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Article

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LENGTH OF TRANSMISSION LAG FROM MONETARY POLICY RATE (MPR) AND BROAD MONEY SUPPLY (M2) TO INFLATION IN NIGERIA

Alfa, Yakubu¹
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Abstract

This study examines the length of transmission lag from monetary policy rate and money supply to inflation in Nigeria between the periods of January 2007 to March 2018. Using Autoregressive Distributed Lag (ARDL) model, the study reveals that changes in MPR does not transmit instantly to inflation but does so only after delaying for sometimes, changes in the operating targets only impact on the ultimate target (inflation) after long period. It takes changes in MPR about 20 months to impact significantly on inflation, similarly, changes in M2 takes about 25 months to influence inflation in Nigeria. This suggest that the new operating framework (MPR) introduced by the Central Bank of Nigeria (CBN) does not effectively impact on inflation within the desired period. Therefore, it is recommended that the operating framework be streamlined to ensure the reduction in the transmission lag of monetary policy to inflation in Nigeria.

Keywords: Monetary policy lag, MPR, M2, ARDL.

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1.0 INTRODUCTION

The length of time it takes monetary policy action to transmit to inflation and other macroeconomic variables has been a subject of much debate over many years. The debate was more serious in the 1960s when two opposing views, one led by Friedman (1960) and the other by Culbertson (1961), appear in the literature. An important question that dominates the debate revolves around how long it takes monetary policy's effect on the economy to be felt or noticed. For Friedman (1960)⁴, monetary policy affects economic conditions only after a lag that is both long and variable, and the length and the variability depend upon the economic and financial conditions of a country. He uses this conclusion to justify a policy of constant growth in money supply in preference to any actively anti-cyclical monetary policy.

Contrary to the Friedman's submission, Culbertson (1961) argues that the general character of economic fluctuations does not seem to support the long-lag theory. He opined that if both government stabilization policies act with a long and variable lag, how to explain the surprising moderateness of the economic fluctuation suffered in many past decades? He concludes that monetary actions can have their direct effects within three to six months. While Friedman-Culbertson's debate gave inspiration to many subsequent studies on the length and variability of monetary policy lag, empirical findings from such studies were mixed. For example, the finding of Gruen, Romalis and Chandra (1997) suggest that the lags of monetary policy for the Australian economy became slightly longer over time seem to support Friedman (1960). However, studies by Kareken and Solow (1963), Mayer (1967) and Asghar and Hussain (2014)⁵ seem to find more evidence in support of Culbertson's (1961).

High inflation creates uncertainty and worsen economic performance. Hence the role of monetary authority is imperative. However, if such roles are not effective within the desired period, then, the public confidence in the monetary will be eroded and that could undermine the effectiveness the monetary policy.

Asekunowo (2016) observed that, inflation in Nigeria was not effectively curtailed by the monetary authority. As a result, Nigerian businessmen were able to pass the increases in marginal costs of production on to the Nigerian consumers in form of increases in the prices of consumer durables and non-durables produced in the country. This has both microeconomic and macroeconomic consequences. At the microeconomic level, the unfair wealth redistribution that may accompany an upward movement of prices could encourage hoarding of unspent income, increase the cost of borrowing and therefore, constrain investment spending by businessmen. At the macroeconomic level, an upward inflationary pressure may make the export of goods and services in an economy to dwindle because the prices of tradables may become less competitive in the international markets (Asekunowo, 2016). Therefore, understanding inflation in Nigeria is very important because it plays vital role in determining the efficacy of monetary policy regime adopted by the Central Bank of Nigeria (CBN).

In Nigeria, the conduct of monetary policy centered on the monetary policy framework that was changed in 2006 with price replacing quantity as the operating target. The new operating target i.e.,

⁴ Friedman (1960) estimated the lag length of monetary policy transmission to be close to two years (about 23 months on average). He argues that sometimes when Federal Reserve System takes action, the effects takes 5 months and in some occasions, 10-month or 2 years.

⁵ Asghar and Hussein (2014) show that monetary policy affects economic conditions only after about 9-month while for Kareken and Solow (1963) and Mayer (1967), it was about 12-month and 15-month, respectively.

Monetary Policy Rate (MPR) serves as the anchor rate that signals the stance of monetary policy. The Monetary Policy Committee (MPC) fine-tune the rates in desired direction to impact on the ultimate target. An increase in MPR signifies the intention of the Central Bank of Nigeria (CBN) to embark on a contractionary monetary policy that slowdown inflation. This action of the CBN is transmitted to affect commercial banks' special deposits as well as their reserve requirements and that resulted to a fall in money supply (M2) leading to increases in the interbank lending rates (LDR) which in turn, transmit into commercial banks' cost of lending fund to customers of different categories. This in-effect, decrease the economic activities through a decline in demand and ultimately lead to reduction in inflation rate. Conversely, a reduction in MPR stimulates the economy through rise in M2 and subsequently impact positively on the output. Thus, this justified the choice of M2 and LDR as intermediate target variables to transmit to the ultimate target.

Successful conduct of monetary policy requires monetary policymakers' understanding of transmission lag as it will assist them in determining the precise time to take decisions and the expected impacts of such decisions on a target. However, the complexity of the process of monetary transmission and the associated uncertainty about its timing make it difficult for the monetary authority to quantify the overall effects of policy changes on output or inflation. This is further constrained by imperfect knowledge about shocks which are likely to adversely affect inflation as well as the timing of the transmission channels (Ajayi, 2007). Overall, it is arguable that the actual or exact effects of transmission mechanism of monetary policy on inflation in Nigeria is difficult to ascertain.

Although the transmission process from a monetary action, through intermediate channels, to the target variables described above was not left out in the discussion of many previous studies, however, not much is done in terms of the length of time (lag) it takes monetary impulse to transmit from one channel to the next. In addition, the response of the economy to monetary expansion or contraction is not random, but the timing of the consequences is indeed problematic. Many studies such as Culbertson (1961) show a disappointing lack of consistency in measuring the time lags from monetary impulses to changes in inflation. These results indicate substantial differences of opinion on timing. The major problem was that, either meaningful results are rather imprecise, or the precise results are easily challenged (Rosenbaum, 1985). Earlier attempts to tackle the aforementioned problems have been invariably in the regression framework or in its more sophisticated VAR variants. These approaches implicitly take the lag length as fixed but only the lag coefficients as time-varying, both are likely to be time-varying. This has serious implication for the conduct of monetary policy (Nachane & Lakshmi, 2001).

Therefore, it is important to have an accurate estimates of monetary policy lag to ensure that the actual impact of a given monetary policy change on inflation is as close as possible to the targeted impact. This is because the difference between the actual and target inflation rates determines by how much monetary policy has to be adjusted. A survey of some selected literature indicates that estimates of exact length and variability of lag of monetary policy variables (MPR and M2) differ considerably. For example, Ehrmann (2000) finds relatively fast transmission of monetary policy variables to prices, ranging between two and eight quarters and between twelve and twenty quarters for France and United Kingdom respectively. In contrast, Mojon and Peersman (2003) find that the effects of monetary policy shocks on target variables in European economies are much more delayed, with the maximum reaction occurring between sixteen and twenty quarters after the shock. The lack of consensus on the exact length of lag is attributable to many factors including inability of most studies to clearly separate lag length from lag variability and measuring the former independent of the later, varying methodologies and the choice of monetary policy variables. For example, Tanner (1979) develops a distributed lag model of nominal magnitudes of money supply changes in which the lag length is fixed but the coefficients are time varying, an approach similar to that by Cargill and Meyer

(1972). However, both approaches only amount to measuring the varying impact and magnitudes rather than varying lags per se. Given the above, it is important to note that the variations in findings of previous studies on the length and variability of monetary policy lag are too wide to draw strong conclusions on the exact length of time (month or quarters) it takes monetary policy action to transmit to target variables.

Though, the CBN authority has changed the monetary policy framework in 2006 with a view of achieving price stability through fine-tuning the MPR trigger the impact of the policy on the ultimate target (Inflation), yet, the inflation to some extent is not being influence within the desired period, Thus, this study will contribute to the empirical literature and provide policy recommendations on the length of transmission lag from MPR and M2 to inflation, using Nigerian data.

Following the introduction, Section 2 provides stylized facts on monetary policy rate and some selected variables. Section 3 covers review of theoretical and empirical literature. Section 4 contains the methodology. Section 5 presents and discusses the results while conclusion and recommendations forms part of section 6.

2.0 STYLIZED FACTS ON MONETARY POLICY RATE AND SELECTED VARIABLES

2.1 Trend Analysis of Monetary Policy Rate and Broad Money Supply in Nigeria

It is argued that a change in monetary policy rate (MPR) has the tendency of transmitting to commercial bank rates (interbank rates and lending rates), This may create shocks that tend to move actual inflation rate to a desired direction within the target rates.

The CBN in 2006 introduced a new operating framework that aimed at improving the transmission mechanism of monetary policy. In the new structure, the MPR serves as the anchor rate and the signal for the stance of monetary policy.

