A Polynomial Regression Model of Monetary Policy Rate in Nigerian Economy

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Abstract
This study examined the impact of monetary policy on economic growth in Nigeria. In the model specified, money supply, currency in circulation and lending are the Jointly Determined variables while monetary policy rate (MPR), the Pre-determined variable .The result indicates that the currency in circulation is the only significant factor with monetary policy rate while the duo of money supply and lending have not been impacted on significantly by Monetary policy. MPR was found to be effectively guided by monetary policy instrument than money supply and lending. This is based on the fact that monetary policy react more to change in currency in circulation than it does to money supply and lending in Nigerian money market .Thus the polynomial regression model statistic of t-value, Pr(|t|),Multiple R-squared, F-statistic and P-value showed that the best fitted model for monitoring effectiveness of monetary policy is currency in circulation. In the light of this, the effectiveness of monitoring monetary policy in Nigeria maybe promoted by keeping a tab on currency in circulation as against other monetary target variables.

Keywords: Monetary Policy, Currency in circulation, Lending, Polynomial Regression, Money Supply

Introduction
Statistics are crucial in determining the economic growth of the country in knowing the performance and effectiveness of economy. Monetary policy as the name implies is one of the major economic stabilization weapons which involve the measures designed to regulate and control the volume, cost, availability and direction of money and credit in the economy to achieve some specific macro-economic policy objective. It is a deliberate attempt by the monetary authority (Central Bank) to control the money supply and credit condition for the purpose of achieving certain broad economic growth.

Klein,1992 defined MPR as a rule and regulations imposed by the monetary authority into controlling the money supply, inflation and achieve economic growth. The Central Bank of Nigeria (2006) defines monetary policy as that which deal with the terms condition under which money and credit are provided to the economy by the monetary authority.

Several authors have researched into the link between monetary policy instruments and commercial banks activities. However, they failed to incorporate or establish direct link between monetary policy tools in analyzing the effect of macroeconomic stability such as banks' lending activities, money supply, currency in circulation etc. Gertler and Gilchrist

(1994) conducted a study that specifically looked at how bank business lending responds to monetary policy tightening. Their study reveals that business lending does not decline when policy is tightened. In contrast to Gertler and Gilchrist (1994) study, Kashyap and Stein (1995) find evidence that business lending may respond to a tightening of monetary policy. They find that when policy is tightened, both total loans and business loans at small banks fall, while loans at large banks are unaffected. The differential response of small banks may indicate they have less access to alternative funding sources than large banks and so are less able to avoid the loss of core deposits when policy is tightened. Gambacorta and Lannoti (2005) investigated the velocity and asymmetry in response of bank interest rates (lending, deposit, and inter-bank) to monetary policy shocks (changes) in Italy from 1985-2002 using an Asymmetric Vector Correction Model (AVECM) that allows for different behaviours in both the short-run and long-run. Van den Heuvel (2005) argued that monetary policy affects bank lending through two channels. They argued that by lowering bank reserves, contractionary monetary policy reduces the extent to which banks can accept reservable deposits, if reserve requirements are binding. The decrease in reservable liabilities will, in turn, lead banks to reduce lending, if they cannot easily switch to alternative forms of finance or liquidate assets other than loans. Punita and Somaiya (2006) investigated the impact of monetary policy on the profitability of banks in India between 1995 and 2000. The monetary variables are banks rate, lending rates, cash reserve ratio and statutory ratio, and each regressed on banks profitability independently. Lending rate was found to exact positive and significant influence on banks' profitability, which indicates a fall in lending rates will reduce the profitability of the banks. Also, bank rate, cash reserve ratio and statutory ratio were found to have significantly affect profitability of banks negatively. Their findings were the same when lending rate, bank rate, cash reserve ratio and statutory ratio were pooled to explain the relationship between bank profitability and monetary policy instruments in the private sector. Amidu and Wolfe (2008) examined the constrained implication of monetary policy on bank lending in Ghana between 1998 and 2004. There study revealed that Ghanaian banks lending behaviour are affected significantly by the country's economic support and change in money supply. A similar study was conducted for Ghana by Mohammed and Simon (2008). The work of Somoye and Ilo (2009), on the impact of macroeconomic instability on the banking sector lending behaviour in Nigeria between 1986 to 2005, also revealed the mechanism transmission of monetary policy stocks to banks operation. The result of co integration and Vector Error correction showed that there exist a long-run relationship between bank lending and macroeconomic instability. Younus and Akhta (2009) examined the significance of Statutory Liquidity Requirement (SLR) as a monetary policy instrument in Bangladesh. Using descriptive analysis techniques like trend analysis and summary statistics, they found that statutory liquidity requirement has experienced infrequent changes and past evidence has shown that reduction in SLR produced positive impact on bank credit and investment especially prior to the 1990s. One of the major objectives of monetary policy in Nigeria is price stability. But despite the various monetary regimes that have been adopted by the central bank of Nigeria over the years, inflation still remains a major threat to Nigeria's economic growth. Nigeria has experienced high volatility in inflation rates, since the early 1970.

