FINANCIAL INNOVATIONS AND ASYMMETRIC EFFECTS OF MONETARY POLICY SHOCKS IN NIGERIA

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ABSTRACT

In the aftermath of the global financial crisis, there is the rebirth of macroeconomic analysis about output fluctuations, which emphasizes asymmetric eects of monetary policy shocks and the quest for a consensus towards eliminating the asymmetric monetary policy eects. These asymmetric eects have been attributed to a number of factors, including risk aversion by economic agents, uncertain expectations during economic downturns, downward stickiness of prices, financial market distortions or credit market imperfections amongst others. Of recent, the world has witnessed tremendous evolution and growth of innovations in financial services. Though consensus views about the impact of such innovations are yet to be established, opinions vary on its monetary policy implications. It is argued that financial innovations can influence the eectiveness of monetary policy. The revolution in the electronic payment system in Nigeria tends to have a direct impact on monetary policy decisions. This study examines the asymmetric eects of monetary policy in Nigeria and the role of financial innovations in mitigating the asymmetry. A Non-linear Autoregressive Distributed Lag (NARDL) Model was adopted with data spanning January 2010 to December 2018. The findings from the series of tests suggest that financial innovation eliminate asymmetric eects of monetary policy. This has important implications for monetary policy, as it highlights the fact that financial innovations can dampen the adverse impact of monetary tightening during economic recession.

Keywords: *Monetary policy, asymmetric, nonlinear ARDL and Financial innovations*
JEL Code: *C51, D82, E52, P34*

1. Introduction

The financial crisis of 2007-2008 prompted global debate on some economic theories that had long been widely adopted as policy advice globally (Skidelsky, 2010). The financial crisis raised critical questions about the effectiveness of conventional monetary policy tools, in particular, the debate on the effectiveness of interest rate as a monetary policy tool during economic recession. This informed the need for unorthodox monetary policy tools to address the crisis. It also provided a basis for the rebirth of macroeconomic analysis about output fluctuations, which emphasizes asymmetric effects of monetary policy shocks.

In simple terms, asymmetric monetary policy effect is the proposition that over the business cycle, monetary policy does not have equal impact on output or employment. Monetary policy tightening, according to Welse (1999), Florio (2004), Peersman and Smets (2001), Cover (1992), Karras (2013), Santoro et al (2014), and Ulke and Berument (2016), is generally more efficient and effective than expansionary monetary policy. In the literature, these asymmetric effects have been attributed to a number of factors, including risk aversion by economic agents, uncertain expectations during economic downturns, and downward stickiness of prices, amongst others (Barnichon, Mathes and Sablik, 2017).

However, there is a vast body of literature which traces output fluctuations to financial market distortions or credit market imperfections (Bernanke and Gertler, 1989; Bernanke et al, 1996; Bernanke et al, 1999). The aftermath of the financial crisis has witnessed the appreciation of the asymmetry in monetary policy and the quest for a consensus towards eliminating the asymmetry in monetary policy effects (Ravn, 2013). Research suggests that an unexpected negative monetary policy shock will decrease both demand for capital and net worth of firms, consequently, inducing further slide or dip in the value of investment and output. The key point is that in an economy with deep financial markets, negative effects of monetary policy shocks could be easily mitigated as firms through innovations could continue to attract funds from potential lenders during the economic downturns (Caglayan, Kocaaslan and Mouratidis, 2016). Using an instrumental variable Markov regime switching (MRS) framework, Caglayan et al (2016) investigated the effects of frictions in the financial market on the transmission of monetary policy shocks. Specifically, the study examined the role of financial deepening in the mitigation of adverse monetary policy shocks as proposed by the financial accelerator mechanism.

[2]See also Levine (2005) and Papaioannou (2007) for detailed surveys of this literature.