Figure 1: MPR and M2 Growth rate



Source: CBN Online Database

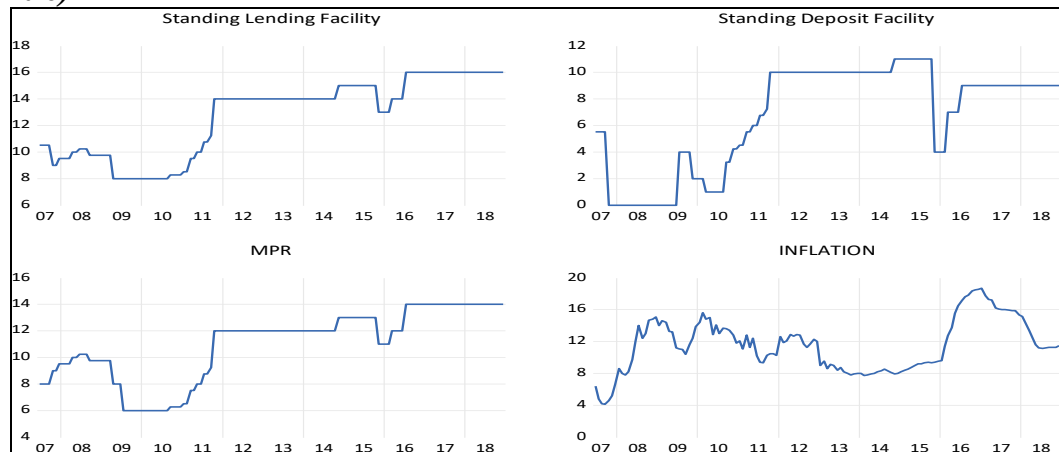
Figure 1 shows that MPC had changed MPR at different periods while M2 has an upward trend throughout. The changes in MPR are based on deliberate actions by the CBN to tighten or ease the economy, respectively. The implication of MPR increase is to generate a response of other money market rates (interbank rate, prime lending rate, among others) to a desired direction. For instance, with increase in the MPR, investors and other economic agents are restricted to some extent to

undertake loans for investment and that is expected to slowdown economic activity and subsequently bring down the level of inflation in the economy. Thus, an increase in MPR signal's that CBN is embarking on a contractionary or tight monetary policy regime to counteract inflation. In general, it could be observed that the CBN has increased MPR over the years more than the number of times it was decreased. This suggests that there are more periods of inflationary challenges in Nigeria than periods of low economic activity (recession) , and these phenomena have constituted a serious drag on the growth of the Nigerian economy. Furthermore, broad money supply (M2), unlike MPR, has upward movement throughout the period under review. However, increase in money supply, could triggers demand pull inflation especially when the economy is at full employment level of income³. This is evident in the monetarist claim that inflation is a monetary phenomenon and perhaps, explains the reason for persistent inflation in the Nigeria⁶.

2.2 MPR and Interbank Call Rates

The monetary policy rate is the CBN's interbank overnight unsecured interest rate. Under the 2006 monetary policy framework introduced, there are corridor approach, which covers the Standing Lending Facility (SLF) and Standing Deposit Facility (SDF), they were introduced to reduce the variation of the markets rates from the MPR.

Figure 2: MPR, Standing Lending Facility, Standing Deposit Facility, and Inflation (2007-2018)

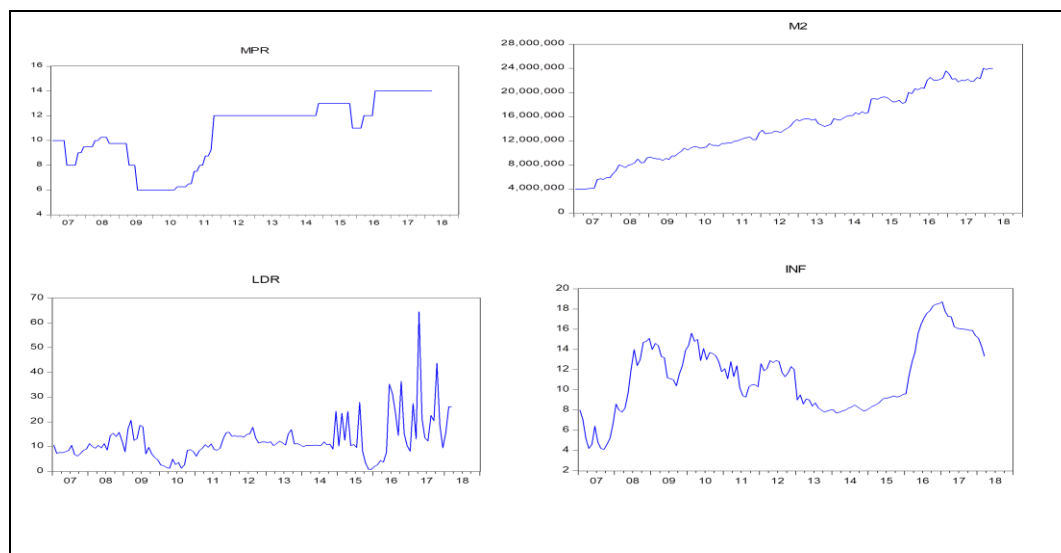


Source: CBN Online Database

Figure 2 shows the movement of SLF, SDF, MPR and inflation. The MPC changed MPR several times, between 2007 and 2018, in response to the expected rise in inflation. The SLF and SDF were also changed and set around MPR with the aim of reducing the divergence of the market rates from the MPR.

On the other hand, inflation increased significantly from a single digit of 5.60 percent in 2007, moving to 8 percent in 2008. It remained high throughout the period except, from 2013 to 2015 when it declined drastically to single digit. It reached a peak of 18 percent in 2016, respectively. The period of high inflation rate coincided with period of excessive government spending and or economic crisis period.

⁶ For Nigerian economy to attain full employment level, structural rigidities need to be addressed. Thus, for now, we assume that the economy is operating at full employment level.

Figure 3: Trend of MPR, M2, LDR and INF (2007 – 2018)

Source: CBN Online Database

Figure 3 shows the trend of MPR, M2, LDR and INF in Nigeria. The periods of high rates were attributed to increases in counterparties risk aversion. MPR was changed 16 times, with 12 times increase and 4 times decrease. It increased continuously from 8 per cent in the first quarter 2008 to 10.25 per cent in the second quarter of 2008. It was decreased to 6 per cent in the third quarter 2010, before changing it to 13.0 per cent in the fourth quarter of 2014. The frequent upward review of MPR signifies the inflationary pressure facing the economy. The tightening actions reflects increase in the interbank money market rates (both secured and unsecured). Furthermore, broad money supply (M2) witnessed an upward movement, this implies that, on average, the amount of liquidity injected into the Nigerian economy has been on the increase since 2007. However, the trend of the interbank lending rate (LDR) was relatively unstable. It was less than 10 per cent on the average in 2007 but falls drastically to less than 2 per cent in the first quarter of 2010 and falls further to less than 1 per cent in the last quarter of 2015. Since the first quarter of 2016, LDR has been on the increase, reaching a peak of 27.46 per cent in the first quarter of 2017 but falls marginally to 26.21 per cent in March 2018.

2.0 LITERATURE REVIEW

3.1 Theoretical literature

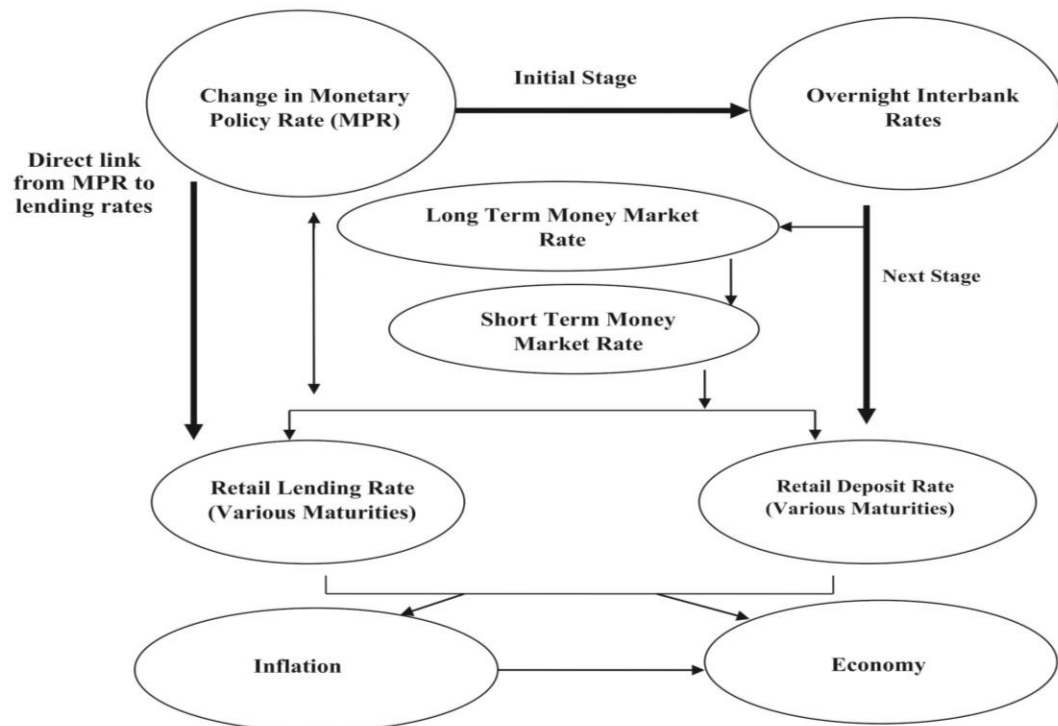
The theoretical underpinning of the monetary policy lag is attributable to the proposition put forward by Friedman (1960), it subsequently received considerable attention from monetarist. With divergent views on the lag length. Meghana (2016) and Friedman (1960, 1967) defined lag of monetary policy as the timing relation between the resulting monetary series and resulting series of effects of monetary actions. Friedman (1967) notes that monetary actions affect economic conditions only after a lag that is "both long and variable". He distinguishes among three basic lags: the recognition lag; the administrative lag; and the operation lag. The recognition lag is the time between the need for a monetary action to be taken to address an economic problem and the time such need is recognized by the monetary authority. The length of recognition lag depends, among other things, on the phases of the business cycle. It was believed by some monetary authorities to be longer at the peaks than at the troughs. For example, the U.S. Federal Reserve Bank (2015) and Meghana (2016) recognize the need

for monetary action only about three months after the trough in a business cycle and about six months after a boom had started.

The Administrative Lag (or decision or action lag) is the period of time between recognizing the need for monetary policy action and the time the action is actually taken by the monetary authority. The length of the administrative lag varies with the type of monetary policy (expansionary or contractionary) being considered, monetary transmission channel (interest rate, exchange rate or asset price) used and the decision making processes of the monetary authority. In monetary literature, the administrative lag and the recognition lag taken together are termed inside lags because they fall within the jurisdiction of the monetary authority. Sometimes, it is difficult to distinguish between the recognition lag and the administrative lag because the time between recognition of the need for action (recognition lag) and the taking of action (administrative lag) may so overlap that the administrative lag becomes the recognition lag (Meghana, 2016).

