MONETARY POLICY REACTION FUNCTION OF THE CENTRAL BANK OF NIGERIA: A NONLINEAR APPROACH

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DECLARATION

Ihereby declare that the work in this dissertation titled, *"*MONETARY POLICY REACTION FUNCTION OF THE CENTRAL BANK OF NIGERIA: A NONLINEAR APPROACH*"* has been carried out by me in the Department of Economics Ahmadu Bello University, under the supervision of Dr. Aliyu Rafindadi Sanusi and Dr. Lawong Damian Bernsah. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at this or any other institution.

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CERTIFICATION

This dissertation titled, "MONETARY POLICY REACTION FUNCTION OF THE CENTRAL BANK OF NIGERIA: A NONLINEAR APPROACH" by MUDI, Salisu meets the regulations governing the award of the degree of Master of Science (M.Sc.) Economics of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This dissertation is dedicated to my parent AlhajiMahmud (Mudi) Bauchi and late Hajiya Salamatu Usman cradle inspiration and multidimensional support in my life. May Almighty Allahu (SWA) reward you and bless your descendants, amin.

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Abstract

Empirical evidence shows a divergence between the way the Central Bank of Nigeria changes its policy rate in reaction to the variations in macroeconomic variables and the models used to estimate such reaction. This study empirically examined the linearity assumptions, and hence, re-estimates a nonlinear Monetary Policy Reaction Function (MPRF) for the Central Bank of Nigeria (CBN), which was hitherto, variously, estimated using linear method. The study employed quarterly data from 2007Q1 to 2016Q2 to estimate an Exponential Smooth Transition Regression (ESTR) model. Results show that the trend (time horizon) is the transition variable. For comparative purposes, a simple quadratic nonlinear model was estimated, in which the central bank's reaction to changes in exchange rate is assumed to be nonlinear relation. The quadratic model was estimated using the Nonlinear Two Stage Least Square (N2SLS), which appears to strengthen the findings from the ESTR. The results of the ESTR revealed that the MPRF of CBN is empirically nonlinear and that changes in the monetary policy rates do not appear to follow the Taylor's Principle. It was also found that the CBN, as expected, reacts to inflation and exchange rates volatilities quite significantly. The reaction is, however, aggressive when inflation exceeds the threshold value of 10 percent. In addition, it was found that only the current and none of the leads, of inflation was significant. This is interpreted as reflecting the inability of the CBN to correctly forecast inflation beyond the current quarter. Hence, the study recommends that the CBN should focus on developing greater capacity for inflation forecast, which is a critical requirement for a smooth transition to the inflation targeting framework.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Research

The Monetary Policy Reaction Function (MPRF) of the Central Bank of Nigeria (CBN) gives the summary of how the CBN changes its interest rate decision in response to changes in macroeconomic variables relative to some targets. The MPRF with respect to inflation is an upward sloping relationship between the real interest rate and inflation rate. Bernanke & Frank, (2008) also explained MPRF as a relationship between inflation rate and unemployment rate,it summarizes how central banks react to changes in macroeconomic variables. In Nigeria, the actions of the CBN exert substantial influence on the behavior of economic agents and by and large the general performance of the macro-economy. Hence the MPRF is sine qua non for understanding and predicting actual monetary policy action because it provides the means for assessing the current stance as well as forecasting the future path of monetary policy action.

Towards the end of twentieth century, monetary policy objective almost always and everywhere aimed at dampening inflation(MIles & Scott, 2005, p. 377), Nigeria is not an exception. Granting independence to CBN in 2007 and consolidation of commercial banks in 2004 paved a smooth way for the eventualoperation of inflation targeting (IT) in Nigeria (Bello 2014). Under inflation targeting framework, investors will know the targeted inflation rate, and this simplifies their ability to anticipate interest rate changes, and hence, widen their expectation horizon which is important in investment decision and also economic stability.

However, economic activitiesare typically characterized by periods of expansionsand of contractions. These lead to fluctuations in economic activities and policy instability. Hence the

dire need for a regulatory policy or policy fine-tuning. One of the effective measures availableto control these fluctuations or to stabilize the economy is monetary policy (mostly by using the Monetary Policy Rates).The CBN through its Monetary Policy Committee (MPC) conducts monetary policy in Nigeria. The MPC uses the instrument of monetary policy available with the bank to affect the cost and/or supply of money. More often than not, MPC takes monetary decision through adjusting the Monetary Policy Rate (MPR) in an attempt to affect short term interest rate. This is because monetary policy in Nigeria is designed to promote a steady and stable macroeconomic environment for the achievement of non-inflationary output growth, single digit inflation, stability in naira exchange, financial sector soundness and external sector viability through effective control of monetary aggregates(CBN, 2013).

On the other hand, according to Blanchard, Amighini, & Giavazzi, (2010),macroeconomic policy is perceived as a game between the policy makers (CBN in this context) and the economy (people and firms). This is born out of the interaction of policy and the economy not only with currentbut also with future expectation of inflation and changes in output. Thus, expectationis among the significant triggers and drivers of inflation in Nigeria, because more than 40% of inflation in Nigerian economy is driven by expectation (Ahmad, 2012). This necessitated the need for an explicit and quantifiable central bank reaction function that put in to consideration the inter-temporal instrument variation through which a policy rate can be determined using a clear approximation of a set of variables identified in such a reaction function, (Agu, 2011). The MPRF will enable the prediction of actual policy action and also provide a means for assessing the future path of monetary policy action.

On the policy part, one of the four major pillars CBN anchors its monetary policy is“proactive and rule based”.This is in line with the fact that, monetary policy in Nigeria is anchored on four

pillars, which are; (i) the monetary policy to be proactive and rule based, (ii) inflation as a monetary phenomenon, (iii) public expectation of future inflation is considered in setting prices and wages and (iv)The independence of CBN to conduct monetary policy without control of the political authority (CBN 2011p.8). But there are doubts about the extent to which these describe monetary policy in Nigeria(Bello, 2014 and Siri, 2009). Thus, this is still open for further investigation.The said proactive and rule basedpolicy making is captured in Taylor's rule which said for monetary policy to stabilize prices,nominal interest rate must be raised more than the level of inflation.

However, the reaction function of Central Bank of Nigeria has been estimated by different studies using different approaches. Most of these studies estimated a Taylor-type reaction function (See for instance the studies of Bello, 2014;Tolulope and Ajilore, 2013; Agwu, 2007; and Ogli, 2008). This is anaftermath ofthe work of J.B. Taylorwhich paved a new route in the study of monetary economics(Taylor, 1993). The Taylor rule becomes almost pervasively acceptable in both developed and developing countries due to its efficiency, simplicity and capability in tracking historical monetary policy.

Furthermore, it is also evidencedthat the CBN reaction function has been estimatedby previous studiesmostly usinglinear model, that is, with the assumption that CBN is minimizing a linear quadratic loss function with a symmetric response to changes in macroeconomic variables.However, there are clear empirical and theoretical evidences showing that in reality central banks can, and mostly do, have an asymmetric preference.They are known to assign different weights to the same percentage changes in positive and negative inflation and output gaps.Hence, they have a nonlinear reaction function.

In addition, empirical evidence has shown that monetary authorities react more aggressively to positive inflation gaps (that is when the inflation is above the targeted inflation) and lessaggressive to negative inflation gaps (when the inflation is below the target). Also their reaction is more spontaneous on negative output gap (when the output fall below the potential) than the positive one (when it is above the potential output). This is a source of nonlinearity of MPRF (Castro, 2008; Ncube & Tshuma, 2010; and Naraidoo & Paya, 2012). It is also verified that monetary policy behaviors are inherently nonlinear processes with asymmetric adjustments over different phases of business cycles, that is, the monetary policymakers tend to be more aggressive on inflation during the expansion phase and on the other hand, more aggressive on stabilization of output during the "down turn" phase andthus, nonlinear.Hence, the fluctuations during business cycles are seen as a cause of asymmetry in the preference of monetary policy makers to the variation in of inflation and output hence, nonlinearity (Bruinshoofd & Candelon, 2004; Petersen, 2007 and Surico, 2007).

Furthermore, even in spite of the independence of central banks, political heat can,and very often do,induce asymmetries in the behavior of central banks towards their mandates(Blinder, 1997). More so, from the theoretical point of view, under the traditional Keynesian assumption,nominal wages are flexible upward but rigid downward which gave rise to a quasi-convex Average Supply (AS) curve.This impliedly means that the inflation-output tradeoff may indeed be nonlinear. This,therefore,invariably leads to the nonlinearities in the reaction of monetary policy to the changes or variation in the macroeconomic variables.

1.2 Research Problem

Inflation targeting (IT) has been embraced by central banks in many countries as a framework for managing inflation. A strong and positive indication shows that Nigeria has been making

preparation to move in to IT as a framework for monetary policy since January 2000(CBN, 2011).If sufficiently adopted, this may lead to stability of macroeconomic environment as evidenced in other countries. For that,it requires as a prerequisite, a sound technical knowhow by the monetary authority (CBN) to effectively manage inflation expectation of the market (Bello, 2014). In the same vein, the problem of ineffective forward looking monetary policy process within a broader and longer space-time horizon in Nigeria could be resolved.

Furthermore, the main policy instrumentCBN uses for monetary policyis the Monetary Policy Rate (MPR). The central bank changes this rate to reflect its policy stance and therefore its path overtime traces the reaction of the monetarypolicy authorities to anticipated and actual changes in its targets. Although the behavioral trend of monetary policy decisionson MPR over time appears to suggestregime changes/nonlinearities, empirical evidence on the existence of theseregime changes/nonlinearities is yet to be established. Thus, unraveling the possibility that nonlinearities exist in themonetary policy reactions will undoubtedly enhance market understanding of the CBN policy decision which is important for investment decisions.

A number of attempts have been made by various studies to estimate the reaction function of CBN. Allof these studies assumed that the CBN is minimizing a linear quadratic loss function with a symmetric response to its primary mandate which necessitated the utilization of a linear model in their estimation (see for instance, Agwu, 2007; Ogli, 2008; Agu, 2011; Tolulope and Ajilore, 2013; and Bello, 2014).However, the connotation that CBN behaves in a symmetrical manner when adjusting monetary policy rates in response to changes in some of macroeconomic variables may be fallacious when it ought to be asymmetrical.This will spell out a number of setbacks to the bank's policy. One of these setbacks is that the predictability of the monetary policy will be grossly undermined. Secondly, the resultant poor predictability of policy

undermines the capacity of the MPR to properly anchor inflation expectations which could continue to drive inflation higher. Thereby making the central bank appear to be inflation biased.These will end up eroding monetarypolicy credibility and reduce CBN's ability to manage inflation expectationsince systemic mistakes could be committed thereby yielding sub-optimal policy outcomes.This work sets out to relax the assumption of linearity and empirically investigate the nature of the reaction function of CBN. If appropriately done, the reaction function can be used by the players (That is, financial markets and other sophisticated investors) to predictfuture path of the monetary policyaction. In order to achieve this,the following questions emanated from the problem statement;

i. Does the CBN follow a nonlinear policy rule in its interest setting?
ii. Does the CBN change its policy rate according to the *levels* of inflation, output gap or exchange rates?
iii. What is the impact of the policy asymmetry on the objective of the CBN?

1.3 Objectives of the Study

The broad objective of the study is to estimate a (Taylor-type) reaction function of CBN taking in to consideration the asymmetries in its response to its primary mandate. The specific are:

i. To empirically examine the linearity assumption in the estimates of the MPRF in Nigeria,
ii. To identify the key variables to which CBN reacts to in setting its interest rate and to
iii. Examine the asymmetric preferences of the CBN in setting the MPR.

1.4 Justification for the Study

The response of CBN to the dynamics or changes in macroeconomic variables is unclear and sometimes confusing. Also, effective management of expectation is a salient feature of operating

a smooth and successful IT which Nigeria has the intention of adopting. Therefore,the need for a clear and quantifiable MPRF which helps tremendously in the effective management of expectation cannot be overemphasized. Furthermore, a well estimated MPRF will help in understanding monetary policy actionand also enable financial markets and other private sectors to take a rational and optimal investment decision. This hasthereforespelled out the need for this research work.

Several studies have estimated the MPRF of the CBN. Known to this study include but not restricted tothe studies of (Agwu, 2007; Ogli, 2008; Siri, 2009; Agu, 2011; Tolulope andAjilore, 2013; and Bello, 2014). One fact that is common to all these works is that they all utilized a linear model with the assumption that the CBN behaves in a symmetrical manner in adjusting its mandate.This research work intends to take a diversion from the existing studies by testingfor nonlinearity in the model.This is because empirical studies show that on the average nonlinear models seems to outperform the simple linear model in terms of tractability of the actual interest rates (Ncube andTshuma, 2010). Moreover, the suspicion of nonlinearity in the reaction function of CBN by this study has both empirical and theoretical bases as demonstrated in the works of (Blinder, 1997; Nobay and Peel, 1998; Bec, Salem and Collard, 2002; Castro, 2008; Ncube and Tshuma, 2010; Naraidoo and Paya, 2012)to mention but few. These works have argued that despite the popularity of the linear models of the MPRF, in reality the reaction functions of central bank are mostly nonlinear. This work therefore seeks to make its contribution by estimating a nonlinear Taylor-type reaction function of CBN. To the best of the researcher's knowledge, only two studieshave estimated a nonlinear MPRF in Africa. These studies areNcube andTshuma (2010) and Naraidoo andPaya (2012) that have estimated for South Africa, and there are none estimated for Nigeria.

Methodologically, the existing studies of MPRF of the CBN mostly made use of cointegration, simple gap model and Generalized Method of Moments (GMM), Ordinary Least Square (OLS), bound testing, error correction, and multivariate Garch to estimate a linearform of the MPRF without a thorough investigation of its nature/structure by utilizing any form of linearity test. This study will add empirical value to the pool of existing knowledge by testing for linearity and estimate as appropriate a nonlinear monetary policy reaction function for CBN using Smooth Transition Regression (STR) model. This is because the STR is capable of explaining both intuitively and structurally the nonlinear behavior of monetary policy. Hence, this willimprove the understanding and predictability of monetary policy action by the financial markets, capital markets and monetary policy analysts.

1.5 Scope of the Study

This study estimates a nonlinear (Taylor-type) MPRF of the CBN using quarterly data from 2007:Q1 to 2016:Q2. The selection of the period is due to,among others, the replacement of MRR with MPR in December 2006. Another reason for the choice of the period is because the CBN started using external MPC members in 2007 as stated in. Hence the period will yield necessary and sufficient data for the estimation.

1.6 Limitation of the study

A key limitation to this study, like in many others, relates to the reliability and accuracy of the secondary data used. For instance, reliance on statistical methods to compute such important measure as the output gap because the potential output is not directly observable, means that cautions must be exercised in interpreting the results. While efforts are made to ensure the integrity of the data, a number of issues inherent in the collation at the source call for some caution, which the author diligently exercised, in the interpretation of the results. The scope of

the study, which is 2007 to 2016, is chosen due to the fact that MPC became open for external members in 2007 and also the change of MRR to MPR in December 2006.

1.7 Organization of the Study

The study is structured in five chapters; Chapter one is the general introduction which comprises the background to the study, research problem, questions, objectives, justification for the research, scope and limitation of the study. Chapter two contains the review of the literature by presenting the conceptual, theoretical and empirical issues, while the general overview of the study is presented at the last part of the chapter. Methodology is presented in chapter three, while chapter four provided the presentation and discussion of the results. The summary, conclusion and recommendationsare done in chapter five.