The revolution in the electronic payments system, which is the latest form of financial innovation in Nigeria, tends to have a direct impact on monetary policy decisions. For instance, the greater use of this alternative form of money can substitute for the traditional form of money to the extent that it can replace the use of other liquid financial instruments, thereby undermining the effectiveness of monetary policy (Tule and Oduh, 2017). Also, increased financial innovation by way of securitization can make individual households to turn to financial markets when planning their consumption, while at the same time holding a larger proportion of their wealth in financial assets like bonds and equity. Such decisions can result in financial disintermediation and greatly limit the credit channel of money transfer mechanism. In this study, we investigated the presence or otherwise of the asymmetric effects of monetary policy and the role of financial innovations in the transmission of monetary policy shocks over the course of the business cycle. The model used in the study permits us to test directly the influence of financial innovation in mitigating the effects of monetary shocks as suggested by the proponents of the financial accelerator mechanism. In the model, an interaction term between monetary policy shock and financial innovations indicators was introduced. The resulting model was estimated by a Non-linear Autoregressive Distributed Lag (NARDL) Model, as suggested by Shin, Yu and Greenwood-Nimmo (2011).

Following the introduction, the rest of the study is structured as follows: section 2 provides a review of both the theoretical and empirical literature. Section 3 presents the stylized facts on financial innovation while section 4 contains the research methodology. Section 5 discusses the empirical results while section 6 concludes the study with key policy recommendation.

2. Brief Literature Review

There is a well-established literature on the asymmetry of monetary policy shocks. Keynes (1936) recognized the asymmetry in macroeconomic aggregates to monetary policy shocks and attributed this to rigidity in nominal wages. Keynesians argue that nominal wage and prices are more rigid downward than upward, resulting in a “kinked” aggregate supply curve with the implication that the effects of contractionary monetary shocks are not symmetric (Ülke and Berument, 2016). If nominal wages are sticky upward, adverse monetary policy shocks will be non- neutral, whereas positive monetary shocks will be neutral. According to Agenor (2001), there are varieties of reasons for the asymmetry in wage and price adjustments. First, workers often express strong resistance to nominal wage cuts. This implies that reduction in real wages can only be induced by a rise in rate of inflation. Second, although workers are resistant to downward adjustments to wages, they may favour quick adjustments in wages on the upper bound. As a result, wages are more flexible around the upper bound than around the lower bound. The reason for the downward stickiness of wages may be explained by the efficiency wage doctrine. The efficiency wage considerations state that firms may offer higher wages to promote commitment and raise staff morale in order to maintain or improve productivity of the workforce and reduce turnover costs associated with rapid rate of quitting.

Within the Keynesian IS-LM framework, an additional explanation for the asymmetry in monetary policy shock is traceable to the likelihood of the occurrence of a liquidity trap. A liquidity trap could be defined as a situation in which the difference between the monetary policy rate and inflation (real interest rate) is very low to the extent that nobody is motivated to hold debt, and an additional decrease of the interest rate would encourage someone to hold debt (Hicks, 1937). This phenomenon was suspected in the financial crash of 2007-2008, arising from the prevailing low levels of policy rates (Krugman, 2010). Uncertainty of expectations or deflation is one of the major causes of liquidity trap (Akram, 2016).

New Keynesians, such as Ball and Mankiw (1994) provide explicitly microeconomic foundations for asymmetry in a model where firms can costlessly set prices every second period but are subject to a menu cost if they do change prices between periods. Given that there are menu costs associated with price adjustments, firms may not resort to price adjustment at lower level up to a threshold beyond which they will be compelled to adjust prices despite the menu cost of doing so. In this context, prices tend to be less rigid upward than downward because negative shocks are less likely to trigger price adjustment, if there is trend inflation, than positive shocks of equivalent magnitude. The typical firm is less willing to absorb the menu cost and adjust its actual price in the face of negative shock because part of the price adjustment will come about as a result of inflation. On the contrary, positive shocks trigger adjustments in desired relative prices and actual prices at the same time, because actual prices are being eroded by inflation. Similar conceptual models have been developed by others, such as Blanchard and Kiyotaki (1987), Caballero and Engel (1992, 1993), and Tsiddon (1993) to explain how existence of menu costs can result in asymmetric adjustments in prices and asymmetric effects of monetary policy shock.