In our attempt to monitor effectiveness of monetary policy rate in Nigeria economy, we employ a statistical tool known as Polynomial Regression Model. Polynomial regression

model is a form of linear regression in which the relationship between the independent variable X and dependent variable Y is modeled as an n^{th} order polynomial. Polynomial regression models are special cases of the general linear regression or multiple regression models (Neter etal, 1996). They contain squared and higher order terms of predictor variables making the response function curvilinear. Thus, a polynomial model of order 2 is given as:

$$Y_i = \beta_0 + \beta_1 X_i + \beta_2 X_i^2 + \boldsymbol{\varepsilon} \quad \textbf{(1)}$$

The three econometrics models used in this research to capture the effectiveness of implementation and monitoring of monetary policy rate in Nigeria Economy are as follows:

$$Ms = f(MPR) + \boldsymbol{\varepsilon}_i \quad (2)$$

$$L = f(MPR) + \boldsymbol{\varepsilon}_i \quad (3)$$

$$C = f(MPR) + \boldsymbol{\varepsilon}_i \quad (4)$$

Polynomial regression models of order 2 from the above equations, when written in explicit form becomes,

$$Ms = \beta_0 + \beta_1 MPR + \beta_2 MPR^2 + \boldsymbol{\varepsilon}_i \quad (5)$$

$$L = \beta_0 + \beta_1 MPR + \beta_2 MPR^2 + \boldsymbol{\varepsilon}_i \quad (6)$$

$$C = \beta_0 + \beta_1 MPR + \beta_2 MPR^2 + \boldsymbol{\varepsilon}_i \quad (7)$$

Where β_0, β_1 and β_2 are estimable Parameters; Ms, L, C and MPR represent money supply, lending, currency in circulation and monetary policy rate respectively.

Materials and Methods

To analyze the data collected, polynomial models of order 1, order 2 and order 3 are employed. The polynomial model assumed squared and higher-order terms of the predictor variable(s), making the response function curvilinear as given below:

$$Y_i = \beta_0 + \beta_1 X_i + \beta_2 X_i^2 + \boldsymbol{\varepsilon}_i \quad (8)$$

Despite the curvilinear nature of the response function for the regression model in equation (8), it is a special case of the general linear regression model as shown below

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots\ldots + \beta_{P-1} X_{i,P-1} + \boldsymbol{\varepsilon}_i \quad (9)$$

Where β_0, β_1, $\beta_{2,\ldots..}$, β_{P-1} are parameter,X_{i1}, X_{i2},….., $X_{i,P-1}$ are independent variables and $\boldsymbol{\varepsilon}_i$ independently identically distributed with (o, δ^2_i). Model (9) can be stated as

$$Y_i = \beta_0 X_{i0} + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots\ldots + \beta_{P-1} X_{i,P-1} + \varepsilon_i \quad (10)$$

where $X_{i0} = 1$ or $Y_i = \sum_{K=0}^{P=1} \beta_k X_{ik} + \varepsilon_i$ with $X_{i0} = 1$