CHAPTER TWO

LITERATURE REVIEW

This section reviews related literature on monetary policy reaction function. The review is sub-divided in to conceptual, theoretical and empirical, and the last part of this chapter will provide an overview of monetary policy in Nigeria.

2.1Review of Concepts

This section provides the contextual operational meanings of some key concepts like; monetary policy, Monetary Policy Committee, monetary policy reaction function and the Taylor ruleas used in this work.

Monetary policy is the deliberate use of monetary instruments (direct and indirect)at the disposal of the central bank in other to achieve macroeconomic stability. The macroeconomic stability comprises of achievement of internal balance (internal balances include the achievement of price stability, low unemployment and high stable economic growth) and external balance(a country is said to have achieved an external balance when it has attained Balance of Payments (BOP) equilibrium and exchange rate stability). Similarly, monetary policy can be seen as a deliberate action of the monetary authorities to influence the quantity, cost and the availability of money credit in order to achieve the desired macroeconomic objective(which is the achievement of internal and external balances). This is done through changing money supply and/or interest rate with the intention of managing the quantity of money in the economy (CBN, 2011). Summarily, monetary policy means the policy directed at controlling money supply and interest rates (Jochumzen, 2010). In Nigeria, CBN is saddled with the responsibility of conducting monetary policy.

The Monetary Policy Committee (MPC) was reconstituted as a result of the enactment of CBN act (2007) by the national assembly. The act stated that among others; "*that the committee is reconstituted in order to facilitate the attainment of price stability and to support the economic policy of the federal Government "*. The composition of MPC consist of the chairman who is the CBN Governor, the four deputy governors of the bank, the two members of the board of director of the bank, three members appointed by the president and two members appointed by the Governor.

The MPC is the highest policy making committee of the CBN and is saddled with the responsibility within the bank for formulating monetary and credit policy. The functions of MPC *inter alia*include; to review economic and financial conditions in the economy, determine appropriate stance of policy in the short and medium term, review regularly the CBN monetary policy framework and adopt changes when necessary and lastly to communicate monetary or financial policy decisions effectively to public and ensure the credibility of the model of transmission mechanism of monetary policy. The MPC meets every other month to look at salient monetary policy issues except otherwise, that is in the event of emergency(CBN, 2016).

The Monetary policy Reaction Function (MPRF) is the upward slopping relationship between the inflation rate and unemployment rate. When the inflation rate increases, a central bank wishing to fight inflation will raise interest rate to reduce output thus increase the unemployment rate. MPRF is an upward relationship between real interest rate and inflation rate (Benernke & Frank, 2008). The MPRF is explained by Taylor's rule, LM curve and/or Okun's law. Technically speaking, MPRF gives the summary of how monetary authorities react to changes in macroeconomic variables(Agu,2011).

Taylor's rule explains how a central bank should adjust short term interest rate (for example MPR in Nigeria) in response to changes in inflation and output gaps.Inflation gap is the difference between the real, observed or expected inflation rate and the targeted inflation rate, while output gap, is the difference between the real output and the potential output. The rule maintains that interest rates should beincreased when inflation rises above its target or when real GDP rise above its potential level. Thus, increase in the interest rate will press credit supplyto pull down demand and curb prices, hence stabilize the economy.But on the contrary, when inflation or real GDP falls below their targeted values, interest rates should be reduced to boost the economy.

Moreover, Taylor's ruleis a monetary policy rule that describes how much a central bank should change the nominal interest rate in response to changes in inflation, output and/or other economic conditions. Specifically, the rule maintains that for a one per cent increase in inflation, central bank should raise the nominal interest rate by more than one percent. For instance in US, Taylor's rule stipulated that the federal funds rate be raised by 1.5 percentage point for each 1 percentage point increase in inflation. The rule also postulated that interest rates are reduced by 0.5 percentage point for each percentage point fall in real GDP below its potential as pointed out by (Taylor, 1993 and Ncube & Tshuma, 2010).

According to Castro (2008), the traditional Taylor rule is an optimal policy rule that is derived from the minimization of a symmetric quadratic central bank loss function assuming that aggregate supply function is linear. Before the work of Clarida, Gali, and Gertler (1998) who introduced a forward-lookingness to Taylor rule,the original Taylor rule assumes that central banks use past or present values of inflation and output gaps to set interest rate, that is, backward

looking,(Castro, 2008).Worthy of noting is that the original Taylor's rule assumes that the response of interest rates to economic conditions is linear and time invariant.

2.2Theoretical Literature

There are a considerable number of theories that explain the theoretical underpinnings that portray the behavior of monetary policy in reaction to the variations of macroeconomic variables.That is, how monetary authorities react to changes in wages, prices, output and/or employment. The MPRF provides the summary of how monetary authority changes interest rate decision in response to variations in macroeconomic variables. In a typical Taylor rule, the variables that are considered are inflation and output. Understanding how these variables are determined will provide a clearer understanding of the MPRF.This study reviews some of the contending monetary theories in order to have theoretical illumination and hence provide the theoretical basis forthis study. It is worthy of note that the following theories are interconnected because, the shortcomings inherent in one led to introduction of another. These theories includethe neoclassical theory, Keynesian theory and new Keynesian theory.

One of the distinguishing features of neoclassical economics is the separation of real and nominal variables, hence the classical dichotomy. The classical economists were fully aware that the market economy could deviate from the equilibrium level of output and employment, but they believedthat the deviation will be temporary and short lived. They held onto the belief that the market mechanism will efficiently and effectively restore full employment equilibrium and therefore full employment is a normal state of affairs(Snowdon and Vane, 2005).The classical theory laid little emphasis on either factors that determine aggregate demandor policies which could be used to stabilize aggregate demand in an attempt to promote full employment. To them government intervention in form of activist stabilization policy is null and void.

According to Neoclassical theorists, the level of realoutput is independent of the quantity of money in circulation in the economy. The level of output depends on the level of input and the efficiency of the usage, hence the neutrality of money on determination of real output.To classical economists, money is just a "veil" covering the underlying real forces in the economy. In other words, money is just a convenient medium of exchange which enables the market participants to do away with the problem of barter. The classical theory is built based on the flexibility of prices, wages and interest rate and also the Say's law dictumto maintain long run equilibrium. Say's law posited that supply will always create its own demand, hence the market will always clear. They believed that the economy can experience changes in the structure of final demand but no prolong deficiency and involuntary unemployment(Snowdon and Vane, 2005, p. 49; Jürg, 1987).

Neoclassical theory used Quantity Theory of Money (QTM) to explain the determination of nominal variables in the economy or system. The QTM states that money supply and price level in an economy are in direct proportion to one another, in other words, there is a direct and proportional relationship between supply of money and price level in the economy. The scholars that either contributed to the development of QTM or have been associated with its prescriptions include; Fischer, Mills, Marshall, Ricardo, Hume, Cantilon, Pigou, Hayek and Milton Friedman(Snowdon & Vane, 2005). The QTM can be represented by the income version of Fischer's equation of exchange;

MV = PT……..... (2.1)

Where M is the money stock, V represents the velocity of circulation of money**,** that is, the rate at which a unit of money circulates in affecting transaction in a year. P is some measure of price level (for instance, consumer price index). T is the total volumeof monetary transactions that take

place in an economy in one fiscal year. Worthy of noting in the classical model is that consumption, savings and investment are all functions of interest rate.

The Keynesian theory emanated from the General Theory of Employment, interest and Money of J.M. Keynes (1936). The theory came in to being as a result of short comings inherent in the Neo-classical theory.The theory propounded that the national income depends on the volume of employment (Keynes, 1936, p 247; Snowdon and Vane, 2005). The theory also posited that macroeconomic equilibrium is consistent with involuntary unemployment. The traditional Keynesian theory postulated the principle of**e**ffective demand in conjunction with equilibrating role of changes in output instead of price, hence a sharp contrast to the classical theory. Keynesian theory advocated for government intervention or programs to expand aggregate demand through deficit financing which will create additional employment.

In contrary to the Neoclassical model where investment depend only on interest rate, in Keynesian theory, investment expenditure depends on the expected profitability of investment and the interest rate which represent the cost of borrowing funds. Consumption expenditure depends on income rather than interest rate, thus it is endogenous and passive. The axiom of effective demand is a salient feature of Keynesian principle, it stated that in a close economy with surplus potentials, the level of output/employment is determined by the level of aggregate planned expenditure which comprises two components; householdexpenditure (C) and investment expenditure from firms (I), also,the theory stressed multiplier principle. Since more output requires more labor, output multiplier imply employment multiplier. Going by the Keynesian IS-LM model, the multiplier affect the slope of the IS curve. The IS curve will be flatter as the value of multiplier gets larger and vice-versa(Snowdon & Vane, 2005).

According to Keynesian theory, the determination of interest rate is purely a monetary phenomenon determined by the "liquidity preference" of the public in juxtaposition with the supply of money which is determined by the monetary authority (exogenously).Liquidity preference is the desire of investor to hold liquid rather than illiquid asset. In other words it is the preference for holding cash rather than other assets. It was first propounded by Keynes in 1936. The theory added the precautionary and speculative motives to the existing classical transactionary motive for holding money. Furthermore,it is only the speculative motive that is sensitive to interest rates. Unlike the Neo-classical concept where money is neutral in the determination of output, in Keynesian theory, money is not neutral. Thus, an increase in money supply leadsto reduction in interest rate and hence stimulates aggregate spending through an increase in investment and the subsequent multiplier effect on output and employment. This relationship can be systematically depicted as follows;

$$+\boldsymbol{\Delta M} \rightarrow -\boldsymbol{\Delta R} \rightarrow +\boldsymbol{\Delta I} \rightarrow +\boldsymbol{\Delta Y} \rightarrow +\boldsymbol{\Delta L} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.2)$$

Where **+**,**-** and Δ symbolize increase, decrease and change respectively, M is money supply, R is interest rate, I is investment expenditure, Y is output and L is employment. The relationship above shows that an increase in money supply will lead to a reduction or fall in interest rate which will translate to an increase in investment and as a result, both output and employment will rise.

The antagonists of Keynesian theory posited that despite the empirical evidences backing the theory, there are some weaknesses inherent in the theories themselves. For instance, the Keynesian theory maintained that fluctuations in output and employment arise principally due to fluctuations in nominal aggregate demand which in turn have real effect due to nominal price and wage rigidities. But these rigidities according to the opponents of Keynesians were just

assumed rather than explicitly explained(Ball, Mankiw andRomer, 1988). Aligned, according to Akerlof and Yallen,(2008),which is in line with the arguments of Ball, et al. (1988), the macroeconomic effect of price rigidities is larger than the cost of rigidities to the price setters (menu cost). More so, that non adjustment of price to fall in demand leads to large tumble in output and welfare. The Keynesian theory is also been criticized for being too aggregative, hence it lacks a micro-foundation.

The foundation of New Keynesian Policy Model (NKPM) was laid in the 1970s by Stanley Fischer, Edmund Phelps, John Taylor and a considerable number of other authors who have produced a torrent of research within the Keynesian tradition that strive to build a microeconomic foundation of wage and price stickiness or a micro foundation of macroeconomics (Gordon, 1990). The NKPM pointed out that nominal rigidity can result from optimizing choices of agents in a well specified model. This has solved the problem of the lack of proper explanation of the source of rigidities of wages and prices inherent in the traditional Keynesian theory. The traditional Keynesian theory uses ad-hoc imposition of rigidities without explicit explanation of its source. According to Gordon (1990), the task of NKPM is to explain why changes in the aggregate price level are sticky, hence the reason why price changes do not mimic nominal GDP. Thus, NKMP is about the choices of monopolistically competitive firms that set their individual prices and accept the level of real sales as a constraint. Another salient feature of NKMP is that it combines the theoretical rigors of Real Business Cycle (RBC) theory with Keynesian apparatus like monopolistic competition and nominal rigidities to promulgate a more suitable model.

Furthermore, according to Gali (2009), the NKPM imbibes several tools associated with RBC models such as dynamic stochastic general equilibrium (DSGE) models based on optimizing

behavior of household, firms, rational expectation and market clearing. Nominal rigidities establish the main sources of monetary policy non-neutrality. They are introduced as constraints on the frequency with which firms and workers can adjust their nominal prices and wages. Such constraints made wages and prices setting decision to become forward looking, (Richard, et al. 1999 and Galí, 2009). The NKPM attributed importance to monetary policy rule which entails the endogenous components of monetary policy rather than the effect of exogenous changes in monetary policy instrument. Consequently, NKPM framework can be used as a means for evaluating the desirability of alternative rules as well as determining the optimal rule using welfare based criterion.

The New Keynesian Policy Model is not devoid of criticisms.The opponents of the theory maintained that the framework failed to uncover relevant sources of policy tradeoffs. That is, the tradeoffsbetween inflation stabilization in form of cost-push and output gap using New Keynesian Philips curve. The NKPM advocated that central banks should completely focus on stabilizing inflation with no concern for output and employment losses that the policy might have caused; this is seen as detrimental to policy by the adversaries of NKPM (Galí, 2009).

Taylor's rule is a variant of the NKPM that put forward one of the most acceptable policy rule in the study of monetary policy. Contemporarily, the salient objectives of monetary policy are price stability (that is, low and stable inflation) and full employment (actual output equal to potential output). The Taylor rule provides a monetary policy approach for achieving these objectives (Petersen, 2007 and Ncube and Tshuma, 2010). Specifically, Taylor rule is a linear algebraic rule propounded by J.B. Taylor in 1993, andthe rule specifies how the Federal Reserve ought to adjust its policy rate according to changes in inflation and output gap. The following rule is put

forward by Taylor (1993) to characterize the implementation of monetary policy in the United States:

$$\mathbf{i_t = r + \pi_t + \alpha(\pi t - \pi^*) + \beta y_t} \quad \text{.....(2.3)}$$

Where i_t is the nominal federal funds rates, r is the long run equilibrium real interest rates. π_t is the year on year inflation rate, π^* is the targeted inflation and y_t is the percentage deviation of real GDP from the potential output. The long run equilibrium real interest rate is set to equal to 2 to match the historical data on real per-capita output growth. Also, the inflation target is said to equal to 2 while α and β are both set equal to 0.5. Taylor's suggested coefficients can be rewritten using eq. (2.3) as follows:

$$\mathbf{i_t = 1 + 1.5\pi_t + 0.5y_t} \quad \text{.....(2.4)}$$

The coefficient of inflation is built to be above one, thus, Taylor principle. This implies that, the central bank must react more than one to one to inflation and this will therefore cause the real interest rate to increase when inflation increases. The constant, represents a linear combination of long run equilibrium real interest rates and the inflation target. A change in the intercept is always interpreted as a change in the inflation target.

The Taylor rule is thus described as a policy rule that incorporates good attributes of monetary policy such as transparency, accountability and credibility. It can therefore be argued that the publication of central bank communiqué to the public is a sign of adherence to the Taylor rule. Furthermore, when the central bank reveals its commitments to price stability and thereby takes a logical step towards achieving it, the public will therefore keep its expectations of inflation low and stable. Also, financial markets will anticipate central bank next move and increase market interest rates shortly when inflation starts increasing.

However, Taylor, (1993) maintained that the Taylor rule should not be adopted unconditionally without considering the peculiarities of the economy as well as the prevailing condition of the economy. This consideration will make such monetary policy to be systemic, consistent, transparent and credible, and hence, will mitigate the time inconsistency inherent in the discretionary monetary policy. More so, it is worthy of note that, the CBN might not strictly follow Taylor principle in changing its policy rate, because, sometime, CBN changes other instruments like Cash Reserve Ratio (CRR), asymmetric corridor and/or liquidity ratio to curb inflation without necessarily changing the MPR.