The operation lag (or the effects lag) refers to the period of time between the adoption of monetary policy and the final effect of the policy on economic activity. For analytical convenience, this lag is divided into intermediate lag and outside lag. The intermediate lag relates to the moment at which action is taken by the monetary authority and the moment at which the economy is faced with changes in interest rates and the money supply through monetary action. The outside lag (or impact lag) refers to the time involved between changes in interest rates, total reserves, credit rationing, etc., and their effects on aggregate spending, income and output of the economy. It is the time between the change in the intermediate targets and the response of the ultimate objectives such as inflation or other economic variables of interest. The length of outside lag was believed by most Central Banks to be much longer than the length of inside lag and is estimable.

3.2 Theoretical Framework



3.3 Monetarists Theory of Monetary Transmission

The monetarist perspective is credited to Friedman (1967) as explained by Meltzer (1995). The theory recognizes the interplay of relative prices with at least three assets, namely, money or base money which provides services as a medium of exchange; bonds or securities which yield a nominal return or interest; and the stock of real capital or claims to real capital. The monetarist perspective acknowledges that "The transmission process begins in the asset market". It does not say, however, what triggers it or how the process starts. It recognizes the open market operations by the central bank which, in this view, is "a simultaneous change in the stocks of base money and securities". In the "traditional quantity approach", an open market operations purchase increases the base money and reduces the stock of debt held by banks or the public; the reverse case of open market sales decreases the base money and increases the public's debt holding (Kuttner & Mosser, 2002). This perspective seems not to recognize that even in portfolio of assets, the mechanism which triggers the relative choices in the quantities of asset holding is the relative prices of the assets which create a "compositional variation effect" in obedience to what is termed "the law of compositional variation" in the portfolio of assets (Ndekwe, 1999).

The logic of the monetarist channel of monetary transmission, according to Kuttner and Mosser (2002), is that changes in asset composition outstanding, brought about by monetary policy would lead to relative price changes which, in turn, can have real quantity effects. The effect of the monetarist perspective is the use of a rule championed by Milton Friedman as opposed to discretionary operations of central banks in monetary policy, even though the monetary policy transmission mechanism is not the same as the discretionary policy. This study adopts the monetarists' theory of monetary transmission as its analysis of monetary transmission is considered to have explained the scenario in Nigeria better than other theories.

3.4 Review of Empirical Studies

Asghar and Hussain (2014) study the effect of monetary policy lags on inflation in Pakistan using monthly data spanning 1995: M1 to 2008: M12. Applying a distributed lag model, his findings reveal that monetary policy (i.e. changes in broad money supply) affects prices significantly after 9-months lag. The empirical findings reject Friedman's viewpoint and his proponents' claim that monetary policy is ineffective due to attached long and variable lags. However, a major drawback of this study is that the analysis is restricted to the growth rate of broad money supply as if it is the only monetary variable that could induce a change in inflation. The use of money supply as the only channel of monetary transmission to inflation leaves much to be desired in terms of quantifying the delay or lag associated with the monetary transmission process.

Havranek and Rusnak (2013) collect a sample of sixty-seven previous studies and examine why the reported transmission lags of monetary policy in the studies vary. The study uses meta-analysis to investigate both how transmission lags differ across countries and how different estimation methodologies within the vector auto-regression (VAR) framework affect the results. After imposing inclusion criteria, 198 impulse responses were taken from the sixty-seven previous studies from the developed and the post-transition economies. The results reveal that the cross-country variation in transmission is robustly associated with differences in financial development. The key result of meta-analysis is that a higher degree of financial development translates into slower transmission of monetary policy. More generally, the results imply that monetary transmission may slow down as the financial system of emerging countries develops since financial innovations allow banks to protect better against surprise shocks in monetary policy. The major limitation of this study is that it surveys only studies that employ VAR methods in investigating the effects of monetary policy shocks on the price level. The neglect of other studies conducted using other methods of analysis without empirical justification gives room for further questions about the findings of the study.

Nishiyama (2009) re-examines the Svensson's (1997) inflation targeting framework by explicitly taking into account the lagged effect of monetary policy using a simple model of optimal reaction function for Canada. The study also used the model to analyze the long-run stabilization cost to the central bank of Canada. Result suggests that the central bank of Canada and/or the government should set a relatively high inflation target when confronted with a relatively long monetary policy lag. This can be interpreted as another justification for targeting a positive inflation rate in the long-run.

Khan (2008) investigates the length of time (lag) it takes an unanticipated change in monetary policy to transmit to output growth and inflation in Pakistan from July 1991 to September 2006. The study employs the multivariate structural vector autoregression (SVAR) with the imposition of long-run restrictions. Results of the study show that an unanticipated positive shock in the monetary policy increases industrial output but reverted to its original level over 23 to 32 months horizon. It was also evident from the study that as far as the transmission mechanism is concern its impact is more pronounced on inflation as compared to output. 75 per cent of the effect of shock on inflation was realized during 12 months and 90 per cent was realized during one and half year. However, this study suffers methodological limitations as it uses SVAR without incorporating structural breaks and leads in the model. When SVAR is used without breaks, the estimated values for the parameters may not be reliable as they may be overestimated.

Malik (2006) tests the hypothesis that the effects of money supply changes were transmitted into output and inflation after some time lag. Results indicate that changes in monetary policy influences inflation with a lag of six months and then took another year to reach the peak. Real GDP also responded to the changes in the reserve money in the same way. The response began after three months, reached a peak in twelve months and then again came to zero after one and half year. He further found that during high inflation monetary authority's degree of leaning against the wind was almost zero due to two possible reasons. One reason could be that Central Bank while deciding on the growth of money gave more importance to the future target level of inflation and growth rate of real GDP while ignoring the deviations of inflation and real GDP from their trends in the past. The second reason could be that the monetary authority did so due to the fear of losing high growth. Tasneem and Waheed (2006) investigate how different sectors of the Pakistan economy respond to monetary shocks. The study uses monthly data covering 1999:M1-2004: M12. His findings show that there were sectors specific variations in the real effects of monetary policy. Interest rate shocks influenced manufacturing, wholesale and retail trade, and finance and insurance sectors after a lag of 6-12 months. Besides this, monetary policy shocks did not have any influence on agriculture, mining and quarrying, construction and ownership and dwelling sectors.

Khan and Schimnelfleming (2006) examine the relative importance of monetary and supply-side factors of inflation in Pakistan and their lag effects. Their study applied co-integration and vector error correction mechanism covering a high-frequency data set over the period of January 1998 to June 2005 to understand the relationship between wheat prices, CPI and monetary policy. Results indicate that the monetary factors have played a significant role in inflation, affecting inflation with a lag of about one year. Furthermore, Batini and Nelson (2001) update and extend Friedman's (1972) evidence on the lag between monetary policy action and the response of inflation. The study draws evidence from the United Kingdom and the United States data for the period 1953–2001 on money growth rates, inflation, and interest rates, as well as annual data on money growth and inflation. Findings from their panel regression reaffirm the Friedman's result that it takes over a year before monetary policy actions have their peak effect on inflation. This result has persisted despite numerous changes in monetary arrangements in both countries. However, the study fails to capture the dynamic general equilibrium models which are very necessary for accounting for the effect of monetary transmission lags.

In Nigeria, numerous studies were carried out on channel transmission mechanism of monetary policy, monetary policy reaction function, exchange rate passthrough and interest rates passthrough, among others. Such studies include Adeoye and Shobande (2017), Adeleke, Oboh and Shobande (2015), Adeoye and Shobande (2015); Oke and Shobande (2016) and Mesangan and Shobande (2016). Other studies included; Tokunbo (2005) evaluates the lag effect of monetary policy in Nigeria using a quarterly data covering 1986 to 1998 on Monetary Growth Model. His result indicates that monetary policy affects inflation after a lag of about 5 quarters.

Akinlo (2019) examines the effectiveness of the monetary policy transmission mechanism in Nigeria by estimating a sticky-price DSGE model using the Bayesian estimation approach. The study employs quarterly data from 2000:1 to 2019:4. Empirical results show that the monetary policy transmission channels are effective in transmitting policy impulses to the economy within this regime. However, the monetary aggregate framework that is made explicit dampens the achievement of this framework. Oyadeyi and Akinbobola (2018) investigate the response of the different monetary policy channels of transmission to several macroeconomic variables in Nigeria and established the dominant channel on output from the period of 1986 to 2017 using quarterly data. The study adopts the structural break and structural VAR methods in achieving the objectives and found a significant standard deviation real effect on each monetary policy channel in the short term, while it also found that innovations arising from a channel itself caused the greatest shock on its future values. The findings further demonstrated that each monetary policy channel had a weak influence on output, with interest rate channel being the dominant channel of monetary policy on output.

Adeoye and Shobande (2017) studied the monetary transmission mechanism in Nigeria using the vector auto regression and vector error correction techniques on a quarterly data spanning 1985:Q1 – 2015:Q4. Findings show that money supply, expected inflation, real interest rate and exchange rate are crucial for any meaningful output growth, suggesting that manipulation of these variables is essential for the effectiveness of monetary policy in Nigeria. Although these studies have contributed to the existing literature on monetary policy transmission channels, they do not consider the length of time (lag) it takes monetary policy to transmit across the various channels of transmission.

To the best of our knowledge, the only study that centred on estimating the period taking for monetary policy to impact on inflation is Tokumbo (2005) that evaluates the lag effect of monetary policy in Nigeria using a quarterly data covering 1986 to 1998 on Monetary Growth Model. His result indicates that monetary policy affects inflation after a lag of about 5 quarters. However, the study was carried out prior to the introduction of new monetary policy operating framework which had been replaced by the monetary policy rate in 2006. Also, the period covered by the study was 1986 to 1998 which is 14 years ago, therefore, the change change both in size and dynamics.