Therefore the response function for regression model (9) is

$$E(Y) = \beta 0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_{P-1} X_{,P-1} \quad (11)$$

Where $E(\varepsilon_i) = 0$,

if we let $X_{i1} = X_i$ and $X_{i2} = X_i^2$,we can write regression model (8) as

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \varepsilon_i \quad (12)$$

This is the form of general linear regression model (8). While regression model (7) illustrates a curvilinear regression model where the response function is quadratic, model with higher-degree polynomial response functions are also particular cases of the general linear regression model

The polynomial regression model

$$y_i = a_0 + a_1 x_i + a_2 x^2{}_i + \ldots\ldots\ldots + a_m x_i^m + \epsilon_i \quad (I = 1,2,\ldots\ldots,n)$$

can be expressed in matrix form in terms of a design matrix x, a response vector ỹ, a parameter vector ã, and a vector ε_i of random errors. The ith row of x and ỹ will contain the x and y value for the ith data sample. Then the model can be written as a system of linear equations

$$\begin{pmatrix} y_1 \\ y_2 \\ y_3 \\ . \\ . \\ . \\ y_n \end{pmatrix} = \begin{pmatrix} 1 & x_1 & x_1^2 & \ldots\ldots & x_1^m \\ 1 & x_2 & x_2^2 & \ldots\ldots & x_2^m \\ 1 & x_3 & x_3^2 & \ldots\ldots & x_3^m \\ . & . & . & . & . \\ & & & & \\ 1 & x_n & x_n^2 & \ldots\ldots & x_n^m \end{pmatrix} \begin{pmatrix} a_0 \\ a_1 \\ a_2 \\ . \\ . \\ a_m \end{pmatrix} + \begin{pmatrix} c_1 \\ c_2 \\ c_3 \\ . \\ . \\ c_n \end{pmatrix} \quad (13)$$

which when using pure matrix notation, it is written as

$$\tilde{y} = X\,\tilde{a} + \varepsilon_i \quad (14)$$

The vector of estimated polynomial regression coefficient (using ordinary least squares estimation) is

$\grave{a} = (X^T X)^{-1} X^T \tilde{y}.$
(15)

This is the unique least squares solution as long as x has linearly independent columns. Since 'x' is a vandermonde matrix, this is guaranteed to hold provided that at least m+1 of the x_i are distinct (for which m<n is a necessary condition).

When polynomial regression involves only one predictor (independent) variable with order two, it is called one predictor variable second order. E.g

$$Y_i = \beta_0 + \beta_1 X_i + \beta_2 X_i^2 + \boldsymbol{\varepsilon}_i \quad (16)$$

The above polynomial model is called a second-order model with one predictor variable because the single predictor variable is expressed in the first and second powers.

$$E(Y_i) = \beta_0 + \beta_1 X_i + \beta_2 X_i^2 \quad (17)$$

Where $x_i = X_i - X$

When it involves only one predictor with order 3, it is called one predictor variable – third order

$$Y_i = \beta_0 + \beta_1 X_i + \beta_2 X_i^2 + \beta_3 X_i^3 + \boldsymbol{\varepsilon}_i \quad (18)$$

Where $x_i = X_i - X$

When it involves two predictors with order 2, it is called two predictor variables-second orders. The regression model is

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2}^2 + \beta_{11} X_{i1}^2 + \beta_{22} X_{i2}^2 + \beta_{12} X_{i1} X_{i2} + \boldsymbol{\varepsilon}_i \quad (19)$$

Where $x_{i1} = X_{i1} - X_1$ and $x_{i2} = X_{i2} - X_2$

$$E(Y_i) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_{11} X_1^2 + \beta_{22} X_2^2 + \beta_{12} X_1 X_2 \quad (20)$$

Results

The data used in this research are eleven (11) years information on Monetary Policy Rate (MPR), Money Supply, Currency in circulation and Lending by Commercial Banks as published by the Central Bank of Nigeria between years 2002- 2012. The Polynomial regression models fitted into the data are order 1, order 2 and order 3; and their measures of validity were tabulated as follows:

Table 1: Fitting of polynomial regression model for money supply.