From the above theories reviewed, it is glaring that;

i. The Neoclassical theories believed that full employment is a normal state of the economy and that unemployment is cured by the self-adjusting mechanism of the economy, hence, to them, government intervention policies are uncalled for. Whereas in Keynesians and New Keynesians theory, the equilibrium state of the economy has an inherent involuntary unemployment and they therefore advocated for government programs to expand aggregate demand through deficit financing in order to create additional employment.

ii. In the Neoclassical theory, prices are determined using money supply. This is because the relationship between money supply and price level is direct and proportional and velocity of circulation of money is assumed constant in their famous QTM. On the contrary, in Keynesian theories, because of the liquidity preference, the demand for money function might shift unpredictably causing velocity to vary. Thus change in money supply may offset the change in velocity in opposite direction. And also because of price stickiness in both Keynesian and New Keynesian theories, direct relationship between money supply and price level do not hold.

iii. In Keynesian theory, determination of interest rate is purely a monetary phenomenon determined by liquidity preference (demand for money) of public and money supply which is exogenously determine by the monetary authority. Therefore, the Keynesian and New Keynesian theories transmit through interest rate which qualifies them to be indirect monetary theories. On contrary, the classical theory transmits directly not through interest rate and hence it is a direct monetary theory. This is in line with the findings ofLawong, 2013, pp. 59-60.

iv. It is deduced that, the new Keynesian model incorporated or synthesized the RBC and the traditional Keynesian theories to come out with a more sophisticated model.Thissophisticated model, capture a forward-looking policy rule which can evaluate the attractiveness of alternative rules as well as the choice of optimal rule via welfare base criterion which is absent in alternative theories.Hence,The NKPM is therefore the best theory that befits the contemporary monetary policy matters. Thus, this work will be anchored on the NKPM.

v. Lastly, the Taylor rule is a variant of the NKPM, and it is conceived of as one of the best monetary policy rule because it incorporates good qualities of monetary policy such as credibility, accountability, transparency and consistency. These attributes gave Taylor rule an edge over other policy rules, and hence, its adaption in this study.

The reviewed theories explained price and output/employment determination in different theoretical underpinnings, and thus aids the choice of the New Keynesian Policy Model (Taylor rule) as the theoretical frameworkfor this study.

2.3Empirical review

There exist a number of empirical studies on MPRF; some of these studies reviewed utilized a linear model in their estimation of MPRF while some made use of nonlinear model to estimate the reaction function of monetary policy. In this section, these empirical studies will be presented, systematized, analyzed and evaluated.

Thisstudy reviewed several empirical works on MPRF. These literatures can be broadly polarized in to two related but differentiated strands; the linear MPRF and the nonlinear MPRF. From Column 1 of table 2.1in appendix F, the researchers that estimated the linear model of MPRF are;(Clarida, Gali, &Gertler, 1998a and 1998b; Agwu, 2007; Henry, et al. 2008; Ogli, 2008; Siri, 2009; Agu, 2011; Tolulope andAjilore, 2013 and Bello, 2014). On the other hand, those that estimated the nonlinear model of MPRF are; (Nobay and Peel, 1998; Martin andMilas, 2001; Bec, et al. 2002; Doladoy, et al. 2003; Bruinshoofd andCandelon, 2004; Petersen, 2007; Surico, 2007; Castro, 2008; Cukierman and Muscatelli, 2008; Ncube andTshuma, 2010 and NaraidooandPaya, 2012).

From the studies presented in table 2.1, column 2 in appendix F; it is evident that the studies are carried out in Africa (Ghana, Kenya, Nigeria and South Africa), Asia (Japan), Europe (Denmark, France, Germany, Italy, Spain and United Kingdom) and USA. It is also glaring that the research works done in Asia, Europe and US mostly estimated the nonlinear model whereas only two researches in Africa; Ncube and Tshuma, (2010) and Naraidoo and Paya, (2012), both in South Africa estimated a nonlinear model. However, all the researches consulted that are conducted in Nigeria estimated a linear model of MPRF.

Majority of the research objectives as evidenced in column 3 of table 2.1 in appendix F, were to investigate either the existence of asymmetric preferences of central banks or to analyze the

applicability of nonlinear Taylor rule and therefore nonlinearity in monetary policy.These include for instance the works of (Martin &Milas, 2001; Bec, Salem, & Collard, 2002; Bruinshoofd&Candelon, 2004; Petersen, 2007; Castro, 2008; Ncube&Tshuma, 2010; and Naraidoo&Paya, 2012).However, other objectives like that of Martin andMilas, (2001)is to investigate the effect of the adoption of IT on monetary policy, while Clarida, et al. (1998) and Clarida et al. (2000) estimated a forward looking MPRF. The objectives of studies that estimate the reaction function of CBN and CBK (Central Bank of Kenya) were to estimate the reaction function and to check if the central banks follow a Taylor rule see for instance(Henry, Musa, and Isaya, 2008; Siri, 2009). But the objective of Bello, (2014) slightly differs, because his' is to investigate the micro-foundation and estimate the reaction function of CBN (he used NKPMframework).

It is clear from column 4 and 5 of the table 2.1 in appendix F that variables used in the studies are divided in to dependent and independent variables. The empirical studies consulted have the same dependent variable which is nominal interest rate or policy rate with exception of Henry et al, (2008)that used monetary aggregate as dependent variable instead of nominal interest rate. This is simply because of the lack of sophisticated and fully functional financial system in Kenya as at the time they conducted their research(Henry*et al*, 2008).

On the part of independent variables, most of the literature reviewed used inflation and output gaps as their independent variables as enshrined in the specification of Taylor's rule to estimate their baseline models. Some studies estimated MPRF of an open economy that is by augmenting exchange rate in their exogenous variables; see for instance (Agwu, 2007; Ogli, 2008; Siri, 2009; and Agu, 2011) for more empirical evidence. Bello (2014), in his estimation of a Taylor-type CBN MPRF, has augmented the MPRF with the log of external reserve and the exchange rate to

the traditional Taylor's rule. This is because external reserve is one of the key factors the MPC refer to before taking monetary policy action. Furthermore,some of the studies used different independent variable, for example;Bruinshoofd and Candelon (2004), used money supply, interest rate spread and growth rate of real balances as their independent variables. Also, Agu (2007) in his historical model added credit reserve and private credit to the right hand side of the equation. A path breaking development in the estimation of MPRF is the inclusion of FCI by Castro (2008) and expected financial indicator gap by Naraidoo and Paya (2012) to the independent variables. According to Naraidoo and Paya (2012), the rationale behind using FCI is to check if assets prices are considered when central banks are adjusting interest rates. Castro (2008) added that FCI is used to know whether the central banks are targeting the relevant economic information encompasses in a group of financial variables not in a single financial variable.

From column 6 in table 2.1 in appendix F;It is clear that a large percentage of studiesreviewed in this studyused quarterly data in their analysis. The coverage of the data ranges from Bello (2014) who covers from 2007 to 2013, to Martin and Milas (2001) with the coverage of 1963 to 2000. The selection of time frame by the researches are wide enough to make significant inferences. Furthermore, fewer but considerable number of the remaining researches consulted used monthly data with scope arrays from Agu (2007) with 1999:1 to 2005:12 to that of Peterson (2007) with 1960:1 To 2005:12. This also is large enoough to make a significant projection with.

Also in column 6 of table 2.1 in appendix F, it can be seen that different estimation techniques were used by different scholars to estimate MPRF of central banks of various countries covered by the researches consulted. Bulk of them used GMM to either estimate the nonlinear model for instance (Bec, et al. 2002 ; Doladoy, et al. 2003 and Surico 2007), or to estimate a linear model,

like the works of; (Clarida, et al. 1998; Clarida et al. 2000 ; Henry, et al. 2008 and Bello, 2014). However, another cluster of the researches consulted used Smooth Transition Regression (STR) to judiciously estimate the MPRF of some central banks. For example, buinshoofd (2004) used Logistic Smooth Transition Authoregression while Peterson (2007), Castro (2008) and Ncube and Tshuma (2010) used Logistic Smooth Transition Regression (LSTR). Cukierman and Muscatelli (2008) used a more advanced version of STR which is Hyperbolic Tangent Smooth Transition Regression.Other estimation techniques were also used by the remaining researchers like Nobey and Peel (1998) who made use of Bayesian econometrics, Martin and Milas (2001) who utilized simple nonlinear structural framework and Naraidoo and Paya (2012) that used rollin and recursive regressions to make both in-sample and out of sample forecast. Agu (2007) and Siri (2009) used Ordinary Least Square (OLS) method While Agu (2011) and Tolulope and Ajilore (2013) used cointegration technique.

Through looking at the estimation techniques used by the researchers, it can be deduced that;

i. The most used estimation technique is GMM, followed by STR then OLS, cointegration and few others.
ii. The OLS is incapable of estimating a nonlinear model because of the classical assumption of linearity inherent in it.And that cointegration method is mostly used to check for a long run relationship as well as the speed of the adjustment process and hence, can not be used to estimate a nonlinear model. see for instance; (Gujarati, 2003; Brooks, 2008).
iii. Although GMM and Bayesian nonlinear model can estimate nonlinear model, but STR is a better method because it offers basic and intuitive structure to explicitly explain nonlinear monetary policy behavior (Petersen, 2007). Moreover, according to Ncube and

Tshuma (2010), STR is capable of justifying why and when the central bank change its interest rate. For the above reasons, this research will use the STR as our model and nonlinear least square as our estimatimation technique.

From column 7 of table 2.1 in appendix F, the results of almost all the works embarked on ascertaining the existence of nonlinearity in the MPRF have remarkably accepted the null hypothesis of the existence of linearity (the results show that nonlinearity exist). However, there are few contentions on the issue of existence of the nonlinearity in the MPRF of some countries because few works contradicts these results, for instance,Doladoy, et. al (2003)and Castro (2008) rejected the existence of nonlinearity in the MPRF of US, this is in opposition with the results of Peterson (2007) and also that of Surico (2007) that establshed the existence of nonlineariry in the Fed'sobjective function. In the same vein, the empirical result of Bruinshoofd and Candelon (2004)rejected the null hypothesis of the exitence of linearity (reject nonlinearity) in European countries with exception of UK and Denmark, and this has therefore opposed the results of(Martin and Milas, 2001; Bec, et al. 2002; Doladoy, et al. 2003; Cukierman and Muscatelli, 2008) that established the existence of nonlinearity inthe reaction function of European countries. Nonetheless, it can be objectively argued that the MPRF of both Europe and US are nonlinear because the majority of the results or findings have established that.

Furthermore, the empirical results of Clarida, et al.(1998)and Clarida et al. (2000) confirmed that the MPRF of the central banks of Italy, France, US and UK are all forward looking in their policy decisions. This is in line with the empirical finding of Bello (2014) which posited that the MPRF of CBN isforward looking one. On the other hand, the results of Henry,et al. (2008) and Siri (2009) depicted that the MPRF of Kenya and WAEMU countries follow Taylor's rule respectively. However, the findings of Siri (2009) went further to prove that the MPRF of the

central banks of Ghana and Nigeria are not strictly following the Taylor's rule. This is in line with finding of Bello (2014) which stated that CBN is not following Tayor rule specification.

The findings of Agu (2007) and Ogli (2008) showthe significance of inflation in the MPRF of CBN while Agu (2011) empirically showed that there is no long run relationship among monetary variable in Nigeria. Using the same estimation technique, the findings of Tolulope andAjilore (2013) shows the effectiveness of MPRF in achieving price stability in the midst of long run persistent inflation. Beside maintaining that MPRF of CBN is a forward looking one, the findings of Bello (2014) also showed that monetary policy in Nigeria is a anti-cyclical one.

It is clear from the results reviewed, that, nonlinearty exist in the MPRF of the central banks of European countries, Japan and US as revealed by numerous researches. However, to the best of the researcher's knowledge, only two works are carried out on the nonlinear MPRF in Africa (both in South Africa) by Ncube and Tshuma (2010) and Naraidoo and Paya (2012) both of which established the existece of nonlinearity in MPRF South African Reserve Bank (SARB). More so, all the resarches conducted in Nigeria that are reviewed estimated linear MPRF.

In summary, it is factual from the review that all the researches carried out in Nigeria on the MPRF of the CBN available and consulted by this study work assumed that the CBN is minimising a linear quadratic loss function and invariably having a linear reaction function. Thus, the use of linear models by the researchers. However, despite the little contention, it wasclear that nonlinear exist in the MPRF of many countries in Africa, Asia, Europe and USA.Aligned also,Enders (2015, p. 408),maintained that the assumption that economic processes are linear can offer a useful approximation to the actual track of economic variables. Nonetheless, policy makers can make serious and dangerous errors if they ignor the empirical

evidences that nonlinearity exist. To avoid this errors, this work will bridge this gap by testing for linearity and estimate a nonlinear model using STR in Nigeria.

2.4 An Overview of Monetary Policy in Nigeria

Prior to the introduction of Structural Adjustment Program (SAP), that is 1959 to 1986; the CBN used direct monetary controls to implement its monetary policy which accommodated the exchange rate targeting monetary policy framework. Exchange rate targeting was used as a monetary policy framework in Nigeria from 1959 to 1974. It was abolished in 1974 due to the extinction of the Bretton Woods system of exchange rate in 1972 (CBN, 2011). However, monetary targeting framework was put in to practice after the abolition of exchange rate targeting and hence the indirect monetary control.

The regime switch from fixed peg exchange rate to a managed floating exchange rate made an indelible mark in the history of monetary policy in Nigeria. Allowing market forces to determine exchange rate led to depreciation of naira and as a result, affected the general level of prices of imported goods. Furthermore, the shift from exchange rate targeting marked the beginning of a strategic shift to demand management as a means of containing inflationary pressure and correcting the balance of payments deficits or problem. The indirect monetary controls were initiated and fully implemented in Nigeria in 1992 (see for instance,Ogli, 2008 and Bello , 2014for more empirical evidence). The indirect controls require as a precondition, a sound, standard, developed and a competitive financial system for it to function well. On the contrary, the Nigerian financial markets at that time were underdeveloped and uncompetitive enough to ensure a smooth operation of the market to achieve the desired goal at inception (CBN, 2011).

The implementation of monetary policy in Nigeria can be broadly polarized in to two different regimes; direct and indirect controls. Each regime was necessitated by the prevailing

macroeconomic policy objective of the government or policy makers. The direct control was implemented in 1959 (from the inception of CBN) and was abolished in 1985 (CBN, 2011). Within these periods (1959 to 1985), the CBN or government focus varied in accordance with the variation of the prevailing economic need or plan. The CBN focused on developing and maintaining a sound domestic currency within 1960 to 1962, hence operating a passive monetary policy regime (CBN, 2011). The focus shifted to the sufficient supply of credit in the economy with the aim of ushering in development with less inflationary pressure in 1962 to 1963. In other to achieve Balance of Payment (BOP) equilibrium around 1964 to 1965, the CBN placed a ceiling to the rate of expansion of commercial banks advances through credit rationing.

The civil war of 1966 led to the lifting of credit restriction to enable the government to finance the war. This was accompanied by an aftermath of deficit financing, inflationary pressure and BOP deficit. Remedies were put in place throughout the period of 1966 to March 1972 to resolve the menace. The increase in oil earnings around 1972 to 1976 shifted the monetary policy focus to expanding domestic aggregate output and to curb inflation. However, increase in the oil revenue resulted in increase in aggregate demand and money supply. This resulted to excess liquidity and as a result, selective credit control policy was maintained in juxtaposition with interest and exchange rate policies. In corollary, stabilization securities were introduced to mop up excess liquidity in the banking system which may lead to inflation.