This study will contribute to the existing literature by ascertaining the efficacy and the timing of the new monetary policy operating framework (MPR) on inflation, especially as the inflation rate keep increasing in Nigeria. The findings the paper will provide a guide to the Monetary Policy Committee members in carrying out monetary policy decisions

4.0 METHODOLOGY

The paper estimates length of transmission lag from monetary policy rate (MPR) and broad money supply (M2) to inflation in Nigeria. The study adopts Autoregressive Distributed Lag (ARDL) model in line with Pesaran and Shin (1995, 2009). Two reasons justified the choice of the model in this study First, ARDL model is applicable irrespective of the order of integration of variables as long as none of

the variables is integrated of the order of two. Second, given the objective of this paper (ie estimating the lags of monetary variables), the ARDL model is most suitable.

This is evident in the general ARDL specification in which each independent variable in the model is expected to be lagged backward until the optimum lag length is reached. This approach, which is in line with Asgar and Hussain (2014), has the potentials of ferreting out the lag structure of the monetary variables of the type used in this study. The Pesaran's et al (2009) general ARDL (p,q) is given as:

$$Y_t = a_0 + a_1t + \sum_{i=1}^p \phi_i y_{t-i} + \beta' x_t + \sum_{i=0}^{q-1} \beta'^*_i \Delta_i x_{t-i} + \mu_t \quad (1)$$

$$\Delta x_t = P_1 \Delta x_{t-1} + P_2 \Delta x_{t-2} + \dots + P_s \Delta x_{t-s} + \mu_{ts} \quad (2)$$

Where

Y_t = dependent variable; y_{t-i} = autoregressive component of the model

X_t = independent variables; x_{t-i} = the distributed lag component of the model

$a_0, a_1, \phi_i, \beta', \beta^* = \text{parameters of the model}$

μ_t and μ_{ts} are serially uncorrelated disturbances

P_i = $k \times k$ coefficient matrices such that the autoregressive process in Δx_t is stable, ($i = 1, 2, \dots, s$).

However, following and modifying the ARDL model in Asghar and Hussain (2014), the ARDL model is specified in terms of the variables of this study as:

$$INF_t = a_0 + \sum_{i=1}^n \beta_{1i} INF_{t-i} + \sum_{i=0}^n \beta_{2i} MPR_{t-i} + \sum_{i=0}^n \beta_{3i} M2_{t-i} + \sum_{i=0}^n \beta_{4i} LDR_{t-i} + \mu_{it} \quad (3)$$

Where:

α_0 = intercept (Spot multiplier which measures the instant change in INF when MPR, M2 or LDR changed)

$\beta_{1i}, \beta_{2i}, \beta_{3i}$ and β_{4i} = partial slopes (Delayed multipliers which measure how changes in the lag values of the MPR, M2 or LDR affect INF).

INF = monthly inflation rate; MPR = monthly monetary policy rate, $M2$ = monthly broad money supply, LDR = monthly lending rate

MPR_{t-i} = Lagged values of monetary policy rate ($i = 0, 1, 2, \dots, n$)

$M2_{t-i}$ = Lagged values of broad money supply ($i = 0, 1, 2, \dots, n$)

LDR_{t-i} = Lagged values of Lending rate ($i = 0, 1, 2, \dots, n$)

μ_{it} = Residual term of regression equation

The choice of MPR, M2 and LDR as predictors of INF in equation (3) is based on two theoretical positions on how monetary policy transmission mechanism affect output and inflation. The first view, led by the monetarists, suggests that an increase in money supply will lead to an increase in price which in turn generate inflation thereby lowering the interest rate which tend to stimulate investment and speed up the growth of the economy (Adeoye & Shobande, 2017). The second view is the scholastic criticism of the monetary policy presented by Keynesian economists that the interest rate channel is the standard Keynesian channel of monetary transmission. The Keynesians suggest that a fall in real interest rates lowers the cost of capital, causing a rise in investment spending, thereby leading to an increase in aggregate demand and a rise in output (Minskin, 1996).

However, the basic assumption about the ARDL model in equation 3 above is that changes in MPR and M2 transmit directly to the ultimate target (inflation) without, first, affecting the intermediate targets. The implication of this assumption is that equation 3 may underestimate the lag length of MPR and M2 and may give misleading results. The result may suggest that length of monetary

transmission lag is short (contrary to Friedman's conclusion), whereas it may not be so. To circumvent the limitation in equation (3), Purvis (1990) uses Lucas's (1976) formulation to describe a long lag from monetary policy changes to prices (inflation). In this study, we re-specify equation 3 by decomposing it as:

$$LDR_t = a_0 + \sum_{i=1}^n \beta_{1i} LDR_{t-i} + \sum_{i=0}^n \beta_{2i} MPR_{t-i} + \mu_{it} \quad (4)$$

$$M2_t = a_0 + \sum_{i=1}^n \beta_{1i} M2_{t-i} + \sum_{i=0}^n \beta_{2i} LDR_{t-i} + \mu_{it} \quad (5)$$

$$INF_t = a_0 + \sum_{i=1}^n \beta_{1i} INF_{t-i} + \sum_{i=0}^n \beta_{4i} M2_{t-i} + \mu_{it} \quad (6)$$

Equation 4, 5 and 6 were estimated independently. Equation 4 shows that the effect of a change in MPR by the CBN is first transmitted to LDR, the change in LDR is then transmitted to M2 (equation 5) and the change in M2 is finally transmitted to inflation as shown in equation 6. Therefore, equation 4, 5 and 6 were estimated separately in section 4.

4.1 Estimating Transmission Pass-through from MPR and M2 to Inflation in Nigeria

To estimate the pass-through effect of monetary policy to inflation and hence, the response of inflation to shocks arising from changes in monetary variables, the impulse response functions (IRF) was used. This is in line with Zubair et al. (2013) and Sanusi (2010) who defines pass-through to the endogenous variable over T periods as the accumulated effect of a structural one standard deviation shock to the exogenous variable in period t. The pass-through to inflation (INF) over T periods is defined as the accumulated effect of a structural one standard deviation shock to MPR and to M2 in period t on inflation in period T. The accumulated response measures the effects of MPR and M2 changes on inflation. Mathematically, the dynamic pass-through elasticity can be calculated using the following ratios:

$$PT_t = \frac{\% \Delta INF_t}{\% \Delta MPR_0} \quad (7)$$

$$PT_t = \frac{\% \Delta INF_t}{\% \Delta M2_0} \quad (8)$$

Where;

$\% \Delta INF_t$ = percentage change in inflation between period 0, when the initial exchange rate shock hits, and period t

$\% \Delta MPR_0$ = percentage change in monetary policy rate at time 0;

$\% \Delta M2_0$ = percentage change in money supply at time 0

4.2 Types and Sources of Data

This study uses monthly data on inflation (INF), broad money supply (M2), commercial banks' lending rates (LDR) and monetary policy rate (MPR) to estimate the length of transmission (lag length) from monetary policy action to inflation in Nigeria. In this study, INF refers to a monthly growth rate of general price level represented by basket composition of composite consumer price index (CPI) (base November 2009 = 100). M2 consists of currency in circulation plus current account deposits and time deposits with commercial banks. Currency in circulation consists of coins and notes of different denominations while time deposit is the current account of customers with commercial banks. LDR is the prime rate that commercial banks charge their most credit-worthy customers which

are determined by the overnight rate that banks use to lend to one another. MPR, as used in this study, is the anchor rate with ceiling (SLF) and floor (SDF) rates which the CBN lends receive deposits from commercial banks.

The choices of LDR, M2 and MPR variables are on the basis that they are part of the policy variables in the monetary policy framework currently use by the CBN ". In such a target, MPR and M2, among other variables, are the major nominal anchors. In the conduct of monetary policy, MPR is used by the CBN as the operating target and M2 as the intermediate target. Data for all the variables (INF, LDR, M2 and MPR) were obtained from the online database of CBN. The data cover a period of one hundred thirty-five (135) months from January 2007 to March 2018. The choice of monthly data for the study was on the basis that, high frequency data are more required for monetary policy implementation. Also, in Nigeria, the performance of monetary aggregates (such as M2, MPR, and other monetary variables like cash reserve requirement (CRR)) and the impact of their changes on target variables (such as inflation) are often both.

4.3 Unit Root Test: Kwiatkowski-Phillips-Schmidt-Shin (KPSS) and Elliott-Rootenberg-Stock (ERS)

Two unit root tests, the KPSS and the ERS, were used in this study to examine the stationarity property of the data set. This is unlike most previous studies such as Sanusi (2010) and Asgar and Hussain (2014) that use augmented dickey-fuller (ADF) and Phillips-Perron (PP) for unit root testing. The choice of KPSS and ERS was not only informed by the imperatives of comparison of results and consistency but also to avoid the problem of high size distortion associated with ADF and PP unit root test options. Zivot and Andrews (1992) note that the ADF and PP tests suffer from high size distortion while KPSS is robust in the midst of serial correlation and heteroscedasticity. ERS takes into account the possibility of the existence of serial correlation in the errors (Guaita, 2008). The critical values for the ERS statistic are computed by interpolating the simulations results provided by Elliott, Rothenberg and Stock (1996). Unlike ERS where the null hypothesis is non-stationary, the null hypothesis for KPSS is that the process is stationary. The critical values (CV) are those tabulated by Kwiatkowski, Phillips, Schmidt and Shin (1992) based on the asymptotic results discovered by the authors. Thus, rejection of the null hypothesis occurs if $KPSS > CV$.

4.4 F-Bound Test of Co-integration

To test for the existence of a long-run relationship among the variables of the study uses the bound test approach developed by Pesaran et al. (2001) to test presence of the long run relationship between the variables.. The choice of bound test approach is to escape some of the limitations identified with Johansen-Juslius' (1991) test of co-integration. A major limitation of Johansen-Juslius' (1991) test is its' condition which states that all the variables must either be I(1) and none is I(0).

5.0 PRESENTATION AND DISCUSSION OF RESULTS

5.1 Pre-Estimation Statistics

The pre-estimation statistics considered in this study are the seasonality test, the unit root test, the multi-co integration test and trend analysis. Their results are reported in table 1, table 2 and figure 2 respectively.