Another potential source of asymmetric monetary policy shock is found in the “credit constraints” models (Gertler, 1988; Bernanke and Gertler, 1989). Adverse selection models posit that banks are less willing to lend to riskier borrowers when market rates are high, hence a contractionary monetary policy can result in tighter credit constraints. A rise in the policy rate, for instance, may increase both deposit rates and market interest rates, but banks may be unwilling to increase loan rates because it will increase borrowers' debt burden and render borrower more prone to bankruptcy and default. To maintain or improve the quality of their loan portfolio, banks may choose to ration credit. Thus, a contractionary monetary policy can result to tightening of credit constraints, thereby magnifying the impact of the initial shock on borrowing and spending. On the other hand, an expansionary monetary policy lowers market rates and relaxes the credit constraints without necessarily leading to higher demand for loans and spending required to stimulate the economic during periods of slow growth. In summary, if credit constraints are binding contractionary monetary policy leads to further tightening of the credit constraint and magnified adverse shock on borrowing and spending, implying an asymmetric bias to monetary policy actions.

Gertler (1988) and Bernanke and Gertler (1989) offer alternative perspective on how the credit constraints can contribute to asymmetric effects of monetary policy. In a system where there is low collateral and borrowing must be backed up by collateral, quick reductions in investment are more probable than sharp upsurge. This is because credit constraints are more binding during downturns when net worth is low due largely to a slide in price of assets. Hence, conventional interest rate channel may be less effective than quantitative measures during downturns than in upturns, leading to asymmetric effects of monetary policy. Jackman and Sutton (1982) model attributes the asymmetric responses to consumption behavior. As implied by the Permanent income Hypothesis, expansionary monetary policy relaxes the credit constraints but spending increases less than proportionately because part of the increase is saved. On the contrary, contractionary monetary policy forces constrained consumers to reduce spending by the full amount that their loan payments increase.

Another source of asymmetry of monetary policy found in the literature is the confidence and expectations factor. During downturns, there is usually loss of confidence and expected profitability of investment dampens. In such context, firms will invest less even if the monetary policy is expansionary (Dixit and Pindyck (1994).

There is a vast body of empirical literature on the asymmetric effects of monetary policy shocks, especially on developed and advanced economies like Cover (1992), Morgan (1993), Macklem (1995), Ravn and Sola (1996), Karras (1996), Karras and Stokes (1999), Shen and Chiang (1999), Balke (2000), and Santoro et al, (2014).

Recently, the literature has been extended to some emerging economies like Ülke and Berument (2016) for Turkey. Essentially the focus of the existing empirical studies on measure and test of presence of asymmetric effects have been on three variables: the sign and size of monetary policy shocks and the initial magnitude of some additional variables. With regards to the sign, Covers (1992) and Morgan (1993) find that a positive innovation in monetary policy variables has an asymmetric effect on output; for instance, hike in the funds rate tended to have a significant negative effect on economic activity in the US, whereas reductions proved to be neutral. In a similar manner, Karras (1996) find that the size of impact of unanticipated monetary policy shocks differs in industrial countries; the impact of unanticipated monetary expansion tended to increase output by less than equivalent monetary contraction tended to reduce output. On the size of monetary policy shocks, Ravn and Sola (1996) in accordance with the menu cost models, find that there are asymmetric effects associated with small and large changes in nominal demand; such that large shocks tended to be neutral while small shocks tended to have real effects.

Lastly, on the third variant, initial sign or magnitude of another variable, Agenor (2001) and Caglayan et al (2016) are among the few studies available. Caglayan et al (2016) explore the role of financial deepening in assessing the non-linear effect of monetary policy on real output over the course of the US business cycle. They show that monetary policy has a significant impact on output growth during recessions and that financial deepening plays an important role by dampening the effects of monetary policy shocks in recessions.

Turning to financial innovations, its impact on various technical aspects of monetary policymaking cannot be overemphasized. Monetary policy transmission and effectiveness of specific instruments are influenced by difference aspects of financial innovation. Central banks have a huge responsibility of fine-tuning their monetary policy to react readily to financial development and innovation generated by new waves of globalization and regulatory changes in the financial sector (Dabrowski, 2017). In the light of this experience, Tule and Oduh (2017) leverage on error correction model, general method of moments and trend analysis to assess the effects of financial innovations on Nigeria's monetary policy. The study concluded that financial innovation enhances the efficacy of the financial system and the interest rate channel of monetary policy transmission, but increases uncertainty in the monetary policy environment and the output gap. The study avowed that by increasing the cost of implementing monetary policy, it dampens the potency of the operating target through its impact on money velocity, demand for money and the stability of the money multiplier. Hence, our study extends the body of literature by accounting for both the magnitude of the initial size of other financial innovations variables as well as the sign of the asymmetric effects. In the methodology, our study extends Caglayan et al (2016) approach for the US, by measuring the asymmetric effects of monetary policy shocks in Nigeria in the face of rapid and substantial financial innovations.