Due to the sustained excess liquidity in the system, cash reserve requirements, direct credit ceiling, interest rates changes, stabilization securities and other measures were used to maintain monetary restraint policy. Between period of 1976 to 1981, the monetary policy instrument were the same but fine-tuned between the periods of 1981 to 1985. These include selective credit control to encourage small scale enterprises, marginal upward adjustment of interest rates,

maintaining the same Cash Reserve Requirements (CRR), stating the legal aggregate credit expansion and guidelines on the sectoral allocation of banks' loan and advances to improve some selected sectors in the real economy (see for instance Ogli, 2008 and CBN, 2011).

The Indirect Controls; the introduction of SAP in July 1986 has diametrically changed the economic atmosphere in Nigeria. The program aimed to put in place a market system that will efficiently allocate resources and hence do away with the bottlenecks inherent in direct controls. This was done through exchange control liberalization, trade liberalization and the liberalization of financial sector among others. In an attempt to mop up the liquidity in the banking system in 1989, the government directed the withdrawal of all public sector account from commercial banks. However, this policy was reversed in 1999 when the government transferred the retail function of CBN to commercial banks. Other adjustment during that period include; rationalization of sectoral credit controls, deregulation of interest rate, reintroduction of the use of stabilization securities in 1990, increase in the commercial bank minimum paid up and the abolition of mandatory credit allocation mechanism in October 1996. Also, in strive to migrate from direct to indirect controls; Open Market Operation (OMO) was brought to the limelight.

The full pledge deregulation of interest rates in 1996 allowed banks to determine the term structure of their interest rates with respect to their customers. This did not deprive CBN its discretional right or power to ensure smooth operation in money markets through the interest rates or policy rates. The shift of the implementation of monetary policy from direct to indirect controls which was an aftermath of SAP, refocus the monetary policy horizon to a short term horizon (one year) from 1986 to 2001. Numerous targets and instruments were adopted during the one year time length given the broad objective of monetary policy for that year. The primary technique of monetary policy was OMO which was conducted holistically using Nigerian

Treasury Bills (NTBs). This operated in juxtaposition with Cash Reserve Ratio (CRR) and the liquidity ratio (LR). The year 2002 marked the commencement of a two year medium term monetary program aimed at solving the problem of time inconsistency of monetary policy as well as reducing the overreaction due to temporary shocks.

In December 2006, MRR was replaced with MPR. The MPR is believed to be more effective in steering interest rates and was brought down to 10 per cent from 14.0 per cent MRR with a lending rate of 13.0 per cent and a deposit rate of 7.0 per cent, (seeOgli, 2008). This culminated to a 600 basis points (bp) corridor with a standing facility aimed at reducing volatility in interest rates and more specifically interbank rates. CBN maintain the use of reserve requirements and discount window operations. Furthermore, the non-remuneration of the overnight standing deposit facility rendered discount widow operations less significant.

The 2007 general election, impact of the scarcity of refined petroleum product and pipeline vandalization in the Niger-Delta among others posed a potential rise in inflation which was at a single digit of 8.5 percent.On the other hand, because of the forecasted downside risk, in June 2007, MPR was reduced by 200 basis points from 10 percent to 8 percent and interest rate corridor was reduced from +/-300 to +/-250 basis points around the MPR(CBN, 2017). Consequently, the deposit facility was brought down to 5.5 percent while lending was brought down to 10.5 percent from 7 and 13 percent respectively. In addition, there was increase in the issuance of primary market instruments to mop up the liquidity of about 100 billion naira at that time (CBN communiqué no.50).

The conduct of monetary policy by the central bank of Nigeria between 2008 to 2011 was to a large extent influenced by the Global Financial Crises (GFC), which started in 2007 in the United States and stretched to other regions both developed and emergine markets, Nigeria

inclusive. The GFC created liquidity crises in the banking system, large quantum of non-peforming credits, large capital outflows and pressure on exchange rates, decline on oil prices and falling external reserves, spiky drop in government revenue, huge fiscal injections and collapse of the capital market. Corollary to the GFC, the CBN fundamentally adopted the policy of monetary easing andQuantitative Easing (QE) to address the problem of liquidity shortages in the banking system from September 2008 to September 2010. The monetary policy easing put in place during this period (September 2008 to September 2010) include progressive reduction of MPR from 10.25 percent to 6 percent, stoppage of aggressive liquidity mop-up since September 2008, reduction of CRR from 4 percent to 2 percent and 1 percent, reduction of LR from 4 percent to 3 percent and 2.5 percent and injection of N620 billio as tier to capital in 8 troubled banks(see for instance, CBN, 2017).

Having restored stability and the re-emergence of liquidity surfeit in the banking system, the central bank adopted a tightening stance from September 2010 to December 2011. This was because, the monetary policy easing in juxtaposition with huge fiscal expansion put much pressure oninflation, exchange rate and external reserve.The tightening was manifested through a progressive increase in MPRfrom 6 percent to 12 percent, an increase increase in CRR from 1 percent to 2 percent to 4 percent and 8 per percent, LR was also increased from 25 percent to 30 percentnet. More so, Net Foreign Exchange Open Position (NOP) was increased from 1 prcent to 5 percent but later reduced to 3 percent., the mid-point of foreign exchange band was shifted from N150/US $1 +/-3 percent to N155/US $1 +/-3 percent. The year 2012 was characterized by continuing threats of inflationary pressure against the backdrop of declining trend in output grouth. Consequently, the MPC maintained MPR at 12 percent with asymmetric corridor of +/-

200. To further maintain the tightening stance, CRR was raised from 8 percent to 10 percent and NOP was reduced from 3.0 percent to 1.0 percent in July 2012 (CBN, 2017).

According to CBN (2017), the main issue facing Nigerian monetary policy makers in 2013 was maintaining alreadymoderated inflation which was achieved in the second half of 2012. Thus, almost all the policy instruments were sustained in order to maintain the status quo. Nevertheless, in 2014, exchange rate experienced a considerable pressure during the second quarter due to largely the impact of US Fed tapering, declining oil prices, depletion of the foreign exchange reserves and the absence of fiscal buffers. In response to these, the CBN moved the exchange rate mid-point from N155/US $1 to N168/US $1 and widen the band around the mid-point from +/-3 percent to +/-5 percent. Furthermore, it was observed that the financial sector was stable in 2014, but nonetheless, a significant fluctuation was observed towards the end of the year. To achieve price and financial system stability in order to boost investor confidence and to reduce decline in foreign exchange reserve, MPR was raised by 100 basis points, that is, from 12 percent to 13 percent while asymmetric corridor was maintained at +/-200 around the MPR. Furthermore, CRR on private sector deposits was raised by 500 basis points, that is, from 15 percent to 20 percent while CRR on public sector was raised by 250 basis points (from 50 percent to 75 percent).

The Nigerian monetary policy space in the first half of 2015 was faced with prolonged weakness in global oil and commodity prices which trickled down to domestic economy through falling foreign reciept and erosion of foreign reserve as well as sustained presure on exchange rate which culminated to slower output growth. Moreover, the overflow of capital reversal coupled with the speculative activities in the foreign exchange market led to a cosiderable depreciation of naira from N180/US $1 at the end of december 2014 to N196/US $1 by the end of June 2015.

More so, the pass-through of import prices and energy cost led to a gradual rise in inflation rate to 9.2 percent from 8 percent during the period. Against this background, systematic measures were taken to curtail speculative activities in the market, to stem the depreciation of the naira and prevent the emergence of multiple exchange rate regimes. Accordingly, the MPR was retained at 13 percent with asymmetric corridor of +/-200 around the MPR, while CRR on public and private sectors deposits were harmonized at 31.0 percent. These measures, stablized the financial markets and tranquilized the expectation. Consequently, the interbank market retes remained within the policy rate corridor, the depreciation of exchange rate moderated and the bearish trend in the capital market reduced towards the end of 2015.However, in November 2015, the MPC, in consideration of the weakening fondamentals of the economy especially the low output growth, rising unemployment and the uncertainty of the global economic enviroment, reduced the MPR from 13 percent to 11 percent and reduced CRR from25 percent to 20 percent with MPR revolving around the asymmetric corridor of +2/-7. Furthermore, the MPC emphasized that the liquidity easing from the reduction of CRR will only be released to banks that are willing to channel it to employment elastic sectors such as agriculture, infrastructure development, solid mineral and industry (see CBN, 2017 for more discussion).

The central bank of Nigeria had to a large extent stabilized the financial system in the midst of the aftermath of Treasury Single Account (TSA) withdrawals and the delisting of Nigeria by JP Morgan. However, the goal of increasing lending to employment generating sectors is yet to be achieved. In view of this, the MPC retained MPR at 11 percent, CRR at 30 percent andasymmetric corridoraround +200/-700(see MPCcommuniqué No.105 for more details). The year-on-year inflation rate reached 11.38 percent in Febuary 2016, this was associated to the structural factors like persistent scarcity of refined petroleum product, exchange rate pass-

through from imported goods, seasonal factors and increase in electricity tarrif other than monetary factors. Accordingly, MPC tighten is stance by increasing MPR by 100 basis points, that is, from 11 percent to 12 percent, raise CRR by 250 basis points that is, from 20 percent to 22.50 percent, return LR to 30 percent and narrow the asymmetric corridor from +200/-700 to +200/-500 basis points. More so, it was observed in May 2016 that the year-on-year inflation rate increased to 12.77 percent in Marcch and 13.72 in April from11.38 in Febuary (CBN communique No. 107). It was noticeable that, while the conditions that necessitated monetary policy tightening are till in place, the economy was faced with unemployment and low output, hence stagflation. Thus, the CBN was faced with the task of balancing stability with growth. as a result, the MPC in May 2016, retained MPR at 12 percent, CRR at 22.50 percent, LR at 30 percent and asymmetric window at +200/-500 basis points around the MPR.. more so, the central bank intoduced a greater flexibllity in the interbank foreign exchange market structure and also retain a small window for critical transactions (see CBN, 2017 and MPC Communique No. 107 for more facts).

It was clear from the overview of monetary policy in Nigeria that:

i. Prior to the Structural Adjustment Program (SAP), that is 1959 to 1985; the CBN used direct monetary controls to implement monetary policy in Nigeria which accommodated exchange rate targeting monetary policy framework.
ii. The exchange rate targeting was abolished in 1974 as a result of extinction of the Bretton Woods system, and as a result, monetary targeting was implemented.
iii. The indirect monetary control was implemented in 1986, and a short term monetary policy horizon (one year) was operated between 1986 and 2001. Furthermore, from 2002 a medium term (two year) monetary program was

commenced in order to solve the problem of time inconsistency and overreaction due to temporary shocks and

iv. Lastly, the CBN reacts to changes in macroeconomic variables by adjusting the Monetary Policy Rate (MPR).

Thus, it can be concluded that, the CBN reacts to the fluctuation of the macroecomic variables by changing not only the MPR, but also, other accommpanying instruments like Cash Reserve Requirements (CRR), Liquidity Ratio (LR) Net exchange rate Open Position (NOP) as well as the asymmetric corridor around the MPR in order to stabilize prices and financial markets. However, when these policy instruments seem to be less effective, for instance between 2008 and 2010 (during the global financial crises), the instruments were complemented with injection of Quantitative easing (QE) to achieve opimal monetary policy goal of price stability and non-inflationary growth.

CHAPTER THREE

METHODOLOGY

This section explains the sets of methods that have been used to achieve the objectives of this study.

3.1 Theoretical Framework

This work is anchored on the New Keynesian Policy Model (NKPM) as the theoretical framework. Corollary to the fact that the NKPM framework clearly provides a rigorous justification for the cost of inflation and the benefit of price stability which is in tendem with the primary mandate of the CBN. More so, the theory postulates that if the cost push inflation (which is exogenously determinedand taken as the white noise u_i) is assumed to be zero,u_i=0, the presence of nominal rigidity will be the only source of possible inefficiency in the level of output. If such happens, inflation will become an indication of an ineffecient level of activity in the economy (Gali,2009). Furthermore, the forward looking nature of price setting and consumption decision in NKPM signifies that both output and inflation depend not only on the value of their determinants, but alsoon their expected future values.Hence, it encompasses the role of expectation and the importance of commitment. This is in line with the Taylor rule which this work intends to estimate and hence, the suitability of the NKPM as the framework of this research.

More so, the NKPM imbibes several tools associated with RBC such as Dynamic Stochastic General Equilibrium (DSGE) models based on optimizing behavior of households, firms, rational expectations and market clearing. Thus, using DSGEwill simplifythe estimation, hence,circumventing the problems attached to the use of macroeconomic models (Lucas

critique).Furthermore, nominal rigidities establish the main sources of monetary policy non-neutrality. The natural level of output and interest rate plays a vital role in the design of monetary policy in the NKPM framework. But in real terms, the natural rates are very difficult to observe.Hence, the use of proxies like detrended GDPas output gap (see Gali,2009; Snowdon and Vane, 2005 and Bello 2014 for more evidence).

The NKPM places much premium on monetary policy rule which entails the endogenous components of monetary policy rather than the effect of exogenous changes in monetary policy instrument. Consequently, NKPM framework can be used as a tool for evaluating the desirability of alternative rules as well as determining the optimal rule using welfare based criterion. This is in line with one of the pillars on which CBN anchors monetary policy in Nigeria (monetary policy should be rule based) for example Taylor rule.The foregoing justifies the situation of the work within NKPM as it is now clear that it provides theoretical postulates that support the choice of the monetary policy rule (that is, Taylor rule) this work intends to use. Moreover, the choice of the NKPM followed Peterson (2007), Surico (2007), Cukierman and Muscatelli (2008) and the study of Bello and Sanusi (2016).

3.2 The Model

Starting with the linearized objective function of the CBN,we followthe NKPM to assume that the CBN maximizes the use of the nominal anchor (i) through a committee's vote. The use of this nominal rate is assumed to be maximized when some sets of the CBN target variables deviate from their respective optimum. The set targets are assumed to be consistent with the mandate of the central bank, which also corroborates the generalized form of the Taylor's rule as express in eq. (3.1)

$$\boldsymbol{i} = \boldsymbol{f}(\boldsymbol{\pi_t}, \boldsymbol{y_t}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.1)}$$

From equation 3.1, i represents the monetary policy rate (MPR), $\pi_t$is the inflation rate and $y_t$is the output gap. π_tIs the current rate of inflation which is used to capture the rate of change in current prices while π_{t+1} is the forecast of future inflation with forecasting horizon of one quarter ahead. Apart from the forecastability, including the lead value of inflation (π_{t+1}) improves the model(Taylor, 1998). This functional expression connotes the specified variables in the baseline Taylor's rule. Explicit form of the functional relation, however, considers a central bank that targets deviations of the actual output from potential level and the deviation of the actual inflation from the expected inflation. In other words, the incorporation of the output gap and a forward-looking central bank is in line with the literature, (see for instance Claridaet al. 1998). These deviations targeted by the CBN can be expressed in eq. (3.2) as:

$$\boldsymbol{i_t = \beta_\pi \pi_t + \beta_{1\pi} \pi_{t+1} + \beta_{YGAP} \tilde{y}_t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.2)$$

Eq. (3.2) is referred to as the rational expectations model which assumes a CBN that incorporates the information on both current inflation and future expected inflation when taking decisions on current Monetary Policy Rate (MPR). The econometric form of the model is expressed as:

$$\boldsymbol{i_t = \beta_\pi \pi_t + \beta_{1\pi} \pi_{t+1} + \beta_{YGAP} \tilde{y}_t + u_t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.3)$$

Where π_{t+1}represent the lead value of inflation (i.e. forecast of inflation for the next quarter).