Table 1: Correlogram Test for Seasonality

Lag	Auto Correlation (MPR)	Auto Correlation (M2)	Auto Correlation (LDR)	Auto Correlation (INF)	PAC	Q-Stat
1	*****	*****	*****	*****	0.978	137.64
2	*****	*****	*****	*****	-0.043	269.60
3	*****	*****	***	*****	-0.061	395.36
4	*****	*****	*****	*****	-0.138	513.53
5	****	*****	*****	*****	0.005	624.46
6	****	*****	*****	*****	-0.074	727.60
7	****	*****	*****	*****	-0.015	823.03
8	***	*****	***	*****	-0.106	910.14
9	***	*****	***	*****	0.083	990.06
10	***	*****	**	*****	-0.011	1063.1

Source: Author's Computation

Table 1 shows the test of seasonality conducted at lag 10, using the correlogram procedure. The result indicates absence of seasonality in MPR, M2 and INF. This is indicated by the autocorrelations for MPR, M2 and INF that diminished continuously as lag lengths increases from lag 1 to lag 10. This suggest that MPR, M2 and INF exhibit a predictable pattern that does not show signs of presence of seasonality in them. However, for LDR, the change in autocorrelation falls as lag length increases, suggesting the presence of seasonality in LDR.

Table 2: Result of KPSS and ERS Unit Root Tests

Variables	KPSS Levels	KPSS Difference	Remarks (KPSS)	ERS Levels	ERS Difference	Remarks (ERS)
INF	0.303*	-----	I (0)	10.51*	-----	I (0)
MPR	0.998	0.125*	I (1)	13.44*	-----	I (0)
M2	1.438	0.046*	I (1)	248.2*	-----	I (0)
LDR	0.659	0.031*	I (1)	0.636	3.510*	I(1)

H_0 (KPSS): Variables are stationary

KPSS Critical Value at 5% = 0.463

* Denotes stationary at 5%

H_0 (ERS): Variables are not stationary

PP Critical Value at 5% = 3.131

Source: Author's Computations

Table 2 shows the results of KPSS and ERS unit root tests conducted using Newey-West Bandwidth and spectral estimation, without intercept and trend. The KPSS results, at 5%, indicates that all the variables, except inflation (INF) are stationary only at first difference. This implies that INF is integrated of order zero [I(0)] while MPR, M2 and LDR are integrated of order one [I(1)]. For ERS result however, INF, MPR and M2 are stationary at levels while LDR is stationary at first difference. Thus, the result of KPSS and ERS tests suggests that the variables are integrated of different orders. The existence of different orders of co-integration of the variables justifies the use of the ARDL model in this study.

Table 3: Result of Canova-Hansen Unit Root Test of Stationarity, Seasonality and Stability
H₀: LDR is stationary at Monthly frequency Data

Frequencies	LM Statistical	Critical values (D.F.)	1%	5%
<i>12 months per cycle</i>	0.044963	2.0	1.070	0.749
<i>6 months per cycle</i>	0.083036	2.0	1.070	0.749
<i>4 months per cycle</i>	0.044880	2.0	1.070	0.749
<i>3 months per cycle</i>	0.074009	2.0	1.070	0.749
<i>2.4 months per cycle</i>	0.044199	2.0	1.070	0.749
<i>2 months per cycle</i>	0.040667	1.0	0.748	0.470
<i>Joint test</i>	0.207656	11.0	3.270	2.750

Source: Author's Computations

Table 3 shows the result of Canova - Hansen unit root test of stationarity and seasonality. This test aims to confirm the KPSS and ERS unit root results for LDR, given that LDR is affected by seasonality and hence, regime shifts. The test was conducted using the Tukey-Hanning Kernel for autocorrelation and heteroscedasticity. The results in table 3 shows that LDR is stationary. This confirms the KPSS and ERS unit root results for LDR. At 5% level. However, frequency for 6 months per cycle is not significant. In general, the null hypothesis that LDR is stationary cannot be rejected at 1% level of significant.

Table 4: Result of Lag Selection for Bound Co-integration Test

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2866.847	NA	2.41e+16	49.07430	49.16874	49.11264
1	-2316.806	1053.069	2.62e+12*	39.94540	40.41757	40.13710
2	-2310.555	11.54118	3.10e+12	40.11204	40.96194	40.45709
3	-2291.590	33.71415	2.95e+12	40.06137	41.28901	40.55978
4	-2284.523	12.08078	3.46e+12	40.21407	41.81944	40.86583
5	-2274.702	16.11733	3.87e+12	40.31969	42.30279	41.12480
10	-2204.309	10.77981	5.08e+12	40.48392	44.35568	42.05581
11	-2184.368	24.54360	4.96e+12	40.41654	44.66604	42.14178
12	-2167.390	19.73476	5.14e+12	40.39983	45.02706	42.27843
13	-2153.393	15.31329	5.67e+12	40.43406	45.43903	42.46602
14	-2137.504	16.29564	6.14e+12	40.43597	45.81867	42.62128
15	-2129.912	7.267744	7.78e+12	40.57970	46.34013	42.91836
19	-2003.249	30.24313*	4.84e+12	39.50853	46.77990	42.46062
20	-1969.468	20.78854	4.49e+12	39.20458	46.85367	42.31002
21	-1951.286	9.945865	5.71e+12	39.16727	47.19410	42.42607
22	-1911.853	18.87379	5.37e+12	38.76671	47.17128	42.17886
23	-1887.431	10.01914	7.08e+12	38.62275	47.40505	42.18826
24	-1826.006	21.00016	5.54e+12	37.84625	47.00628	41.56511
25	-2973.463	NA	2.78e+16	49.21427	49.30669	49.25181
26	-2396.441	1106.357	2.61e+12	39.94117	40.40328	40.12885
27	-2389.936	12.04186	3.05e+12	40.09812	40.92992	40.43594
28	-2369.990	35.60701	2.87e+12	40.03289	41.23438	40.52086
29	-2363.156	11.74675	3.35e+12	40.18440	41.75559	40.82252
30	-2353.231	16.40455	3.73e+12	40.28482	42.22570	41.07308
31	-2336.725	26.19142	3.74e+12	40.27645	42.58702	41.21486
32	-2321.721	22.81610	3.85e+12	40.29291	42.97318	41.38147
33	-2302.377	28.13661	3.71e+12	40.23764	43.28760	41.47634
34	-2289.005	18.56596	3.97e+12	40.28108	43.70073	41.66993
35	-2279.968	11.94980	4.60e+12	40.39617	44.18551	41.93517
38	-2233.889	14.60791	5.47e+12	40.42792	45.32633	42.41735
39	-2222.274	12.28772	6.30e+12	40.50039	45.76849	42.63997
40	-2214.892	7.320212	7.89e+12	40.64285	46.28064	42.93257
41	-2189.101	23.87325	7.41e+12	40.48100	46.48849	42.92087
42	-2177.082	10.33001	8.89e+12	40.54681	46.92399	43.13683
43	-2146.631	24.15983	8.05e+12	40.30794	47.05481	43.04810
44	-2117.988	20.83130	7.70e+12	40.09897	47.21553	42.98927
45	-2090.531	18.15326	7.76e+12	39.90960	47.39585	42.95005
50	-2531.298	33.13053	2.92e+12	40.05113	41.20393	40.51954
51	-2524.019	12.64019	3.35e+12	40.18634	41.69383	40.79886
52	-2512.848	18.70472	3.63e+12	40.26121	42.12341	41.01786
53	-2494.038	30.32982	3.51e+12	40.21764	42.43454	41.11841
54	-2479.395	22.70195	3.62e+12	40.23868	42.81029	41.28358
55	-2457.744	32.22425	3.37e+12	40.15107	43.07739	41.34009
60	8692.743	0.000000	NA	45.8539*	34.9443*	41.4269*

Source: Author's Computations

Before carrying out the co-integration test, it is necessary to determine the appropriate lag length for the test. The optimal length of lag selection for the co-integration test, based on the five information criteria (LR, FPE, AIC, SC and HQ), is reported in Table 4. Sixty (60) lags were tested for optimality and were lagged for a period of sixty months in order to have wide ranges of periods in addition to providing a robust analysis. From table 4, LR suggested a lag length of 19, FPE suggested lag 1 while AIC, SC and HQ show that lag 60 is optimal for the co-integration test. Consequently, this study used a lag length of 60 for the test of co-integration and for the subsequent analyses.

Table 5: Result of F-Bound Test of Co-integration

Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
Asymptotic: n=1000				
F-statistic	1.422605	10%	2.37	3.2
K	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66
Finite Sample: n=80				
Actual Sample Size	138	10%	2.474	3.312
		5%	2.92	3.838
		1%	3.908	5.044

Source: Author's Computations

To determine existence of long run relationship among the variables of the study, the F-Bound test was conducted. The result of F-bound co-integration in table 4 revealed that the F-statistics is 1.422, however, the value is less than 1%, 2.5%, 5% and 10% asymptotic critical values. Therefore, the null hypothesis of no level relationship is accepted. Based on the result in table 4, it can be concluded that the variables of the study do not have a long-run equilibrium relationship. Although, the absence of co-integration among monetary variables and inflation negates the monetarists' theory of inflation, it is often explained by possible non-linearity of the relationship as well as possible existence of fractional co-integration.

However, since the focus of this study is on measuring the speed of transmission of the variables to the ultimate target i.e., inflation, we proceed and estimate the transmission lags of monetary variables to inflation.