3. Stylized Facts on Financial Innovations in Nigeria

The birth of financial innovations stemmed payments through cheques but increased transactions on electronic platforms such as point-of-sale (POS), Internet (web) pay, automated teller machines (ATMs), mobile payments, Nigerian instant payment (NIP), Nigerian electronic fund transfer (NEFT), The mobile-cash, Ebills pay, REMITA, NAPS and Central pay. These innovations in the financial sector changed the narrative in the interaction between nominal income and key monetary aggregates.

The dramatic change recorded in the payments system followed the liberalization of the mobile telecommunications subsector in 2001. This was followed by the systematic banking sector reforms aimed at improving the processes. The usefulness of financial transactions on electronic platforms cannot be overemphasized. Electronic transactions are increasingly becoming indispensable in banking transactions as such platforms as ATMs, NIP, POS, NEFT, and REMITA have changed the pattern of flow of money and business transaction models in the country. In 2009, institutional measures like the Transaction Switching, Stored Value/Prepaid Cards issuance of Mobile Payments Regulatory Frameworks were introduced. Succeeding these measures, in 2011 six Payment Terminal Service Providers (PTSPs) were licensed primarily for handling POS transactions and the primer of the cashes-less policy.

These innovations, particularly from 2009, marked a watershed in the history of payments system in Nigeria. Within the study horizon (2010-2018), Nigerian Instant Payment (NIP) under the Nigerian Interbank Settlement system (NIBSS) recorded a whopping two hundred and thirty five trillion naira (N235 trillion) worth of transaction, accounting for 45.7 per cent of the total transactions within the study horizon despite commencing operation in 2012. This is followed by NEFT, which accounted for 19.3 per cent while M-cash which started operation in 2017 accounted for the least (0.0004 per cent). However, REMITA, despite commencing operation in 2017 remains the toast of the payments system, accounting for 6.2 per cent of the worth of total transactions carried out within the period under review.

In terms of volume of transaction within the study horizon, ATM recorded the highest volume of four million one hundred and seventy eight thousand four hundred and eighty two trillion (4,178,482 million), accounting for 59.4 per cent of the total volume of transaction. This was followed by NIP, which accounted for 19.7 per cent of the total volume of transaction while M-cash remains the least utilized with 0.04 per cent of the total transaction consummated within the study horizon as shown in Figures 1 and 2 below