Eq. (3.3) captures baseline linearized monetary rule which ignores some other important commitments of the CBN. One of these omitted commitments is the weight the CBN could be giving to exchange rate due to the openness of the Nigerian economy and the mandate the CBN commits to in assisting the government to achieve other macroeconomic objectives subordinated to its primary mandates. It also includes other financial and assets markets variables that the MPC takes in to consideration when changing policy rates decision. This complexity will be

accounted for by including exchange rate in the model, which also accounts for the possibility of exchange rate targeting during the sample period.

$$\boldsymbol{i_t = \beta_\pi \pi_t + \beta_{1\pi} \pi_{t+1} + \beta_{YGAP} \tilde{y} + \beta_E EXR_t + u_t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.4)$$

The equation (3.4) incorporates exchange rate EXR_t as suggestedby (Ogli, 2008; Siri, 2009, Agu, 2011 and Bello 2014) to account for the openness of the Nigerian economic.

The central proposition which departs from Agu (2007), Ogli (2008), Tolulope and Ajilore (2013), Bello (2014) and Bello and Sanusi (2016) is the evidence of asymmetries that might exist in the MPR setting behavior of the CBN. For instance, the dissenting behavior among MPC members could be attributed to asymmetries which are either cause by the individual MPC members cognitive capacity (this is consistent with Bounded rationality theory) or as a result of individual preferences of a member. Also the evidence of variations and divergence in MPR decisions across different regimes of CBN governor could also highlight some evidence of nonlinearity in the CBN reaction function. Furthermore, different phases of the business cycle could induce nonlinearity in the reaction of CBN as evidenced during the global financial crises of 2008. The key form of nonlinearity this work tries to capture, however, is the possibility of non-linearity in the weights monetary policy attaches to each of its target variable under different circumstances. For instance, one would not expect the response of policy to say output, to be the same at all levels of inflation. It is conceivable that when inflation is well within its target (below some threshold), the central bank would respond more strongly to changes in output gap (or exchange rate) relative to when inflation is threatening to get out of, or is well outside its target level. In the same vein, for every policy action taken,the central bank's interest rate settingis responding to movement in only one target variable, say, inflation (even when the other is actually changing).One can therefore think of possibility of, say, two regimes of defined by the

levels of inflation (high vs low inflation) or level of exchange rate volatility (high vs low volatility) or even in trend (to capture, say different regimes of the governors). The Threshold Autoregression Models provides a convenient form of this form of non-linearity, by allowing transition from one regime to another with each regime having distinct parameters.Therefore, the baseline policy rule of the CBN can be modified to internalize this nonlinear attributes of the CBN reaction function following Ncube and Tsuma (2010) by adding a nonlinear transition function to (3.4) thus:

$$\boldsymbol{i_t = \beta_\pi \pi_t + \beta_{1\pi} \pi_{t+1} + \beta_{YGAP} \tilde{y}_t + \beta_E EXR_t + \beta_i i_{t-1} + G(s_{t-i}, \gamma, c) + u_t} \ldots\ldots\ldots\ldots\ldots (3.5)$$

Wherei_{t-1}stand for the smoothing parameter (lag value of the dependent variable),G is the nonlinear transition function which captures the transition from one regime to the next or from one phase of the business cycle; (for instance boom), to the other; (for instance recession), $s_{t-i}$is the transition variable which is akin to the primary mandate that triggers changes in MPR decision, γ measures the speed of transition function which ranges from zero to one (0 to 1) and thus the smoothness of the transition function from one regime to the other as suggested by (Van Dijk, Terasvirta and Frances, 2002). The lesser the differential between any two regimes, the smoother and faster will be the regime change from one regime to the next (for instance from high inflation regime to low inflation regime). And c can be interpreted as the threshold between the two regimes in such a way that the function changes monotonically from zero to one Vice versa. The explicit form of the following equation;

$$\boldsymbol{G(s_{t-i}, \gamma, c) = [(1 + exp\{-\gamma(s_{t-i} - c)\})^{-1}]} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.6)$$

The transition function stated above is referred to as the Logistic Smooth Transition Regression (LSTR). An alternative specification to the transition function is the Exponential Smooth

Transition Regression (ESTR);

$$\boldsymbol{G}\,(\boldsymbol{s_{t-i}}, \boldsymbol{\gamma}, \boldsymbol{c}) = \mathbf{1} - \boldsymbol{exp}\{-\boldsymbol{\gamma}(\boldsymbol{s_{t-i}} - \ \boldsymbol{c})^2\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.7)$$

The final form of the nonlinear reaction function is expected to yield a semi-parametric non-linear reaction function of either the LSTR or ESTR as express below:

$$\boldsymbol{i_t} = \boldsymbol{\beta_\pi \pi_t} + \boldsymbol{\beta_{1\pi} \pi_{t+1}} + \boldsymbol{\beta_{YGAP}} \tilde{\boldsymbol{y}} + \boldsymbol{\beta_e EXR} + \boldsymbol{\beta_i i_{t-1}} + (\boldsymbol{\beta_\pi \pi_t} + \boldsymbol{\beta_{1\pi} \pi_{t+1}} + \boldsymbol{\beta_{YGAP}} \tilde{\boldsymbol{y}} + \boldsymbol{\beta_e EXR} + \boldsymbol{\beta_i i_{t-1}}) \boldsymbol{G}(\boldsymbol{s_{t-i}}, \boldsymbol{\gamma}, \boldsymbol{c}) + \ \boldsymbol{u_t} \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.8)$$

3.3Estimation

A nonlinear policy behavior can only be best explained by a nonlinear time series model. There exist a number of competing nonlinear time series models to select from; the Marcov-switching model, Artificial Neural Network (ANN) and the Smooth Transition Regression (STR). This resaerch has chosen STR over others because of the following reasons;

Although the ANN has the advantage of fitting in to the in-sample data to any degree, it isincapable of explaining the structural or intuitive explanation for the observed nonlinearity. Also the Marcov-switching model does not make provision of the intuitionbehind the nonlinear policy behavior because the model assumes that the regime switch are exogenously determined and driven by an unobservable process as observed by (Peterson,2007). On the other hand, the STR provides a structural and intuitive framework to explain nonlinear policy behavior. Specifically, the STR is a nonlinear regression model that allows the regression coefficient to change smoothly from one regime to another. For instance, from low inflation regime to a high inflation regime or from a “boom” regime to a recession regime of the business cycle.

Furthermore, the STR model accommodates endogenous regime switch and thus, offers economic intuitions for nonlinear behaviors. Also according to Cukierman and Muscatelli

(2008), the STR allows short term nominal interest rate to react marginally to expected output and inflation gaps and to change smoothly over the range of the reaction function(Bruinshoofd and Candelon, 2004 and Castro, 2008).Thus, STR provided us with the structural impetus to estimate the nonlinear behavior inherent in monetary policy and also to explain the economic intuition behind the asymmetric policy behavior the reaction function of CBN might portray.

In the case if the LM test of linearity eventually rejects nonlinearity, Two Stage Least Square Regression will be employed to estimate the linear model. This is because the smoothening parameter $\beta_i i_{t-1}$**,**is the lagvalue of the dependent variable which might lead to the problem of endogeneity. When nonlinearity is found, Nonlinear Two Stage Least Square will also be used to estimate the model in other to verify the results of the STR.

In order to achieve the first objective of this study, which is to emperically examine the linearity assumption in the estimates of MPRF in Nigeria, LM linearity test has been carried out. The linearity test is a pre-test, which ascertains the existence of linearity or the lack of it.*Jmulti*softwareis used to check if there is nonlinearity in the model. The null hypothesis of linearity is H_0: $B_1 = B_2 = B_3 = 0$, also, the linear restriction is checked by applying an F-test. It is also used to determine the type of model to be used, that is, either LSTR (Logistic Smooth Transition Regression) or ESTR (Exponential Smooth Transition Regression). The p-values of the F-statistics are labeled F4, F3 and F2. If the lowest p-value falls within F2 or F4, LSTR (Logistic Smooth Transition regression Model) will be recommended. On the other hand, if the smallest p-value falls under F3, ESTR (Exponential Smooth Transition Regression Model) is recommended. In the same vein, the transition variable $S_t$is determined as the variable with the strongest rejection of the null hypothesis (variable with the lowest P-value).IfS_t(transition variable) is an element ofZ_t(exogenous variables), we use the following auxiliary regression;

$$\boldsymbol{y_t = \beta_0^{i} Z_t + \sum_{j=1}^{3} \beta_j^i Z_t s_i^j + u_i^*}$$ ……………………………………………..(3.9)

In a case where S_t is not part of Z_t,for instance, Trendwhich is the time horizon, note that transition variable must not necessarily be amongst the explanatory variable, at times trend may be selected as the transition variable. (See Van Dijk, et al. 2002 and Kavkler, Mikek, Bohm, & Borsie, 2008), we use;

$$\boldsymbol{y_t = \beta_0^{i} Z_t + \sum_{j=1}^{3} \beta_o^i Z_t s_i^j + u_i^*}$$ ……………………………………………..(3.10)

Objectives two and three will be achieved using the nonlinear Taylor model, that is using equation (3.8) which adapted Taylor rule as used by Clarida et al. (2000) and synthesized it with the STR model as specified by Terasvirta et al. (2002)

3.4Data and Data Sources

This work will employ quarterly data from 2007:Q1 to 2016:Q2. Data on inflation rate will be used as the quarterly changes in the aggregate consumer price index. Gross Domestic Product (GDP) will proxy output from the domestic economy and output gap is obtained using Hodrick-Prescott filters. Interbank US Dollar exchange rate is used as foreign exchange. This is so because international transaction between domestic economy and rest of the world is measured in terms of the US dollar. Moreso, the net international reserve of the country is kept in dollar. All the data are obtainable from the CBN online data base with exception of GDP which was obtained from National Bureau of Statistics (NBS).

CHAPTER FOUR

Data Presentation,Analysis and Discussion of Results

In this chapter, presentation, interpretation and discussion of the results are done based on the estimated models and in line with the laid down objectives of the study. Firstly, it starts with the graphical presentation of the variables contained in the reaction function, descriptive statistics, correlation test, unit root test, linearity test and theestimation of the baseline model (theoretical model). Furthermore, the chapter then proceeds with the linearity test for the open economy model as well as its estimation using two models: Smooth transition Regression (STAR) model and a single equation model using Nonlinear Two Stages Least Square (N2SLS) estimation technique.

4.1.1Trend Behavior of Variables

This section provides trend of the series as presented in figure 1. From the plots, the behavior of the series shows that the average behavior of the variables are all trending upwards with the exception of the output gap.

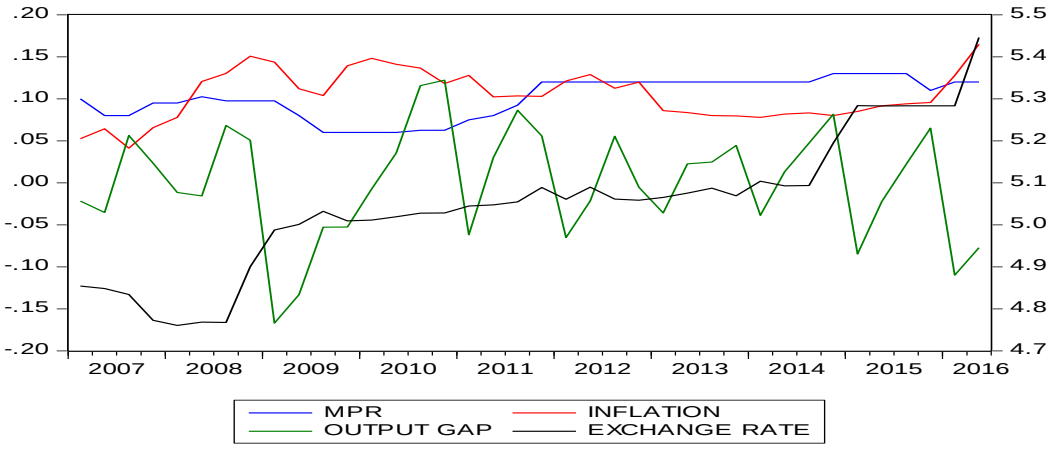


Figure 1*: Trend Behavior of Variables. Note: the right scale is for the log of exchange rates while the left is for MPR inflation and outputgap.*

The upwards trend in the series (monetary policy rate, inflation and exchange rate) suggest that the mean and the auto covariance of the series could be non-zero. Also the fluctuation in the trend is an indication that the series is overtaken by underlying economic fundamentals which are dynamic in nature. Next is to compute the simple statistics in the series and compare how the statistics differ among the variables.

4.1.2 Descriptive Statistics

The use of descriptive statistics enables us to quantitatively summarize, describe and present the main feature of the data in a meaningful way and thus, allows for an easier interpretation of the data. The descriptive statistics is computed in table 4.1.

Table 4.1: Results of Descriptive Statistics

	I	π	*YGAP*	*EXR*
Mean	0.101250	0.104587	1.03E-12	157.4397
Median	0.106250	0.103100	0.003857	157.0150
Maximum	0.130000	0.164800	0.122168	231.7600
Minimum	0.060000	0.041200	-0.166957	116.7900
Std. Dev.	0.023715	0.029301	0.066248	25.53153
Skewness	-0.548103	-0.001776	-0.403893	0.626208
Kurtosis	1.918263	2.296522	2.837209	3.656796
Jarque-Bera	3.755383	0.783582	1.075112	3.166552
Probability	0.152943	0.675845	0.584174	0.205301

Source:Authors computation using E-view 9

The descriptive statistics presented in table 4.1 shows the mean, median, standard deviation and the skewness of the data among others. The standard deviations of MPR, inflation and output gap are relatively low;low value of standard deviation means that the values of MPR, inflation and output gap are close to their respective means on the average, hence, indicating less volatility in the series, while that of exchange rate is high;this means that the values of exchange rate are farther away from the mean on the average which implies volatility. Also, the result shows that the distributions of MPR, inflation and output gap are both negatively skewed, while only the distribution of exchange rate is positively skewed. The statistics of Jarque-Bera further revealed

that the variables of this study could not reject the null hypothesis of normality. Thus, the variables met the requirement of normal distribution. Furthermore, the study will proceed with the correlation test for more understanding of the relationship between the variables.

4.1.3 Correlation Tests

This study employed correlation test in other to find the strength of the relationship between two variables. In other words, the test statistically measures the degree to which changes to the value of one variable predicts change to the value of the other. The results of the test are presented in table 4.2.

Table 4.2: Results of Correlation Test

Variable	*I*	*π*	*YGAP*	*EXR*
I	1.000000			
π	-0.279674	1.000000		
YGAP	-0.077510	-0.189268	1.000000	
EXR	0.492988	0.191488	-0.160754	1.000000

Source: Author's computation Using E-views 9

The results of table 4.2 depicted that MPR has negative correlation with inflation and output gap but has a positive correlation with exchange rate. The magnitudes of the coefficients showed weak correlation between MPR and inflation and a weaker one between MPR and output gap. However, the correlation between MPR and exchange rate is the strongest (0.5), hence, implying that the relationship between MPR and exchange rate is stronger than that of other variables. This furthersuggests that interest rate setting behavior of the central bank responds (stronger) to changes in exchange rate than to other variables, in line with the exchange rate targeting strategy. The weakest correlation, being between interest rate and output gap, suggest that the interest rate setting may not have given strong response to changes in output. In addition, the relatively weak correlation of interest rate with inflation, relative to that with exchange rate further suggests the relative predominance of exchange ratetargeting during the sample period.

Having known the nature of relationship that exists between the dependent variable and the exogenous variables, the study will proceed by interrogating the existence of unit root in the data.