5.2: Length of Transmission Lag through Changes in Monetary Variables to Inflation in Nigeria

The result of the length of transmission lag from monetary policy rate to broad money supply is presented in table 6 below. The result has two peculiar characteristics. First, the estimated coefficients/standard errors are very large and second, the coefficients are negatively signed. The large coefficients/standard errors may appear as strange and perhaps, may not be welcome especially in studies where the focus is on the impacts of such coefficients on a target variable. However, in estimating the lag (not the impact) of monetary policy transmission, having large standard errors is not surprising, given that the deviation of policy outcomes from policy decisions is a frequent phenomenon. In other words, the outcome of every monetary policy decision is always very different from its expectation. Thus, the monetary policy decision makers do not always get it right when determining the precise length of time for transmission of monetary policy impulse. As such, the errors that are due to their decisions are not expected to be as small as possible (Asgar & Hussain, 2014). The estimated coefficients are negatively signed as expected. An increase in MPR would

diminish money supply by making reserves with the Central Bank more costly (Mbutor, Izuchukwu & Sunday, 2011). This justified why the estimated coefficients are negative, suggesting an inverse relationship between MPR and M2.

Table 6: ARDL Result of Length of Transmission lag from MPR to M2 in Nigeria
Dependent variable: M2

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-8499763.	5538741.	-1.534602	0.1508
MPR(-3)	-216402.	836286.3	-2.58765*	0.0238
MPR(-6)	-1518124.	583163.4	-2.60326*	0.0231
MPR(-9)	-1634250.	578312.4	-2.82589*	0.0153
MPR(-10)	-1447917.	545083.7	-2.65632*	0.0209
MPR(-11)	-1539481.	553630.5	-2.78070*	0.0166
MPR(-12)	-1220935.	503008.5	-2.42727*	0.0319
MPR(-13)	-1558228.	498887.0	-3.12341*	0.0088
MPR(-14)	-1496507.	509218.3	-2.93883*	0.0124
MPR(-15)	-1197363.	512265.8	-2.33739*	0.0376
MPR(-16)	-1423378.	530926.7	-2.68093*	0.0200
MPR(-36)	-1156387.	664603.7	-2.73997*	0.0107
MPR(-48)	-843126.2	558990.6	-2.50830*	0.0257
R-squared	0.979380	Mean dependent var		18348006
Adjusted R-squared	0.874561	S.D. dependent var		3389447.
F-statistic	9.343538	Durbin-Watson stat		0.547422

* Denotes significant at 5%; **Source:** Author's Computations

Table 6 is the result of ARDL model showing the length of time (measured in months) it takes changes in MPR (policy anchor) to transmit to M2 (the intermediate target). MPR was lagged backward to a period of four years (forty eight months), which is the optimal lag suggested by AIC, SC and HQ, however, only the lag periods with significant estimates are reported in table 6. On a priori, a change in MPR is expected to transmit to M2, and a change in M2 will then affects aggregate demand and subsequently the level of inflation. Using the MPR to signal monetary policy stance implies an inverse relationship between MPR and M2 as shown by the negative values of the coefficients.

From the estimated result in table 6, MPR becomes significant only at MPR (-3). This implies that the transmission of monetary impulse from MPR to M2 is not instant as it delays for about 3 months before having significant impact on M2. This also suggests that in the first horizon, monetary policy transmits to M2 only after 3 months lags. After that, it takes another three months MPR (-6)) in the second horizon and again, another three months (MPR (-9)) in third horizon for MPR's impact on M2 to be significantly noticed. The significant impact of MPR on M2 was maintained for the next seven months from MPR (-10)) to MPR (-16)). Beyond MPR (-16)), the MPR's significant impact on M2 delays for about nineteen months from MPR (-17)) to MPR (-35)) until it reaches MPR (-36)). Beyond MPR (-36)), MPR's significant impact on M2 delays again for about eleven months from MPR (-37)) to MPR (-47)) until it reaches MPR (-48)).

What could be inferred from the results is that the lag in the transmission of monetary policy is the same in first three horizons (i.e., three months for each horizon) however, the estimated coefficient for each horizon differs. Beyond the third horizon, the lag length varies, and the length of the variability increases and decreases across the horizons. For instance, the delay was seven months in

the fourth horizon and increases to nineteen months in the fifth horizon but decreases to eleven months in the sixth horizon (see table 6). This finding is in line with Friedman (1960) that transmission of monetary policy has both long and variable lag and agrees with Asghar and Hussain (2014) and Havranek and Rusnak (2013) that the length and the variability of monetary policy lag depend upon the economic and financial conditions of a country.

Table 7: ARDL Result of Length of Transmission lag from Changes in M2 Direct to Inflation (INF)

<i>Dependent variable: INF</i>				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-17.15438	1.811051	-9.472057	0.0000
M2	4.05E-07	1.41E-07	2.86817*	0.0141
M2(-6)	1.46E-06	6.18E-07	2.358247*	0.0362
M2(-7)	1.74E-06	5.81E-07	2.989712*	0.0113
M2(-8)	1.95E-06	6.05E-07	3.229176*	0.0072
M2(-9)	2.13E-06	6.47E-07	3.293434*	0.0064
M2(-10)	2.03E-06	6.72E-07	3.019429*	0.0107
M2(-11)	2.69E-06	6.79E-07	3.968254*	0.0019
M2(-12)	2.04E-06	6.90E-07	2.960292*	0.0119
M2(-13)	2.08E-06	6.52E-07	3.191202*	0.0078
R-squared	0.984085	Mean dependent var	11.759	
Adjusted R-squared	0.903181	S.D. dependent var	3.6638	

*Denotes significant at 5%; **Source:** Author's Computations

The result of the ARDL model as presented in table 7⁴ indicates the length of time (measured in months) it takes changes in M2 to transmit directly to INF. The M2 was lagged backward to a period of five years (sixty months) however, only the lag periods with significant estimates are reported. All the estimated coefficients are positively signed, suggesting that money supply and inflation move in the same direction. This supports Fisher's quantity theory of money that increases in money supply, all other things being equal, increases inflation in an economy. The results in table 7 shows that the instant multiplier (M2) is significant, implying that a change in broad money supply (M2) has the tendency of transmitting instantly to the economy and have a significant impact on inflation in Nigeria. However, even if the monetary impulse arising from a change in M2 will delay for about five months from M2(-1)) to M2(-5)) before transmitting to inflation with significant impact at M2(-6)) in the first horizon. The significant impact of M2 on inflation was sustained for the next seven months in the second horizon. The result suggests that M2 has a shorter lag length in the transmission of a monetary impulse to inflation when compared with MPR in this study.

Table 8: ARDL Result of Length of Transmission lag from Changes in MPR Direct to Inflation (INF)

<i>Dependent variable: INF</i>				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.401989	4.096769	0.586313	0.5685
MPR(-10)	-1.462881	0.403175	-3.62840	0.0035
MPR(-11)	-1.714069	0.409497	-4.185794	0.0013
MPR(-12)	-1.857662	0.372054	-4.992993	0.0003
MPR(-13)	-1.684440	0.369005	-4.564812	0.0006
MPR(-14)	-1.771310	0.376647	-4.702840	0.0005
MPR(-15)	-2.166830	0.378901	-5.718722	0.0001
MPR(-16)	-2.066779	0.392704	-5.262948	0.0002
MPR(-17)	-1.960238	0.374638	-5.232345	0.0002
MPR(-18)	-1.870487	0.429416	-4.355887	0.0009
MPR(-51)	-1.478205	0.621429	-2.37872*	0.0348
R-squared	0.990345	Mean dependent var		11.759
Adjusted R-squared	0.941268	S.D. dependent var		3.6638
F-statistic	20.17919	Durbin-Watson stat		1.1467

Source: Author's Computations * denotes significant at 5%

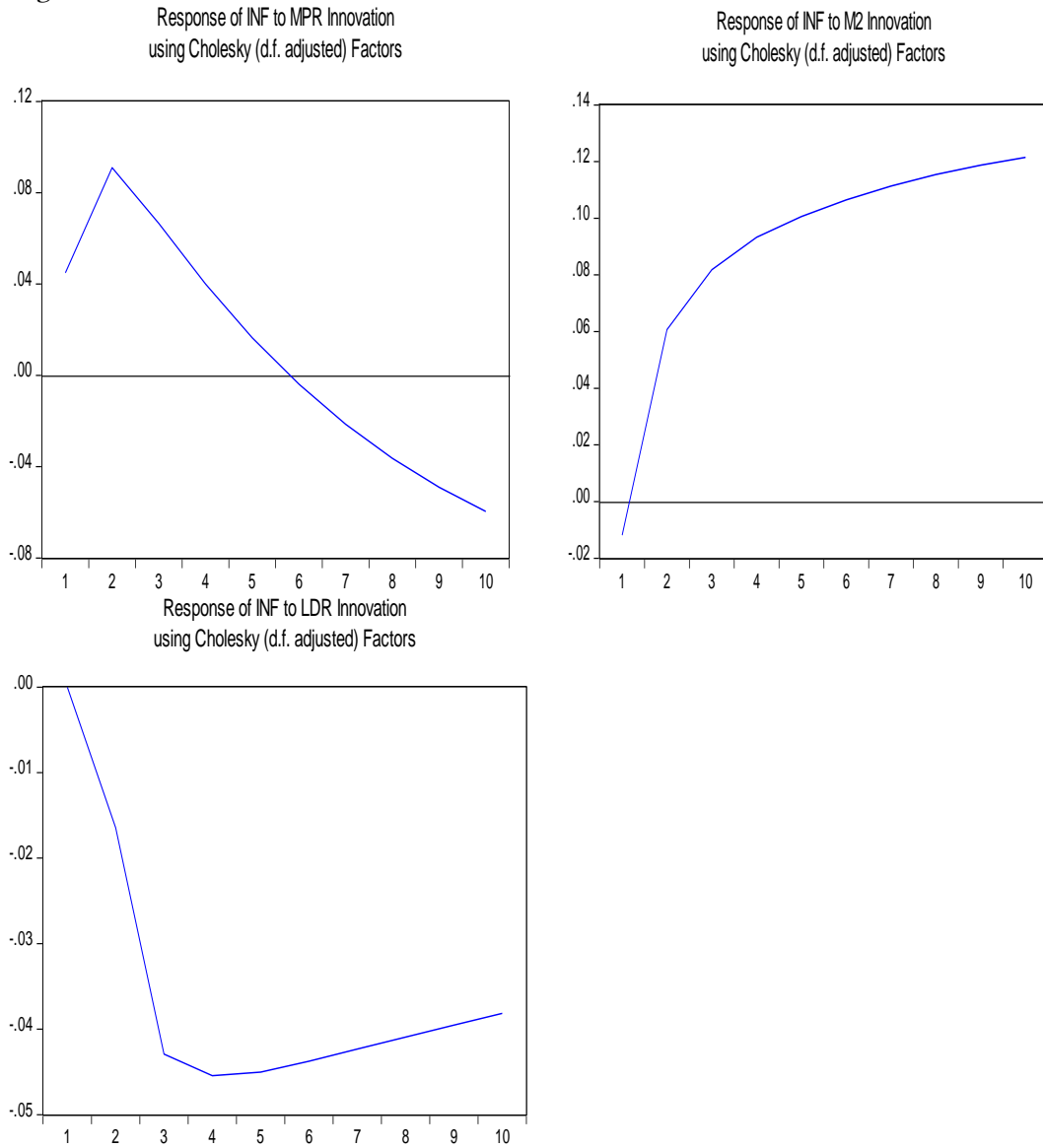
⁴ For detailed result of transmission lag from changes in MPR to Inflation see table 7 (complete) in Appendix.