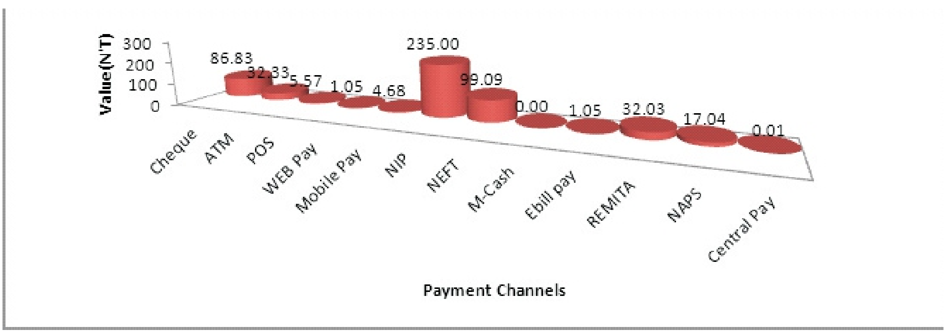

Figure 1: Value of transaction on Payment channels (Trillion), 2010M01–2018M12

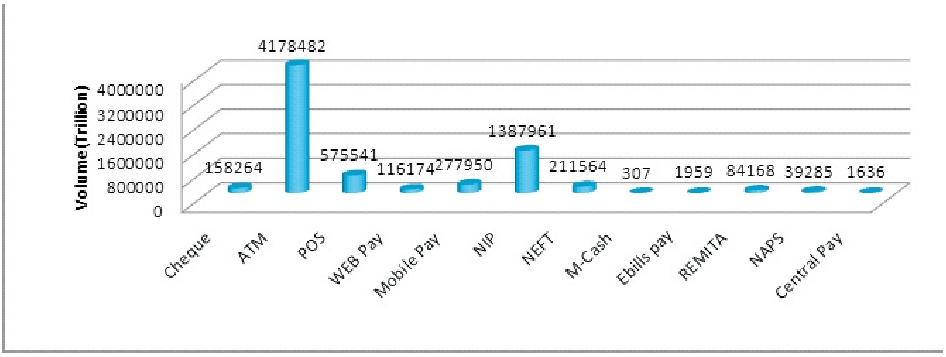

Figure 2: Volume of transaction on Payment channels (Trillion), 2010M01-2018M12

4 Research Methodology

4.1 The Nonlinear ARDL Approach

The speed of movement of macroeconomic variables in the downward direction often varies from their speed of movement in the upward direction, thus signaling the existence of a nonlinear behavior. Hence, relying on the information content in linear relationships to draw inference may be inappropriate (Shin, Yu and Greenwood (2014). Thus implying that the ambivalence of the positive and negative components of regressors around an assumed zero thresholds plays a crucial role in establishing long run economic relationships.

Shin, Yu and Greenwood (2014) derived its asymmetric ARDL model from the work of Pesaran, Shin and Smith (2001). Hence, following the works of Schoderet (2003), Shin, Yu and Greenwood (2014), Ibrahim (2015), Olayeni (2016), Athanasios, Katrakilidis and Trachanas (2016), and Eboreime, Elisha and Ude-Abosi (2016), the non-linear long run equation is specified as:

$$Y_t = \beta^+ x_t^+ + \beta^- x_t^- + \varepsilon_t \quad (1)$$

where x_t is a $k*1$ vector of regressors.
Given that x_t is defined to be a random walk, such that

$$x_t = x_{t-1} + \varepsilon_t, \varepsilon_t \sim N(0, \sigma^2) \quad (2)$$

After recursive substitution, equation (2) can be re-written as

$$x_t = x_0 + \sum_{j=1}^{t} \varepsilon_{t, t=1,...,T} \quad (3)$$

Assuming zero threshold point, we partition the error termas:

$$\varepsilon_t = \varepsilon_t^+ + \varepsilon_t^- \tag{4}$$

Taking partial sum yields

$$\sum_{j=1}^{t} \varepsilon_j = \sum_{j=1}^{t} \varepsilon_j^+ - \sum_{j=1}^{t} \varepsilon_j^- \tag{5}$$

From the foregoing, the following expression follows:

$$\varepsilon_j^+ = \Delta x_j^+, \quad \varepsilon_j^- = \Delta x_j^- \tag{6}$$

since $x_t^{\therefore}$ and $x_t^{\therefore}$ are partial sums of the positive and negative changes in x_t

Hence, x_t which is a $k*1$ vector of regressors is defined as:

$$x_t = x_0 + x_t^+ + x_t^- \tag{7}$$

In line with Pesaran et al (2001), the nonlinear variant of the unrestricted ECM in equation (1) becomes:

$$\Delta y_t = \alpha + \rho y_{t-1} + \omega_2^+ x_{t-1}^+ + \omega_2^- x_{t-1}^- + \sum_{j=1}^{p-1} \theta_j \Delta y_{t-j} + \sum_{j=0}^{q-1} n_j^+ \Delta x_{t-j}^+ + \sum_{j=0}^{q-1} n_j^- \Delta x_{t-j}^- + \varepsilon_t \tag{8}$$

where n_j^+ and n_j^- are the symmetric distributed lag parameters; ε_t is the stochastic error term that is iid (independently and identically distributed) with $\mu = 0$ and variance $= \sigma^2$.