4.1.4 Unit Root Test

In an attempt to have robust results, that is, by avoiding spurious regression results, unit root test is conducted. There exist a number of unit root tests available like KPSS, Elliott-Rothenberg-Stock test, Schmidt-Phillips test, Augmented Dickey Fuller test and Phillips-Perron test among others.Due to the low power and poor performance of some of these tests on small sample as stated by Castro (2008), we employ and report two different unit root test, viz: Augmented Dickey Fuller (ADF) and Phillips Perron (PP), and these results are presented in table 4.3.

Table 4.3: Result of Unit Root Test

Variables	*ADF*		*PP*		
Comment	Levels	1st Difference	Levels	1st Difference	Decision
π	-1.781052 (-3.536601)	-4.741820** (-3.540328)	-2.009864 (-3.536601)	-4.697268** (-3.540328)	I(1)
Log(EXR)	0.668060 (-2.943427)	-3.843159** (-3.540328)	-1.706760 (-3.536601)	-3.872145** (-3.540328)	I(1)
i	-1.790747 (-3.540328)	-5.133957** (-3.540328)	-2.231906 (-3.536601)	-5.185220** (-3.540328)	I(1)

Source; Author's Computation Using E-view 9 *Note: values in parenthesis are the 5% critical values while ** indicates significance at 5% level in both ADF and PP.*

Results from table 4.3 shows that at levels, ADF and PP test statistic value of inflation is less than the test critical value at 5% level of significance, hence, indicating presence of unit root. Taking first difference of the inflation, using both ADF and PP, take care of the unit root and thus, become stationary at first difference I(1). Exchange rate also produced a test statistic value that is less than the 5% test critical value portraying the presence of unit root in the series using ADF and PP at levels. At first difference, using both techniques yielded test statistic values that are greater than the test critical values at 5% level of significance posing stationary at first

difference I(1). More so, the result portrayed that MPR like other variables is not stationary at levels but became stationary at first difference I(1) using both methods.

The unit root tests conducted have therefore indicated that all the variables have unit root problem at levels I(0), but became stationary at first difference I(1). More so, having solved the problem of unit root, the study proceeded with investigating the shape of the reaction function of CBN through linearity test.

4.2 Test of Nonlinearity in Monetary Policy Reaction Function

In an attempt to achieve the first objective of the study, which is to examine the empirical validity of the linearity assumption of the MPRF of the CBN, linearity test is utilized to check whether there exists a nonlinear of the STR type adjustment in the CBN reaction function. Following the tradition in the literature, these tests were conducted, first for the close economy version (baseline)and then, second, for the open economy version of the MPRF.

4.2.1 Linearity Test for Closed Economy

In choosing the transition variable, the test is conducted for all the potential variables in the model and the trend (see equation 3.9 and 3.10). The variable with strongest test rejection (variable with smallest p-value) is chosen as the transition variable and is, hence, *asterisked*. In the same test, the best model to estimate is selected. The best model has the lowest p-value. The results are shown in table 4.4.

Table 4.4: Result of Linearity test and Transition Variable for Baseline model (Closed Economy)

	$i_t = \beta_\pi \pi_t + \beta_{1\pi} \pi_{t+1} + \beta_{YGAP} \tilde{y} + \beta_E EXR_t + \beta_i i_{t-1} + u_t$			
Transition Variable	*F4*	*F3*	*F2*	*Suggested Model*
i_{t-1}	NaN	1.3506e-02	5.0599e-01	Linear
π_t	6.9687e-01	5.1477e-02	2.9492e-01	Linear
π_{t+1}	NaN	4.1352e-02	7.2037e-01	Linear
YGAP	6.1903e-02	8.3676e-01	2.0156e-01	Linear
*TREND**	1.3859e-01	5.0110e-02	6.8916e-01	Linear

Source; Authors Computation Using Jmulti4 Note: * indicates transition variable and NaN indicates Matrix inversion problem

Table 4.4 presents linearity test, choice of transition variable and the selection of the type of model to be used to estimate the closed economy in Nigeria. Trend (time horizon) appears to be the transition variable because it is the variable with the lowest p-value of F-statistics. Also, the test with all the potential exogenous variables (π_t, π_{t+1}, *YGAP*, i_{t-1}) failed to reject the null hypotheses of no nonlinearity and thus, suggesting linear model for all the variables. Note that statistically, when the speed of adjustment parameter $\gamma \rightarrow 0$, $F(s_{t-1})$ becomes a linear AR(p) model. Also, when $\gamma \rightarrow \infty$, $F(s_{t-1})=1$ and also become linear.

This therefore means, when the economy is closed, the CBN reacts linearly to change in inflation and output gaps.This impliedly means that, opening up the economy to external sector creates more fluctuations in business cycles due to *inter alia* exchange rate volatility and international oil price dynamics; this necessitated the central banks to react nonlinearly to changes in some macroeconomic variable (Bruinshoofd and Candelon, 2004; Peterson, 2007 and Surico, 2007). Theresults in table 4.4 shows that the MPRF of CBN under the assumption of closed economy is linear, hence, should be estimated as linear model. Castro (2008) obtained similar results for USA (which is also a close economy in terms of exchange rate).

Next, the study proceeds to estimate the parameters of the closed-economy model using Two Stage Least Square (2SLS).

4.2.2 Estimated Baseline Model of MPRF (Closed Economy)

The baseline theoretical model depicts a Taylor rule that assumes closed economy. To find out if the peculiarities of the Nigerian data fits in to the theoretical model, a linear model will be estimated as suggested by linearity test in table 4.4 using Two Stage Least Square (2SLS). The orthogonolity assumption of the 2SLS provides us with necessary justification and by extension the parameters would be devoid of autocorrelation problem that could occur as a result of including the lag of the dependent variable in the exogenous variables. We have estimated a number of specifications each with different combination of the possible endogenous variables, including the lags of inflation. The result presented here are the best fit based on standard model choice criteria. (Some of these estimations are presented in the appendix). These estimations are presented in table 4.5.

Table 4.5: Result of 2SLS Linear Baseline Model Estimation (closed economy)

Variable	*Coefficient*	*Std. Error*	*P-value*
Instrumental specification: i_{t-1} i_{t-2} i_{t-3} i_{t-4} i_{t+1} i_{t+2} π_{t-1} π_{t-2} π_{t-3} π_{t-4} π_{t+1} π_{t+2} π_{t+5} $Ygap_{t-1}$ $Ygap_{t-2}$ $Ygap_{t-3}$ $Ygap_{t-4}$.			
C	0.000195	0.001010	0.8488
π_t	0.209229*	0.069509	0.0062
π_{t+1}	-0.133606	0.089218	0.1479
$YGAP$	0.059002*	0.024318	0.0235
i_{t-1}	0.503521*	0.176534	0.0090
J-statistic	14.36830		0.2778
R^2	0.346957		
Durbin-Watson	2.374958		

Source: Authors computation using E-views 9. Notes: * is 5% level of significance at which null hypothesis is rejected

From table 4.5 the coefficient of inflation (π_t) has a positive sign and is significant at 5% level. Also, the coefficient is less than one; hence, this implies that the theoretical baseline model does not follow the Taylor's principle. This finding corroborates Bello and Sanusi (2016)and Siri (2009) in the case of CBN, while Naraidoo and Paya (2012) and Ncube and Tsuma (2010) obtained similar result for South African Reserve Bank (SARB).

The estimation of the baseline model (closed economy) also shows that the Nigerian data to a large extent fits in to the theoretical model. Bello (2014) found similar results. We now proceed with the estimation of an open economy model which bears some key feature that is consistent with Nigerian economy.

4.2.3Linearity Test for the Open Economy Model

The traditional Taylor rule (baseline model) contains only two variables which are: inflation and output gap. This study adds exchange rate to the baseline to open up the model to external sector so as to suit the peculiarity of Nigerian economy. This is consistent with the study of Clarida et al (1999) in the case of United States, Boroditskaya and Whittaker (2010) in the case of Russia, Ncube and Thsuma (2010) and Naraidoo and Paya (2012) in the case of South Africa and Bello and Sanusi (2016) for the case of Nigeria. The study proceeds with test for linearity and transition variable identification for the open economy model and the results are shown in table 4.6.

Table 4.6 Linearity Test and Transition Variable for Open Economy

Transition Variable	*F4*	*F3*	*F2*	*Suggested Model*
i_{t-1}	NaN	6.3211e-02	9.4845e-02	Linear
π_t	6.3119e-01	6.5077e-02	2.4951e-01	Linear
π_{t+1}	NaN	1.0874e-01	8.4177e-01	Linear
YGAP	1.5797e-03	8.8876e-01	2.9036e-01	LSTR1
EXR	1.9336e-01	4.9965e-02	1.9346e-01	LSTR2
*TREND**	3.5661e-02	1.3236e-03	4.4772e-01	LSTR2

Source; Authors Computation Using Jmulti4 *Note: * indicates transition variable and NaN indicates Matrix inversion problem*

Table 4.6 presents the preliminary analysis of linearity test of the open model. The choice of transition variable and selection of best model to be estimated in an open economy follows the statistics suggested from the presented results. This test is in-line with selection of the transition variable based on p-value of the F-statistic. It has appeared that the endogenous variable (i_{t-1}),

inflation (π_t) and the expected inflation (π_{t+1}) have all failed to reject the null hypothesis of no nonlinearity, and hence, fall under the AR or linear part of the model. On the other hand, YGAP(output gap), rejected null hypothesis of no nonlinearity and has its lowest p-value under F4, thus, recommends logistics transition of LSTR-type. EXRalso rejects the null hypothesis and hence, established the presence of nonlinearity in the model. Its lowest p-value falls under F3 which suggested exponential transition model of ESTR-type. TRENDhas the strongest rejection for linearity because it has the lowest p-value of all which lies under F3. This therefore means TRENDis chosen as the transition variable which means, over time, the combine effect of the dynamics of inflation and exchange rates induces the MPC to shift its interest rates decision asymmetrically and hence, transits from say, the lower interest rate regime to a higher oneSince the transition variable appears to be the trend, the coefficient of the thresholds (c1 and c2) will provide the time location of threshold values of inflation in the series. For instance, if c=10, we check the corresponding value of inflation at the 10^{th} quarter in the series and use it as our threshold value.Lastly, LSTR2 is overall recommended as the model to be used for the nonlinearities.

From the foregoing, therefore,it can be concludedthat:

i. The Central Bank of Nigeria's MPRF is empirically nonlinear.
ii. The MPC appears to react linearly to changes in current inflation and future inflation expectations and nonlinearly to output gap and exchange rates.
iii. Trend, being the transition variable, is identified as the primary cause of nonlinearity. In other words, the results show that trend which is the combine effect of time horizon of the exogenous variables with exception of output gap(because the time effect of output gap is not considered because it is de-trended using HP filters) induces CBN to shift its

interest rate decision from one regime to another, and hence, nonlinear. This can be interpretedas capturing the different regimes of governors, whose attitudes towards the different target variables (output Vs Inflation) differ substantially.

iv. It also established that the exponential smooth transition regression (ESTR) is the best fit model to be estimated. The transition function of the ESTR bears a U-shape and this shape is defined by the two threshold values; (the values at which the regime switches), that is, the lower threshold, below which the MPC react mildly towards tightening and the upper threshold, above which the MPC will behave very aggressively towards tightening.

4.2.4 Estimate of the Open Economy Nonlinear MPRF

To estimate the nonlinear model, ESTR is employed as suggested in table 4.6, and to verify its efficiency, the study further estimates a simple quadratic non-linear form of the model usingN2SLS estimation technique. Table 4.5 depicts the results of the estimations using the two techniques. The ESTR has AR (linear) and non-linear parts of the reaction function of CBN. Variables that fail to reject the null hypothesis of no nonlinearity fall within the AR part while variables that reject linearity fall under nonlinear part.

Putting the results of ESTR and that of N2SLS in table 4.7 in juxtaposition, it can be deduced that; the result of N2SLS strengthens that of ESTR;both results yielded reasonable estimate that predicted how CBN reacts to the dynamics in macroeconomic variables.In addition, although is not always that the R^2 is desirable when the lagged dependent variable is included in the exogenous variable and also when using an instrumental variable associated estimation.This is because, more often than not, the Residual Sum Square (RSS) is greater than the Total Sum Square (TSS) which can lead to a misleading result, see for instance (Davidson & Mackinnon,

1999).Nevertheless, the R^2value in ESTR is greater than that of N2SLS which indicates that the exogenous variables in the former have more capability to explain changes in the dependent variable (MPR) than the later. Lastly and also importantly, the ESTR model provided an intuitive explanation of the nonlinear behavior of the monetary policy authority in changing policy rate (for example, the transition variable, the threshold values and the speed of regime change) which will be used to achieve the third objected of the study, while the estimates of N2SLS result have no provision for that. The above outlined facts further confirmed the rationale of our selection of the ESTR as our model; hence, interpretation, discussion, conclusion and recommendations of this study are based on the ESTR results in table 4.7.

Table 4.7: Result of Estimated Nonlinear Monetary Policy Reaction Function (open economy)

Variable	N2SLS	LSTR2
	Linear Part	**Linear Part**
π_t	0.234213	0.19648
	(0.0261*)	(0.0088*)
π_{t+1}	-0.127362	-0.10513
	(0.1531)	(0.1511)
i_{t-1}	0.464846`	0.01792
	(0.0125*)	(0.8913)
		Nonlinear Part
C	-0.047459	-0.00063
	(0.0739**)	(0.6188)
YGAP	0.060972	0.02250
	(0.0339*)	(0.2284)
EXR		-2.05939
	Nonlinear part	(0.0375*)
EXR^2	0.000469	
	(0.0747**)	
J-statistic	13.91564	
	(0.176875)	
R^2	0.399932	0.56008
Durbin-Watson	2.417846	
γ		1020.765
C1		15.03382
C2		17.98733

Source: Authors computation using E-views 9 for N2SLS and Jmulti4 for LSTR2. *Instrumental specification for N2SLS:π_{t-1} π_{t-2} π_{t-3} π_{t+1} π_{t+5} i_{t-2} i_{t-3} i_{t-4} i_{t+1} i_{t+2} $Ygap_{t-1}$ $Ygap_{t-2}$ $Ygap_{t-3}$ $Ygap_{t-4}$ EXR_{t-1}. Notes: values in parenthesis are the p-values, * and ** are 5% and 10% level of significance at which null hypothesis is rejected, γ is the slope parameter (speed of adjustment), **C1** and **C2** are the threshold values in the LSTR2.*

Theresults of LSTR2 presented in table 4.7 reveals that MPC reaction to inflation is less than 1 which is (0.19648) and hence, contravenes the stability condition for the Taylor principle to hold, suggesting thatthe CBN is not following Taylor principle, which states that the response to inflation must be greater than one. This may, however, not necessarily be true for the CBN given that the interest rate does not capture the MPC's entire response to inflation or output. It uses a host of other instruments like asymmetric corridor, cash reserve ratio and liquidity ratio, etc. The results show that the coefficient of inflation varies from 0.00,when the inflation is below the lower threshold of between 10%, to 0.196 when the inflation is above 10%, more so, the CBN behaves aggressively when inflation reaches the upper threshold value of 14% or higher. Since trend is statistically chosen as the transition variable, which is the time, and the estimated

threshold values or locating parameters (c1 and c2) are 15 and 18 in table 4.7. We checked quarter 15 in the series which corresponds with (2010:Q3) with inflation value of 13.65% (14%) as the upper threshold and quarter 18 (2011:Q2) with inflation value of 10.23% (10%) as the lower threshold respectively.