The result of the ARDL model as depicted in table 8⁵ indicates the length of time it takes changes in the monetary policy rate (MPR) to transmit directly to inflation (INF). MPR was lagged to a period of five years (sixty months) however, only the lag periods with significant estimates are reported in table 8. In Nigeria, the connection between the MPR and inflation is the kernel of monetary policy. This is because if changes in inflation follow the dictates of the MPR then, monetary policy implementation would be adjudged a success, and a failure if otherwise (Mbutor, Izuchukwu & Sunday, 2011). All the estimated coefficients in table 8 are negatively signed, suggesting that MPR is inversely related to inflation. As expected, increase in MPR causes a contraction in M2, which in turn increases market rates and ultimately reduces inflation. This relationship was established in earlier sections where it was shown that the change in MPR has a certain effect on the interbank rate and money supply. Table 8 also reveals that the transmission of the change in MPR to the economy takes a period of 10 months in the first horizon to have a significant impact on inflation. The significant impact was sustained for the next 8 months from D(MPR(-11)) to MPR(-18)) in the second horizon but delays for about 33 months MPR(-19)) to MPR(-50)) in the third horizon before having significant impact on inflation at MPR(-51)).

5.3 Transmission Pass-through from Monetary policy Variables to Inflation in Nigeria

To measure transmission pass-through from monetary policy to inflation and hence, the response of inflation to shocks arising from changes in monetary variables, the impulse response functions (IRF) was used. The IRF traces out the effect over time on the endogenous variable (inflation) of a structural one standard deviation shock to the exogenous variables (monetary policy variables). Zubair et al. (2013) and Sanusi (2010) defines pass-through to the endogenous variable over T periods as the accumulated effect of a structural one standard deviation shock to the exogenous variable in period t. In this study, the accumulated responses measure the effects of MPR, M2 and LDR on inflation level. The estimated IRF is shown in table 9.

Figure 4: Graph of Accumulated Impulse Response of Transmission Pass-through to INF in Nigeria



⁵For detailed result of transmission lag from changes in MPR to Inflation see table 8 (complete) in Appendix.

Table 9: Accumulated Impulse Response of Transmission Pass-through to Inflation in Nigeria

Months shock (1)	After INF (2)	LDR (3)	M2 (4)	MPR (5)
T = 1	0.902450	0.000000	0.000000	0.000000
T = 5*	0.733882	-0.069222	0.048027	-0.054476
T = 10	0.564296	-0.064937	0.085643	-0.098414
T = 15	0.438565	-0.058657	0.105021	-0.116332
T = 20 **	0.343903	-0.051650	0.113279	-0.119023
T = 25***	0.271568	-0.044643	0.114934	-0.113246
T = 30	0.215528	-0.038034	0.112829	-0.103170
T = 35	0.171566	-0.032019	0.108730	-0.091318
T = 55	0.067957	-0.014475	0.088343	-0.047342
T = 60	0.053019	-0.011520	0.083828	-0.038962
T = 65	0.040776	-0.009017	0.079727	-0.031695
T = 70	0.030711	-0.006905	0.076032	-0.025453
T = 75	0.022421	-0.005130	0.072718	-0.020131
T = 80	0.015584	-0.003642	0.069751	-0.015618
T = 85	0.009942	-0.002399	0.067093	-0.011808
T = 90	0.005287	-0.001362	0.064708	-0.008605
T = 95	0.001451	-0.000501	0.062559	-0.005921
T = 100	-0.001708	0.000212	0.060616	-0.003678
T = 105	-0.004302	0.000802	0.058850	-0.001810
T = 110	-0.006426	0.001287	0.057237	-0.000259
T = 115	-0.008158	0.001684	0.055755	0.001025
T = 120	-0.009565	0.002007	0.054386	0.002084
T = 125	-0.010699	0.002269	0.053115	0.002953
T = 130	-0.011606	0.002480	0.051927	0.003664
T = 135	-0.012323	0.002647	0.050812	0.004241
Structural SD	1.842481			1.842481

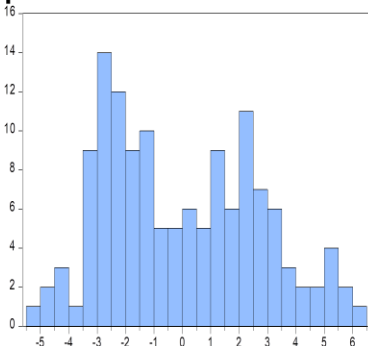
SD: standard Deviation; * Full impact for LDR; ** Full impact for MPR; *** Full impact for M2;

Source: Author's Computations

Figure 4 and table 9 show the impulse response functions (IRF) of transmission pass-through from monetary policy variables (M2, LDR, MPR) to inflation in Nigeria. The result shows that at T = 1 (first month), the immediate effect of a structural one standard deviation shock of MPR, M2 and LDR to inflation about 0.000%. This could be seen both in figure 4 and table 9. This implies that monetary policy measures through change in MPR, M2 and LDR do not transmit immediately to inflation in Nigeria. It delays for sometimes, taking MPR, M2 and LDR about 20 months, 25 months and 5 months respectively, to reach their full impacts, as could be seen in column 5, column 4 and column 3 of table 9. At the points where the variables have their full impacts, a structural one standard deviation shock to MPR is about 11.9 % decrease in inflation, 11.5 % decrease in inflation for M2 and 6.9 % decrease in inflation for LDR. Overall, the result suggests that it takes changes in MPR about 20 months, M2 about 25 months and LDR about 5 months to transmit fully to inflation in Nigeria.

Table 10: Post-Estimation Statistics

Autoregressive Conditional Heteroskedasticity (ARCH) Test			
F-statistic	0.778	Prob. F(20,33)	0.719
Obs*R-squared	1.731	Prob. Chi-Square(20)	0.633
Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	2.949	Prob. F(1,11)	0.114
The result of the ARDL model as presented in table 6 ¹ indicates			
Obs*R-squared	15.65	Prob. Chi-Square(1)	0.000



Series: Residuals	
Sample 2007M01 2018M03	
Observations 135	
Mean	-1.87e-15
Median	-0.368315
Maximum	6.072359
Minimum	-5.476703
Std. Dev.	2.730358
Skewness	0.288752
Kurtosis	2.161934
Jarque-Bera	5.826746
Probability	0.054292

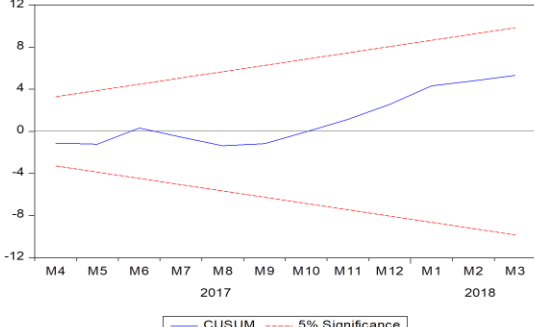


Figure 5: test of normality

Figure 6: test of stability

Source: Author's Computations

The post estimations statistics reported in table 10 shows that the probability value for the test of autocorrelation is 0.719, suggesting the acceptance of the null hypothesis of no autocorrelation in the model. Similarly, the probability value for the test of heteroskedasticity is 0.114 implying that the null hypothesis of absence of heteroskedasticity in the model cannot be rejected. Furthermore, the normality plot reported in figure 5 shows that the Jarque-Bera value and its probability are 5.827 and 0.0543, respectively. Hence, the null hypothesis that the error terms of the data used in the study are normally distributed cannot be rejected. Furthermore, the result passed the test of stability as the CUSUM plot in figure 6 was within the 5% critical lines. Therefore, it could be concluded that the estimated parameters for the study are stable for the period under review.

5.4 Discussions of Findings

Findings from this study reveal that monetary policy actions taken by the CBN to address inflationary pressures do not transmit instantly to affect inflation in Nigeria. Instead, the policy's effect on inflation lagged behind for sometimes before it is noticed. This is evident in the estimated results of the ARDL models. For example, the ARDL model shows that monetary impulse is transmitted from MPR to M2 after lagging behind for about 3 months for each of the first, second and third horizons. Beyond the third horizon, the lag length varies, and the length of the variability increases and decreases across the subsequent horizons. The results also show that the length of transmission of monetary impulse from M2 to INF is shorter than from MPR to M2. This implies that a change in broad money supply (M2) has the tendency of transmitting faster to the economy than MPR in Nigeria. Furthermore, it takes a change in MPR about 10 months in the first horizon to transmit directly to the economy to have a significant impact on inflation. The significant impact was sustained for the next 8 months in the second horizon but delays for about 33 months in the third horizon before having significant impact on inflation in Nigeria. Furthermore, the result of accumulated impulse response function reveals that the full impact of a shock of monetary policy transmission on inflation is realized only after delaying for different periods across MPR, M2 and LDR. For example, it takes changes in MPR about 20 months, changes in M2 about 25 months and changes in LDR about 5 months to respond fully to inflation in Nigeria.