We now re-write Equation (8) as :

$$\Delta y_t = \alpha + \rho y_{t-1} + \omega_2^+ x_{t-1}^+ + \omega_2^- x_{t-1}^- + \sum_{j=1}^{p-1} \theta_j \Delta y_{t-j} + \sum_{j=0}^{q-1} \left(n_j^+ \Delta x_{t-j}^+ + n_j^- \Delta x_{t-j}^- \right) + \varepsilon_t \tag{9}$$

The restricted ECM may be written as:

$$\Delta y_t = NECM_{t-1} + \sum_{j=1}^{p-1} \theta_j \Delta y_{t-j} + \sum_{j=0}^{q-1} \left(n_j^+ \Delta x_{t-j}^+ + n_j^- \Delta x_{t-j}^- \right) + \varepsilon_t \tag{10}$$

4.2 Data and Variables

The study is based on monthly data series that ranges from January 2010 to December 2018. The various time series were expected to capture the dynamics of financial innovation post Global Financial Crisis that heralded the financial sector post consolidation of the banking industry in Nigeria. The Central Bank of Nigeria (CBN) statistics database (2019) and the National Bureau of Statistics (NBS) database (2019) are the sources of data employed in this study.

The data for financial innovation (volume and value), growth (real and nominal gross domestic product) and monetary aggregates were sourced from the Central Bank of Nigeria Statistical Bulletin and National Bureau of Statistics (NBS). Unlike other countries where challenges in technological infrastructure abound, in Nigeria, the computed financial Innovation data exist, which is the addition of all the payment channels in terms of value and volume and will be utilized for the study. However, the quarterly rebased GDP (real and nominal) at 2010 constant prices were converted to monthly frequency leveraging on the Eviews quadratic-match sum technique. This is specifically to ensure that the sum of each converted monthly frequency over a quarter equals the original GDP value. This, in all intent and purposes, guarantees that the original quarterly GDP content before the interpolation exercise is not lost in transit in the course of the interpolation.

The Monetary indicators considered in this study are: M3, which is the broad money (M2) plus foreign currency deposit, interbank exchange rate of Naira to the United States Dollar, interbank call rate, consumer price index (inflation), interactive variable, demand deposit and monetary policy rate. The interactive variable is the product of the monetary policy tool (MPR in Nigerian context) and the financial innovation indicators.

4.3 Model Specification

This study leveraged on the general form of the nonlinear ARDL model to test for the asymmetric cointegration as:

$$\Delta y_t = \alpha + \rho y_{t-1} + \omega_2^{+} x_{t-1}^{+} + \omega_2^{-} x_{t-1}^{-} + \sum_{j=1}^{p-1} \theta_j \Delta x_{t-j} + \sum_{j=0}^{q-1} \left(n_j^{+} \Delta x_{t-j}^{+} + n_j^{-} \Delta x_{t-j}^{-} \right) + \varepsilon_t \qquad (11)$$

where y_t is any of the monetary policy outcomes, such as economic growth, price stability including exchange rate stability; x_t is a vector of exploratory variables, namely, the monetary policy instrument/tool, financial innovation indicators, and other control variables. Furthermore, while *p* and *q* stand for the selected lag order for the dependent and the exogenous variables in distributed lag part, x^{-}_{t-l} and x^{+}_{t-l} connotes the partial sums of negative and positive changes in the specific monetary aggregate indicator. The study used the automatic lag selection framework to obtain the optimal lag order.

We leveraged on the ordinary least square technique to estimate the NARDL model. One of the greatest strengths of the NARDL approach to cointegration like symmetric ARDL is its robustness to degree of freedom. Notwithstanding the fact that our sample size for this study is fairly large enough, because of its high frequency, worthy of note is the fact that NARDL is indifferent to sample size.

4.3.1 Test for Asymmetric Cointegration

Following Pesaran et al. (2001) and Atil et al. (2014), the null hypotheses of no cointegration for the coefficients of the level of y_t, x^+_{t-1} *and* x^-_{t-1} were tested.

$$H_0 = \rho = \omega_2^+ = \omega_2^- = 0$$

4.3.1.1 Decision Rule

- If the empirical value of the F-statistics is greater than the upper bound critical value at the appropriate level of significance, it implies the existence of long run relationship between the variables.
- If the computed value is less than the lower bound, it implies that there is no cointegration.
- If the calculated F-statistics lies between the two bounds, it implies that the test is inconclusive.