The less than unity of the coefficient of inflation could therefore be perceived of as an indication of an accommodative behavior of interest rate to inflation which may generate deliberate bursts of inflation and output. The less than unity of the coefficient of inflation in the result concur with the findings of Siri (2009) and that of Bello and Sanusi (2016) in their study of CBN reaction function. The result is also consistent with the findings of Ncube and Tsuma (2010) and that of Naraidoo and Paya (2012) in their separate studies of the reaction function of South African Reserve Bank (SARB). The coefficient has the expected positive sign and it is significant at 5% level. This demonstrates that the MPC is striving to achieve its primary mandate of price stability by being anti-inflationary in nature. The magnitude of the coefficient of inflation (0.196), illustrates that for a 1% rise in inflation, the MPC will react by raising MPR with about 20 basis points to curb inflation from exceeding the desired limit.

The estimate of the lead value of inflation (forecasted inflation) has a wrong sign (negative) and is not statistically significant. The reason for this could be connected to the fact that under nonlinear economic terrain, it could be very difficult for the CBN to appropriately forecast inflation beyond the current quarter. In other words, the result is implying that during economic fluctuation (for instance, recession or boom), the MPC cannot correctly forecast inflation for the next quarter. This has portrayed the weakness of the forecasting capacity of the MPC.This opposed the finding of Bello (2014) who estimated a linear model, and hence, posited that MPC can forecast one quarter ahead.

More so, the result displayed a positive sign on output gap with a very low magnitude (0.022) and statistically insignificant. This reveals that when output deviates (positively) from its potential level by 1%, MPC will react by increasing MPR by only 0.2 basis points. In other words, a positive output gap indicates that in a situation where if output falls below its potential level, a decrease in MPR will have a stabilizing effect on the economy. This is implying that the MPC is counter-cyclical despite the weakness of the coefficient. The insignificance of the result statistically, may also imply that the MPC does not prioritize output gap when changing MPR.This is in line with the result of Bello (2014) and Bello and Sanusi (2016).It may also be an indication that CBN could be operating a tacit inflation targeting. This is informed by the findings of Naraido and Paya (2012) which revealed that the coefficient of output gap is significant in the reaction function of South African Reserve Bank (SARB) before the period of inflation target and not significant during the period of inflation target.

The result further illustrated that MPC react strongly to changes in exchange rate. The estimate has negative sign, implying that the CBN reacts to the depreciation of exchange rate, in other words, CBN is playing an interventionist role whenever exchange rate exceeds certain band.The coefficient is statistically significant at 5% level and the size is remarkably high.This means that MPC placed more weight on exchange rate than other policy variables, suggesting the predominance of exchangerate targeting. This is not far from the fact that the current high inflation in Nigeria is mostly an aftermath of depreciation of Nigerian naira against the US dollar. The high magnitude of exchange rate further signifies the high correlation between exchange rate and the level of inflation in the Nigerian economy.In support of this result, the study of Sanusi and Bello (2016) disclosed that exchange rate influences the preferences of MPC members up to about 70%. This opposed the findings of Clarider et al. (1998), which showed

that, despite the fact that exchange rate is considerably more volatile than other coefficients; its magnitude in their estimation is substantially low compare to inflation and output gap.

The result also showed that the smoothing parameter has the expected positive sign which suggest that the MPC has tendency of non-accommodative behavior toward inflation.The coefficient is low, (0.018), implying that within a certain threshold (that is, when inflation reaches 14 percent), MPC members are aggressive in adjusting policy rate.The coefficient is statistically not significant, this suits the finding of Cobham, (2005) which maintained that interest rate smoothing is not desirable in an inter-quarter basis because it opposes monetary policy activism.

The speed of regime change parameter (γ) is high (1020.76) posing that the speed of shifting from say a low inflation regime to a high one is high. Since trend is the transition variable, which is the time, the estimated threshold values or locating parameters c1 and c2 are 15 and 18. Meaning that there exist regime switches at quarter 15 (2010:Q3) and 18 (2011:Q2). In other words, MPC act aggressively when inflation exceeds the corresponding values in quarter 15 and 18; 13.65% and 10.23% respectively. This is in line with the single digit "tacit inflation target" of CBN.

It can be deduced from the above discussion that:

i. Empirically, the reaction function of CBN is nonlinear because the LM test of linearity conducted, rejected the null hypothesis of no nonlinearity, and also, the apex bank is not following Taylor principle in the way and manner it adjusts its policy rates because the coefficient of inflation is less than one.

ii. The CBN reacts to inflation when the prevailing rate of inflation exceeds the lower threshold of 10% and reacts to exchange rate volatility when the rate of inflation is below that threshold.

iii. There exist a regime switch from high inflation regime between (2010, Q3)and low inflation regime (2011, Q2). Additionally, the reaction of CBN is mild when inflation is below the lower threshold of 10% (single digit), but was aggressive when the inflation was above the upper threshold of 14%. The result also shows that under the nonlinear terrain, the CBN could not correctly forecast future expected inflation beyond the current quarter.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

In this chapter, a holistic summary of the study, conclusions drawn from the findings as well as recommendations based on the findings of the study are presented.

5.1 Summary

This study sets out to re-estimate the monetary policy reaction function of the Central Bank of Nigeria using a non-linear approach, which was hitherto, variously, estimated using linear approaches. This study, therefore, empirically examined the linearity assumption in the estimates of the reaction function of CBN, identified the key variables to which the CBN react to in setting the policy rate and examined the asymmetric preferences of the CBN in setting interest rate.

The study is anchored on NKPM, which is suitable because it has synthesizes the RBC and the traditional Keynesian theory to produce a more sophisticated model that captures a forward-looking policy rule, which can test the appropriateness as well as help in choosing the optimal rule. Therefore, the baseline model, which is a closed-economy model, and an open-economy model of MPRF of CBN were estimated within the framework of New Keynesian Policy Model. The review of literature revealed that; studies on nonlinearity in the MPRF exist for some European countries,Japan and USA. However, only two studies exist on nonlinear MPRF in Africa, which are all on South Africa. All the studies reviewed on Nigerian on the MPRF were estimated using linear modeling approaches.

Nonlinear models like Marcov-switching model, Artificial Neural Network (ANN) and STR were evaluated, and STR was selected because it provides a structural and intuitive framework for explaining nonlinear policy behavior and it allows the regression coefficients to change

smoothly from one regime to another. Linearity test was carried out and Exponential Smooth Transition Regression (ESTR) was chosen as the best fit model for the MPRF of the CBN. ESTR was chosen because it provided intuitive explanation of the nonlinear behavior of the MPC.

This study empirically found that the MPRF of CBN is nonlinear in nature because the null hypothesis of no nonlinearity was rejected. The estimated reaction function reveals that the CBN has been counter-cyclical in its monetary policy, it reacts to increase in inflation by increasing the policy rate, and hence, it has some accommodative tendency of inflationary shocks. CBN reacts to inflation when it exceeds the threshold value of 10%, but reacts to exchange rate volatility when the level of inflation is within the single-digit band. The study also reveals that the CBN reacts only to current quarter inflation, and does not react to any of the leads of inflation. This may reflect the failure of the central bank to correctly forecast the expected inflation beyond the present quarter. It was further revealed that MPC does not place much emphasis on the output gap when changing their decision on MPR, but places greater weight on the exchange rate. This, we argue, is not surprising, given its volatility and its role in current inflation in Nigeria, hence, displaying the predominance of exchange rate targeting. It was also clear that MPC reacts very aggressively when inflation rate reaches the thresholds of around 14 percent, and when inflation is below 10%, its reaction is mild.

5.2 Conclusion

A key conclusion from this research is that the reaction function of CBN like many other central banks is indeed nonlinear in nature and the CBN forecast-ability of expected inflation is poor. Hence, this will to a large extent affect market expectation of future inflation and price setting behaviors of forward looking firms. Furthermore, because the CBN does not follow the

Taylor'sprinciple, the coefficient on the output gap was insignificant; it is a great sign that the CBN may be adopting the inflation targeting.

5.3 Recommendation

The following recommendations emanated from this study:

i. Nonlinear forecasting models should be used in forecasting inflation instead of linear ones. Since the reaction function of CBN empirically appeared to be nonlinear, nonlinear models will be more accurate and promising in tracking and forecasting inflation which is necessary for optimal monetary policy making.

ii. The monetary policy authority (CBN) should expand the horizon of its ability to forecast inflation so as to reduce information asymmetries between the apex bank and the markets. This can be done by expanding itsinflation and output forecasting unit and considering the adoption of the New Keynesian Policy Model.

iii. The policy rate setting of CBN should be non-accommodative of inflationary pressure (that is, to follow Taylor's principle) so as to solve the problem of high inflation in Nigeria.

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APPENDICES

A1: Descriptive Statistics

Date: 08/27/17
Time: 06:24
Sample: 2007Q1 2016Q2

	I	INFL	YGAP	EXR
Mean	0.101250	0.104587	1.03E-12	157.4397
Median	0.106250	0.103100	0.003857	157.0150
Maximum	0.130000	0.164800	0.122168	231.7600
Minimum	0.060000	0.041200	-0.166957	116.7900
Std. Dev.	0.023715	0.029301	0.066248	25.53153
Skewness	-0.548103	-0.001776	-0.403893	0.626208
Kurtosis	1.918263	2.296522	2.837209	3.656796
Jarque-Bera	3.755383	0.783582	1.075112	3.166552
Probability	0.152943	0.675845	0.584174	0.205301
Sum	3.847500	3.974300	3.92E-11	5982.710
Sum Sq. Dev.	0.020809	0.031767	0.162388	24118.79
Observations	38	38	38	38

B1: Correlation Test

	I	INFL	YGAP	EXR
I	1.000000	-0.279674	-0.077510	0.492988
INFL	-0.279674	1.000000	-0.189268	0.191488
YGAP	-0.077510	-0.189268	1.000000	-0.160754
EXR	0.492988	0.191488	-0.160754	1.000000

C: Unit Root TestC1.1: ADF Test for INFL at levels

Null Hypothesis: INFL has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.781052	0.6936
Test critical values:	1% level	-4.226815	
	5% level	-3.536601	
	10% level	-3.200320	

*MacKinnon (1996) one-sided p-values.

C1.2: ADF Test for INFL at First Difference

Null Hypothesis: D(INFL) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.741820	0.0028
Test critical values:	1% level	-4.234972	
	5% level	-3.540328	
	10% level	-3.202445	

*MacKinnon (1996) one-sided p-values.

C1.3: ADF Test for *i* at First Levels

Null Hypothesis: *i* has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.790747	0.6883
Test critical values:	1% level	-4.234972	
	5% level	-3.540328	
	10% level	-3.202445	

*MacKinnon (1996) one-sided p-values.

C1.4: ADF Test for *i* at First Difference

Null Hypothesis: D(*i*) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.133957	0.0010
Test critical values:	1% level	-4.234972	
	5% level	-3.540328	
	10% level	-3.202445	

*MacKinnon (1996) one-sided p-values.

C1.5: ADF Test for EXR at Levels

Null Hypothesis: LEXR has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.668060	0.9898
Test critical values:	1% level	-3.621023	
	5% level	-2.943427	
	10% level	-2.610263	

*MacKinnon (1996) one-sided p-values.

C1.6: ADF Test for EXR at FIRST Difference

Null Hypothesis: D(LEXR) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.843159	0.0255
Test critical values:	1% level	-4.234972	
	5% level	-3.540328	
	10% level	-3.202445	

*MacKinnon (1996) one-sided p-values.

C2.1: PP Test for INFL at Levels

Null Hypothesis: INFL has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.009864	0.5769
Test critical values:	1% level	-4.226815	
	5% level	-3.536601	
	10% level	-3.200320	

*MacKinnon (1996) one-sided p-values.

C2.2: PP Test for INFL at First Difference

Null Hypothesis: D(INFL) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-4.697268	0.0031
Test critical values:	1% level	-4.234972	
	5% level	-3.540328	
	10% level	-3.202445	

*MacKinnon (1996) one-sided p-values.

C2.3: PP Test for *i* Levels at

Null Hypothesis: R has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.231906	0.4589
Test critical values:	1% level	-4.226815	
	5% level	-3.536601	
	10% level	-3.200320	

*MacKinnon (1996) one-sided p-values.

C2.4: PP Test for *i* at First Difference

Null Hypothesis: D(R) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-5.185220	0.0008
Test critical values:	1% level	-4.234972	
	5% level	-3.540328	
	10% level	-3.202445	

*MacKinnon (1996) one-sided p-values.

C2.5: PP Test for EXR at Levels

Null Hypothesis: LEXR has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.706760	0.7281
Test critical values:	1% level	-4.226815	
	5% level	-3.536601	
	10% level	-3.200320	

*MacKinnon (1996) one-sided p-values.

C2.6: PP Test for EXR at First Difference

Null Hypothesis: D(LEXR) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-3.872145	0.0238
Test critical values:	1% level	-4.234972	
	5% level	-3.540328	
	10% level	-3.202445	

*MacKinnon (1996) one-sided p-values.

D: LINEARITY TEST

D1: Linearity test for Close Economy Model

```
***Sun, 13 Aug 2017 08:43:06 ***
TESTING LINEARITY AGAINST STR

variables in AR part:     CONST R(t-1) INFL(t) INFL1(t) YGAP(t)
param. not under test:
sample range:             [2007 Q3, 2016 Q1], T = 35

p-values of F-tests (NaN - matrix inversion problem):

transition variable      F            F4           F3           F2
suggested model
R(t-1)                   NaN          NaN          1.3506e-02   5.0599e-01
Linear
INFL(t)                  1.9430e-01   6.9687e-01   5.1477e-02   2.9492e-01
Linear
INFL1(t)                 NaN          NaN          4.1352e-02   7.2037e-01
Linear
YGAP(t)                  1.4974e-01   6.1903e-02   8.3676e-01   2.0156e-01
Linear
TREND*                   7.6837e-02   1.3859e-01   5.0110e-02   6.8916e-01
Linear
```

D2: Linearity Test for Open Economy Model

```
*** Sun, 18 Jun 2017 03:15:15 ***
TESTING LINEARITY AGAINST STR

variables in AR part:     CONST R(t-1) INFL(t) INFL1(t) YGAP(t) EXR(t)
param. not under test:
sample range:             [2007 Q3, 2016 Q1], T = 35

p-values of F-tests (NaN - matrix inversion problem):

transition variable      F            F4           F3           F2
suggested model
R(t-1)                   NaN          NaN          6.3211e-02   9.4845e-02
Linear
INFL(t)                  1.9702e-01   6.3119e-01   6.5077e-02   2.4951e-01
Linear
INFL1(t)                 NaN          NaN          1.0874e-01   8.4177e-01
Linear
YGAP(t)                  9.6851e-03   1.5797e-03   8.8876e-01   2.9036e-01
LSTR1
EXR(t)                   4.4731e-02   1.9336e-01   4.9965e-02   1.9346e-01
LSTR2
TREND*                   1.4836e-03   3.5661e-02   1.3236e-03   4.4772e-01
LSTR2
```

E1: Estimation Results

E1.1: Close Economy Model Estimation Using Two Stage Least Square

Dependent Variable: DR

Method: Two-Stage Least Squares

Date: 08/14/17 Time: 02:18

Sample (adjusted): 2008Q2 2015Q1

Included observations: 28 after adjustments

HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Instrument specification: DINFL(-1) DINFL(-2) DINFL(-3) DINFL(-4) DINFL(+2) DINFL(+5) YGAP(-1) YGAP(-2) YGAP(-3) YGAP(-4) DR(-2) DR(-3) DR(-4) DR(+1) DR(+2) DINFL(+1)