Statistic	Order 1	Order2	Order 3
R^2	**0.01746**	**0.0583**	0.0696
F-test	**0.16**	**0.2474**	0.1746
P-value	**0.6985**	**0.7866**	0.9103
Standard error	**111900000**	**11620000**	123500000

The models fitted from the above table are

$Ms = 190157061 + 3656123MPR_1$ (21)

$Ms = 416773584 - 45390481MPR_1 + 1739231MPR_1^2$ (22)

$Ms = 21697621 + 66887427MPR_1 – 8207442MPR_1^2 + 277301MPR_1^3$ (23)

Table 2: Fitting of polynomial regression model for currency in circulation

Statistic	Order 1	Order2	Order 3
R^2	**0.5487**	**0.5824**	0.6007
F-test	**10.94**	**5.579**	3.51
P-value	**0.009118**	**0.0304**	0.0077
Standard error	**3226000**	**3292000**	3441000

The models fitted into the above table are:

$C = 20291978 – 871445MPR_1$ (24)

$C = 11524127 + 3268MPR_1 – 67291MPR_1^2$ (25)

$C = -9765577 + 6793658MPR_1 – 603294MPR_1^2 + 14943MPR_1^3$ (26)

Table 3: Fitting of polynomial regression model for lending

Statistic	Order 1	Order2	Order 3
R^2	**0.2849**	**0.2948**	0.2989
F-test	**3.586**	**1.672**	0.9948
P-value	**0.09079**	**0.2473**	0.4491
Standard error	**89140000**	**93890000**	100100000

The fitted models are:

$L = 27720000 + 1378000MPR_1$ (27)

$L = 173219201 + 5355845MPR_1 – 797659MPR_1^2$ (28)

$L = 395172172 – 57721684MPR_1 + 4790366MPR_1^2 – 155787MPR_1^3$ (29)

Discussion

All the fitted models show linear, quadratic and polynomial relationship between the MPR and each of the money market factors (Ms, C and L) considered in this research. According to table 1, the three models of order 1, 2 and 3 fitted for Money supply are not significant based on their respective P-values of 0.6985, 0.7866 and 0.9103 which are far above a

significant value of 0.05. Their relatively low coefficient of determinations of 1.7%, 5.8% and 6.9% shows a very weak variation in Money supply as accounted for by MPR.
The coefficients of determination (R^2) for the three designated models in table 2 are 54.87%, 58.24% and 60.07% respectively, with respective P-values of 0.009118, 0.0304 and 0.0077 which are reasonably below the acceptable significant level of 0.05.This is an indication of goodness of fit for the Currency in circulation model, with order 3 model being the best fitted at 60.07% variation accounted for by MPR.
Table 3 present the results of the Lending models, and all the results pointed to the fact that Lending in Nigeria commercial Banks have not been impacted significantly by different MPR regimes.

Conclusion

Going by the existing literature, including the ones reviewed in this study, there seems to be an in exhaustive work
on Monetary Policy Rates with special reference to Nigeria economy. In recent times, policy makers in most part of the globe has taken the problem of MPR very seriously due its overriding effect on inflation and in fact have considered it as a major obstacles in their wheels of progress.
With Nigeria's population currently put at over 160 million people compared with Gross Domestic Product (GDP) that is not too encouraging and inflation still sky-rocketing, there is the fear that future living standards may substantially depreciate if adequate checks are not put in place to keep the country's inflation within the acceptable minimum. From the Polynomial regression analysis carried out, it can be reasonably concluded that only Currency in circulation, among other factors of Money Supply and Lending has been mostly impacted by different MPR regimes. Putting timely checks on Currency in circulation by the Central Bank of Nigeria has been one of the effective ways of controlling inflation in Nigeria, and this is what our models 24, 25 and 26 have explained to a reasonable degree of acceptability. Equation 26 (i.e order 3 model of Currency in circulation), being the best fitted, explained the variation of 60.07% in' Currency in circulation' as accounted for by the different regimes of MPR. The remaining variation of 39.93% not accounted for by MPR may be due to other monetary policies not considered in this research.

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