The finding has both theoretical and practical underpinnings. Theoretically, it validates the Keynesian versus Monetarists debate that the effect of monetary policy on an economy is gradual and persistent but can be stimulated when combined with fiscal policy. The results also support Friedman (1960) that monetary policy transmits to the economy only after a long and variable lag. The result explains why the use of MPR as policy variable by the CBN has not been responding as quickly as possible to policy target.

However, broad money supply (M2) has the tendency of transmitting faster to the economy and subsequently affect inflation in Nigeria. This is because M2 has shorter lag length in the transmission of monetary impulse to inflation than MPR in this study. More so, the result of IRF reveals that monetary transmission pass-through to inflation is small and incomplete because the estimated coefficients for all the periods investigated are less than unity. The small transmission pass-through to inflation implies that the response of inflation to changes in MPR and M2 is significantly small in Nigeria.

6.0 CONCLUSION AND POLICY RECOMMENDATIONS

In 2006 the Central Bank of Nigeria introduced the new monetary policy operating framework with Monetary Policy Rate assuming the role of Anchor rate. The aim of the new framework is to enhance efficiency in the conduct of monetary policy in Nigeria. This paper undertakes a review of the performance of this policy after a decade and half of its existence. The findings from the study reveal that changes in MPR does not transmit instantly to inflation but does so only after delaying for sometimes (lag). This agrees with the monetarists' view that monetary transmission process is always associated with lag or delay. However, with regards to the exact length of time (lag) it takes monetary policy to transmit to inflation, different results were obtained across different horizons. For example, it takes a change in MPR about 3 months for each of the first, second and third horizons to transmit impulse to M2 while the length of time varies across the subsequent horizons. The length of transmission from M2 to inflation is shorter than from MPR to M2. Furthermore, the result of accumulated impulse response function reveals that the full impact of a shock of monetary policy transmission from MPR to inflation is realized only after delaying for about 20 months while changes in M2 takes about 25 months and changes in LDR takes about 5 months to respond fully to inflation in Nigeria. The negative coefficient of MPR and LDR suggest that monetary policy measures

through changes in MPR and LDR decrease inflation by about 11 per cent and 6.9 per cent respectively, but delays for about 20 months for MPR and about 5 months for LDR, before impacting on inflation. This uncertainty about the timing of monetary policy lag corroborates Ha (1999). Furthermore, unlike MPR, broad money supply (M2) has the tendency of transmitting faster to the economy to affect inflation in Nigeria. The implications of the findings are that monetary policy has the potential of making an economy recover from inflationary pressure. However, very long transmission lag undermine the effectiveness of monetary policy, thus, the study recommend that the operating framework be streamlined to ensure the attainment of short transmission lag from the MPR to the ultimate target (inflation). Finally, our mixed result about the exact length of lag in transmission of monetary policy suggests the need for more empirical studies to have enough information on transmission lags of monetary policy in Nigeria.

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APPENDIX

Table 1 (Complete): Length of Transmission lag from Changes in M2 Direct to Inflation (INF)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-17.15438	1.811051	-9.472057	0.0000
M2	4.05E-07	1.41E-07	2.86817*	0.0141
D(M2(-6))	1.46E-06	6.18E-07	2.358247*	0.0362
D(M2(-7))	1.74E-06	5.81E-07	2.989712*	0.0113
D(M2(-8))	1.95E-06	6.05E-07	3.229176*	0.0072
D(M2(-9))	2.13E-06	6.47E-07	3.293434*	0.0064
D(M2(-10))	2.03E-06	6.72E-07	3.019429*	0.0107
D(M2(-11))	2.69E-06	6.79E-07	3.968254*	0.0019
D(M2(-12))	2.04E-06	6.90E-07	2.960292*	0.0119
D(M2(-13))	2.08E-06	6.52E-07	3.191202*	0.0078
D(M2(-14))	2.68E-06	7.04E-07	3.811232*	0.0025
D(M2(-15))	2.92E-06	7.91E-07	3.684284*	0.0031
D(M2(-16))	3.53E-06	7.23E-07	4.882387*	0.0004
D(M2(-17))	4.28E-06	6.81E-07	6.276927*	0.0000
D(M2(-18))	3.85E-06	7.49E-07	5.135633*	0.0002
D(M2(-19))	3.31E-06	7.72E-07	4.283183	0.0011
D(M2(-20))	2.97E-06	7.58E-07	3.921477	0.0020
D(M2(-21))	3.40E-06	7.93E-07	4.282538	0.0011
D(M2(-22))	4.06E-06	8.37E-07	4.843630	0.0004
D(M2(-23))	3.36E-06	7.70E-07	4.365388	0.0009
D(M2(-24))	3.66E-06	8.00E-07	4.579078	0.0006
D(M2(-25))	4.40E-06	6.61E-07	6.659565	0.0000
D(M2(-26))	4.51E-06	6.46E-07	6.986925	0.0000
D(M2(-27))	4.20E-06	6.61E-07	6.353105	0.0000
D(M2(-28))	3.97E-06	6.81E-07	5.821895	0.0001
D(M2(-29))	3.28E-06	6.49E-07	5.043881	0.0003
D(M2(-30))	3.17E-06	6.75E-07	4.694907	0.0005
D(M2(-31))	3.23E-06	6.70E-07	4.815552	0.0004
D(M2(-32))	3.12E-06	6.48E-07	4.813711	0.0004
D(M2(-33))	3.17E-06	6.53E-07	4.861228	0.0004
D(M2(-34))	2.67E-06	6.82E-07	3.922667	0.0020
D(M2(-35))	2.69E-06	6.33E-07	4.252779	0.0011
D(M2(-36))	2.84E-06	7.00E-07	4.061970	0.0016
D(M2(-37))	2.52E-06	7.81E-07	3.232764	0.0072
D(M2(-38))	1.69E-06	6.84E-07	2.474802	0.0292
D(M2(-39))	2.16E-06	9.47E-08	0.228358	0.4140
D(M2(-42))	1.97E-06	8.72E-07	2.263513	0.0429
D(M2(-46))	3.01E-06	9.77E-07	3.078763	0.0096
D(M2(-47))	2.59E-06	7.67E-07	3.372732	0.0055
D(M2(-48))	2.81E-06	7.50E-07	3.744090	0.0028
D(M2(-49))	2.83E-06	7.20E-07	3.930683	0.0020
D(M2(-50))	2.51E-06	7.17E-07	3.506000	0.0043
D(M2(-51))	2.90E-06	7.77E-07	3.737214	0.0028
D(M2(-60))	2.16E-06	7.85E-07	2.746252	0.0177
R-squared	0.984085	Mean dependent var		11.759
Adjusted R-squared	0.903181	S.D. dependent var		3.6638

Source: *eviens 9 Output*; * denotes significant at 5%

Table 2 (Complete): Length of Transmission lag from Changes in MPR Direct to Inflation (INF) Dependent variable: INF

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.401989	4.096769	0.586313	0.5685
D(MPR(-10))	-1.462881	0.403175	-3.62840	0.0035
D(MPR(-11))	-1.714069	0.409497	-4.185794	0.0013
D(MPR(-12))	-1.857662	0.372054	-4.992993	0.0003
D(MPR(-13))	-1.684440	0.369005	-4.564812	0.0006
D(MPR(-14))	-1.771310	0.376647	-4.702840	0.0005
D(MPR(-15))	-2.166830	0.378901	-5.718722	0.0001
D(MPR(-16))	-2.066779	0.392704	-5.262948	0.0002
D(MPR(-17))	-1.960238	0.374638	-5.232345	0.0002
D(MPR(-18))	-1.870487	0.429416	-4.355887	0.0009
D(MPR(-19))	-1.968938	0.390388	-5.043547	0.0003
D(MPR(-20))	-2.196554	0.451508	-4.864932	0.0004
D(MPR(-21))	-2.163066	0.498765	-4.336845	0.0010
D(MPR(-22))	-2.157191	0.513229	-4.203174	0.0012
D(MPR(-23))	-2.554658	0.577620	-4.422735	0.0008
D(MPR(-24))	-2.570458	0.518691	-4.955659	0.0003
D(MPR(-25))	-2.118381	0.669260	-3.165261	0.0081
D(MPR(-26))	-1.805330	0.612872	-2.945688	0.0122
D(MPR(-27))	-1.955067	0.627899	-3.113668	0.0090
D(MPR(-28))	-1.602742	0.652282	-2.45713	0.0302
D(MPR(-35))	-1.111782	0.516990	-2.150491	0.0526
D(MPR(-36))	-1.168321	0.491579	-2.37667	0.0350
D(MPR(-37))	-1.551001	0.470869	-3.293912	0.0064
D(MPR(-38))	-1.553245	0.523983	-2.964305	0.0118
D(MPR(-39))	-1.714820	0.482672	-3.552763	0.0040
D(MPR(-40))	-1.564434	0.563691	-2.775341	0.0168
D(MPR(-41))	-1.694666	0.445352	-3.805228	0.0025
D(MPR(-42))	-1.516359	0.472497	-3.209247	0.0075
D(MPR(-43))	-1.553172	0.459712	-3.378573	0.0055
D(MPR(-44))	-1.343702	0.473040	-2.840567	0.0149
D(MPR(-45))	-1.300266	0.418425	-3.107521	0.0091
D(MPR(-46))	-1.388826	0.446297	-3.111889	0.0090
D(MPR(-47))	-1.306788	0.403859	-3.235753	0.0071
D(MPR(-48))	-1.328579	0.413461	-3.213309	0.0074
D(MPR(-49))	-1.103203	0.405173	-2.722795	0.0185
D(MPR(-50))	-1.306694	0.515675	-2.533951	0.0262
D(MPR(-51))	-1.478205	0.621429	-2.37872*	0.0348
R-squared	0.990345	Mean dependent var		11.759
Adjusted R-squared	0.941268	S.D. dependent var		3.6638
F-statistic	20.17919	Durbin-Watson stat		1.1467

Source: Author's Computations; * denotes significant at 5%