Constant added to instrument list

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000195	0.001010	0.192783	0.8488
DINFL	0.209229	0.069509	3.010119	0.0062
DINFL(1)	-0.133606	0.089218	-1.497531	0.1479
YGAP	0.059002	0.024318	2.426239	0.0235
DR(-1)	0.503521	0.176534	2.852254	0.0090

R-squared	0.346957	Mean dependent var	0.001250
Adjusted R-squared	0.233384	S.D. dependent var	0.008485
S.E. of regression	0.007429	Sum squared resid	0.001269
F-statistic	4.362041	Durbin-Watson stat	2.374958
Prob(F-statistic)	0.009033	Second-Stage SSR	0.000981
J-statistic	14.36830	Instrument rank	17
Prob(J-statistic)	0.277810		

E1.2: Open Economy Model Estimation Using Nonlinear Two Stage Least Square

Dependent Variable: DR

Method: Two-Stage Least Squares

Date: 05/22/17 Time: 14:45

Sample (adjusted): 2008Q2 2015Q1

Included observations: 28 after adjustments

HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)

Instrument specification: DINFL(-1) DINFL(-2) DINFL(-3) DINFL(+5) YGAP(-1) YGAP(-2) YGAP(-3) YGAP(-4) EXR(-1) DR(-2) DR(-3) DR(-4) DR(+1) DR(+2) DINFL(+1)

Constant added to instrument list

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.047459	0.025294	-1.876278	0.0739
DINFL	0.234213	0.098218	2.384623	0.0261
DINFL(1)	-0.127362	0.086063	-1.479859	0.1531
YGAP	0.060972	0.026954	2.262096	0.0339
EXR^2	0.000469	0.000251	1.871362	0.0747
DR(-1)	0.464846	0.170918	2.719699	0.0125

R-squared	0.399932	Mean dependent var	0.001250
Adjusted R-squared	0.263553	S.D. dependent var	0.008485
S.E. of regression	0.007281	Sum squared resid	0.001166
F-statistic	3.735896	Durbin-Watson stat	2.417846
Prob(F-statistic)	0.013394	Second-Stage SSR	0.000953
J-statistic	13.91564	Instrument rank	16
Prob(J-statistic)	0.176875		

E1.2: Open Model Estimation Using Exponential Smooth Transition Regression

```
*** Sun, 18 Jun 2017 03:18:09 ***
STR ESTIMATION

variables in AR part:     CONST R(t-1) INFL(t) INFL1(t) YGAP(t) EXR(t)
restriction theta=0:      R(t-1) INFL(t) INFL1(t)
restriction phi=0:        CONST YGAP(t)
restriction phi=-theta:   EXR(t)
transition variable:      TREND
sample range:             [2007 Q3, 2016 Q1], T = 35
transition function:      LSTR2
number of iterations:     231

variable                  start        estimate     SD           t-stat
p-value
----- linear part ------
R(t-1)                     0.18210      0.01792      0.1298       0.1380
0.8913
INFL(t)                    0.19601      0.19648      0.0694       2.8326
0.0088
INFL1(t)                  -0.06509     -0.10513      0.0711      -1.4792
0.1511
EXR(t)                     0.31777      2.05939      0.9396       2.1918
-0.0375
---- nonlinear part ----
CONST                     -0.00048     -0.00063      0.0012      -0.5036
0.6188
YGAP(t)                    0.03383      0.02250      0.0182       1.2336
0.2284
EXR(t)                    -0.31777     -2.05939      0.9396      -2.1918
0.0375
Gamma                      1.26689      1020.76493   0.0000       0.0000
0.9992
C1                         19.75862     15.03382     0.0000       0.0000
0.6510
C2                         20.93103     17.98733     0.0000       0.0000
0.1586

AIC:                             -9.7891e+00
SC:                              -9.3891e+00
HQ:                              -9.6510e+00
R2:                               5.6008e-01
adjusted R2:                      0.5726
variance of transition variable:  105.0000
SD of transition variable:        10.2470
variance of residuals:            0.0000
SD of residuals:                  0.0067
```

Appendix F

Table 2.1: Presentation of the Summary of Empirical Review

S/N	Author(s)/year	Country(s)	Objectives	Dependent variable	Independent variables	Estimation technique/Type of Data	Summary of findings
Linear-based MPRF Literature							
1.	Clarida, Gali, and Gertler, (1998)	UK, France and Italy.	To estimate a forward looking monetary policy reaction functions of the G3 countries (Germany, Japan and US) and E3 countries (UK, France, and Italy).	Nominal interest rate[1].	Output gap and inflation gap.	The study utilized Generalized Method of Moments (GMM). Monthly data was used	The result shows that all the central banks are forward looking; they respond to expected inflation rather than lagged inflation, and hence pursue implicit IT. It also portrays the superiority of IT over fixing exchange rate as a nominal anchor.
2	Clarida,Gali and Gertler (1998b).	US	To estimate a forward looking monetary policy reaction function for the post-war US economy before and after Volcker appointment as Fed's chairman in 1979.	Short term nominal interest rate (funds rate)	Expected inflation and expected output.	GMM was and employed Monthly data was utilized.	The result shows difference between the rules in the sample period and that Volcker-Greenspan period is more stabilizing.
3	Agu (2007)	Nigeria	To find out what do monetary policy makers react to and how they react.	Nominal interest rate	In the historical model, Credit growth, exchange rate, inflation, Credit reserves, private credit.	Ordinary least square with differenced terms was used with monthly data ranging from 1999:01 to 2005:12. And two models were used which are 1, Based on the historical	The result confirm the primacy of inflation in monetary policy reaction function in Nigeria with less significance of interest rate smoothing. Also fiscal dominance could not be traced.

[1] Nominal interest rate is the short term interest rate or policy rate.

					For the Taylor rule, real interest rate, inflation and output gaps were used.	process of CBN and 2, a Taylor type model	
4	Henry, Musa, and Isaya, (2008)	Kenya	To test if The Central Bank of Kenya (CBK) react to changes in inflation and GDP growth in accordance with the Taylor rule.	Monetary aggregate (M3).	Inflation target and output target.	GMM was used and monthly data was utilized. GDP was in annual data but interpolated to monthly data.	The main policy instrument of CBK is monetary aggregate. And that a rise in expected annual inflation by 1% induces the reduction of broad money by 4.2% and in respect to repo is 2.4 which is in line with Taylor rule.
5	Ogli (2008).	Nigeria	To estimate Monetary policy reaction function of CBN using a Taylor-type model and also to estimate the efficacy of monetary policy in influencing macroeconomic variables.	Nominal interest rate.	Inflation gap, output gap and real exchange rate.	Simple gap model was estimated using matlab software to analyze quarterly data from 1999:1 to 2007:4	The result showed the importance of inflation pressure and the role of output in determining the assessment of the CBN on future path of interest rate
6	Siri (2009).	Ghana, Nigeria and West African Economic Monetary Union (WAEMU).	To analyze the reaction function of central banks of Ghana, Nigeria and WAEMU[2].	Nominal interest rate.	Inflation gap, output gap and exchange rate.	Ordinary Least Square (OLS) was utilized. Quarterly data from 1980:1 to 2007:4	The result showed that the central banks of Ghana and Nigeria are not strictly following the original or the adjusted Taylor rule. While on the other hand, WAEMU apply Taylor rule adjusted by the interest rate of France.
7	Agu (2011).	Nigeria.	To develop a model of monetary policy reaction function that will capture the peculiarities in monetary policy formulation behavior of the CBN.	Nominal interest rate.	Price level, broad money supply, premium of parallel market	Cointegration was used to estimate a long run relationship between some macroeconomic	The result portrayed that inflation target have not been closely met in the past. Furthermore, there was lack of long run relationship among

[2] The WAEMU countries include Benin, Burkina Faso, Cote Di'ivoire, Guinea Bissau, Mali, Niger, Senegal and Togo.

					exchange rate and foreign reserve.	variables. The study used monthly data though some variables are interpolated.	monetary variables which is connected to the short run stance of monetary policy for a large part of sample period.
8	Tolupe andAjilore (2013).	Nigeria.	To use Taylor policy rule to examine inflation targeting monetary policy stance of Nigeria.	Nominal interest rate.	Inflation rate, output gap and real interest rate.	Engle-Granger approach to cointegration was utilized to analyze quarterly data from 2000:1 to 2010:4.	The result showed the effectiveness of monetary policy function in order to achieve price stability in the midst of long persistent inflation.
9	Bello (2014).	Nigeria.	To estimate the reaction function of the CBN based on the revealed preferences of the voting members of the MPC.	Nominal interest rate (MPR).	Consumer price index (proxy inflation), log of output gap, nominal effective exchange rate and log of external reserve.	GMM was used to estimate a linear Taylor rule (both baseline and augmented) of the CBN reaction function.Quarterly data of inflation and GDP were used together with MPC meeting (which take place every other month). The study used new Keynesian policy as theoretical framework.	The result shows that MPC are pro-cyclical because they react to inflationary pressure with time horizon of (t+1), hence an anti-inflationary policy with accommodating behavior towards output fluctuations.
Nonlinear-based MPRF Literature							
10.	Nobay and Peel (1998).		To examine an optimal monetary policy of a central bank adopting asymmetric objective function.		Inflation gap and Output gap	The study use Bayesian econometric analysis.	The result shows that social welfare is maximized when the output gap is positive via asymmetric preferences. And that rule is superior to discretion.
11.	Martin and Milas (2001).	UK.	To investigate the effect of the adoption of IT on monetary policy	Nominal interest rate	Inflation gap and output	Simple nonlinear structural framework	After the adoption of IT in 1992, influence of inflation

			and to probe the existence of policy asymmetries in the reaction function of Bank of England (BoE) and also to examine whether UK is using a point or a range target IT To empirically explore the possible asymmetries of the preferences of central bankers using inflation and output gap.		gap.	was employed to analyze quarterly data from 1963 to 2000.	outplayed the influence of output hence, asymmetry of the monetary policy reaction function of BoE. And that BoE pursue a range rather than a point target IT.
12.	Bec, Salem, and Collard, (2002)	Germany, France, Spain and US.	To empirically explore the possible asymmetries of the preferences of central bankers using inflation and output targets.	Nominal interest rate.	Inflation gap and output gap.	GMM was use to estimate the threshold model with monthly data.	The shape of the reaction function is endogenously determine because business cycle influence monetary policy in those countries, hence, asymmetries exist in all the three central bank , hence, nonlinearity of their reaction function.
13.	Doladoy, Maria-Dolorez, and Naveirax, (2003)	European countries and US.	To use a minimalist backward looking Model of economy to analyze a nonlinear Phillip curve using short term nominal interest rate with output following a simple autoregressive process to determine inflation.	Nominal interest rate.	Inflation and output gap.	The study used GMM to analyze quarterly data from Germany, France and Spain and monthly data was used in US. Hansen J test of over identification was used.	All the research areas exhibit evidence of convex (nonlinear) Philips curve with exception of US whose Philips curve tends to be linear. This may be as a result of high real wage rigidity in European markets than in US.
14.	Bruinshoofd and Candelon (2004).	European countries and US.	To investigate whether nonlinear monetary policy exists in Europe.	Nominal interest rate.	Money supply (M3), term spread of interest rate (difference between short term and long term interest rate) and	Logistic Smooth Transition Auto regression (LSTAR) was used to analyze quarterly data.	The result debunked the existence of nonlinearity in the monetary policy of the European economies with exception of Denmark and UK whose linearity null hypothesis was rejected.

					growth rate of real balance (ΔM/P).		
15.	Peterson (2007)	US	To examine if Fed change policy rule according to output or inflation gap and to also check if it follows a nonlinear Taylor rule.	Nominal interest rate.	Inflation gap and output gap.	STR was employed to analyze monthly data from 1960:1 to 2005:12. Hybrid new Keynesian model was utilized as the theoretical framework.	The result shows that Fed follows nonlinear Taylor rule during "golden monetary era" of 1985 to 2005, and followed a linear Taylor rule during the "dark age" of 1960 to 1979. And that the nonlinear rule is superior.
16.	Surico (2007).	US	To empirically investigate monetary policy analysis using a new framework in which policy makers are allowed but not required to weigh differently positive and negative inflation and output from their target values.	Nominal interest rate.	Inflation and output gaps.	GMM was used to estimate to estimate quarterly dataand New Keynesian framework was employed.	Nonlinearity was detected during pre-Volcker regime. And inflation bias was also calculated as 1.5%.
17.	Castro (2008).	Europe, UK and US.	To investigate if Central banks follow a linear or nonlinear rule and also to analyze if the rule can be augmented with a financial condition index containing information of some selected asset prices and financial variables.	Nominal interest rate	Real interest rate, inflation gap, output gap and Financial Condition Index (FCI).	STR was used to estimate the nonlinear model while GMM was employed in estimating the linear model and monthly data was used.	The result shows that ECB and BoE followed a nonlinear Taylor rule while Fed did not follow. Unlike the Fed and BoE, ECB is targeting financial conditions hence making it less vulnerable to the recent financial crunch than Fed and BoE.
18.	Cukiermanand Muscatelli (2008).	UK and US.	To establish both theoretically and empirically the view that Taylor rule are mostly nonlinear due to asymmetries of central bank preferences and the nature of the asymmetries varies across regimes.	Nominal interest rate.	Inflation gap and output gap.	The study used Hyperbolic Tangent Smooth Transition Regression (HTSTR) to estimate and test the nonlinear relationship, while GMM was employed in the estimation of	Findings from both countries shows the existence of nonlinearity. And the asymmetry properties of the loss function change in accordance with regime and the prevailing macroeconomic problem of the day. They propositioned that in the

						the linear model. The standard New Keynesianmodel was used as their theoretical framework. The study made use of quarterly data from 1979:3 to 2007:4.	presence of only RAP,[3] that is, no IAP[4], the shape of the reaction function is concave for both inflation and output gap and convex if it is on the other way round. If RAP and IAP are of equal magnitude, the shape of the reaction function will be linear. And that the reaction function of a strict inflation targeter is linear regardless of the presence of RAP or IAP.
19.	NcubeandTsuma (2010).	South Africa.	To analyze the applicability of nonlinear Taylor rule in explaining monetary policy behavior of South African Reserve Bank (SARB) as well as analyzing the short term interest rate of SARB.	Nominal interest rate.	Inflation and output gap.	LSTR approach was used to analyze quarterly data from 1976:1 to 2008:4.	The study discovered that nonlinear Taylor rule hold in SARB which contradicts other studies that are oblivious of the structural break which coincides with Asian crises.
20.	Naraido and Paya (2012).	South Africa.	To investigate whether the Taylor rule followed by the SARB with or without asset price is portraying a nonlinear functional form and also to examine whether assets price are one of the determinants of interest setting of SARB.	Nominal interest rate.	Expected inflation gap, expected output gap, expected financial indicator gap[5].	Linear and nonlinear as well as parametric and nonparametric models were used to estimate both in-sample and out of sample analysis. Rollin and recursive regression were utilized to estimate	The findings did not reject nonlinear in the monetary policy rule of SARB and it shows that assets prices are considered when setting interest rate. The result also shows the superiority of semi parametric model over others in forecasting the interest rate as the forecasting horizon

[3] RAP means Recession Avoidance Preference, that is, when the monetary authority is more averse to the fluctuation of output in order to avoid recession than inflation.

[4] IAP connotes Inflation Avoidance Preference, meaning; the monetary policy is more averse to price instability (inflation) as a means of stabilizing the economy than the fluctuation of output.

[5] Financial indicator gap is derived from financial index which comprises financial variables such as exchange rate, house price, stock price and other financial variables.

						the model on monthly data that spread from 1986:1 to 2008:12.	lengthens.