CUSUM Square tests
Source: Author's Computation, 2024.

5. Conclusion

The inflation function reveals empirical evidence of the effect of broad money supply (M3/RGDP) and exchange rate on inflation from 1996 to 2023. The ARDL long run output confirms that the ratio of broad money to RGDP as a measure of liquid liabilities to total output in the country exerted the most significant effect on inflation. The outcome therefore suggests the existence of significant relationship between inflation and money supply in the country. Furthermore, with regard to the monetary policy reaction function, the findings does not suggest

a stabilising policy with reference to the reaction to inflation deviation. This is as the sign of the coefficient is not in tandem with a priori expectation which required that the policy rate should have produced a counter cyclical reaction.

The monetary policy reaction to output gap are generally in line with theoretical expectations, and shows a stabilising policy. In fact, the highest impact on the monetary rate is brought about by the deviation in output, which mearnt that despite the several monetary frameworks of the monetary authority, sustaining economic growth in the long run was one of its top priorities during the period under review. Moreover, the result show the dynamic behaviour of exchange rate in the economy. The outcome therefore has the following implications on the Nigerian Economy; first, the growth of liquid liabilities is a determinant of inflation and should be careful monitored by the monetary authority. Secondly, the monetary policy rate could also influence inflation while the behaviour of exchange rate is dynamic, and therefore emphaises the need for the monetary authority to priotise the control of inflation Thirdly, the study suggest that the policy of controlling inflation should be vigoriously pursued in line with the objective of stabilising the exchange rate. In this context, flexible intervention mechanisms should be emphaised by the monetary authority in the use of the monetary framework of inflation targeting.

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