A rejection of the null hypothesis implies that an error correction model must be formulated to account for the short and long run relationships simultaneously.

4.3.2 Test for Symmetry Effect

Both the Short (SRun) and Long (LRun) run symmetry effect used the Wald statistics.

4.3.2.1 The Short Run Symmetric Effect

$$H_0 : n_j^+ = n_j^-, \forall j \quad \text{for all } j = 0, \ldots, q-1$$

4.3.2.2 The Long Run (LR) Symmetric Effect

$$H_0 : \beta^+ = \beta^-$$

$$\text{where} \quad \beta^+ = \frac{-\omega_2^+}{\rho}, \beta^- = \frac{-\omega_2^-}{\rho}$$

If the hypotheses for SRun and LRun symmetric effects are rejected, it implies that the original symmetric ARDL formulation of Pesaran et al. (2001) holds.

However, if the LRun symmetry is not rejected but the SRun is, it implies the following relationship in Eq. (12):

$$\Delta y_t = \alpha + \rho y_{t-1} + \omega_2 x_t + \sum_{j=1}^{p-1} \theta_j \Delta x_{t-j} + \sum_{j=0}^{q-1} \left(n_j^+ \Delta x_{t-j}^+ + n_j^- \Delta x_{t-j}^- \right) + \varepsilon_t \quad (12)$$

Equation (13) will apply if LRun symmetry is rejected but not the Srun;

$$\Delta y_t = \alpha + \rho y_{t-1} + \omega_2^+ x_{t-1}^+ + \omega_2^- x_{t-1}^- + \sum_{j=1}^{p-1} \theta_j \Delta x_{t-1} + \sum_{j=0}^{q-1} \left(n_j^+ \Delta x_{t-j}^+ + n_j^- \Delta x_{t-j}^- \right) + \varepsilon_t \quad (13)$$

The asymmetric responses of

$$M_h^+ = \sum_{j=0}^{h} \frac{\partial y_{t-j}}{\partial x_t^+}, M_h^- = \sum_{j=0}^{h} \frac{\partial y_{t-j}}{\partial x_t^-}, h = 0.1.2, \ldots \quad (14)$$

As $h \sim \infty$ by construction $M_h^+ \rightarrow \beta^+$ and $M_h^- \rightarrow \beta^-$ As indicated earlier, β^+ and β^- represents the asymmetric long run coefficients. The dynamic multiplier $(M_h^+ \text{and } M_h^-)$ traces the dynamic adjustment paths from the initial point to long-run equilibrium through short-run disequilibrium between the variables after the system is hit by a shock.

4.3.3 Test for Causality Effect:

The Short and long Run causality effect tests are based on the Wald statistics.

4.3.3.1 *Short Run Causality Effect*

$$H_0 : n_j^+ = \ldots = n_j^+ = 0 \quad \text{for all } j = 0, \ldots, q-1$$

$$H_0 : n_j^- = \ldots = n_j^- = 0 \quad \text{for all } j = 0, \ldots, q-1$$

4.3.3.2 *Long Run Causality Effect*

$$H_0 : \omega_2^+ = 0$$

$$H_0 : \omega_2^- = 0$$

5. Empirical Analysis and Discussion of Results

5.1 Unit Root Test

The Philips-Perron (PP) unit-root test result is presented in the Tables 1 and 2 (in Appendix). From the results in Table 1, interbank interest rate (ibr) and real gross domestic product (rgdp) are stable at level while from Table 2, all the variables were stationary at first difference. Since there are mixtures of I (0) and I (1) variables, Johansen cointegration methodology cannot be utilized. The method of Autoregressive Distributed Lag model (ADRL) and bound test approach to cointegration testing fit this situation.

5.2 Cointegration Test

In order to test for cointegration using the NARDL approach, two models were estimated for the exchange rate model and two other models for economic growth. In one of the exchange rate models (respectively, the economic growth models), monetary policy shock variable, MPR, was used as the independent variable while in the other the interactive variable, MFN, generated as the product of MPR and financial innovation indices, was used. We test the null of no cointegration using the bounds testing. The results are reported in Table 3 (in Appendix). Since the F- statistics is less than both the lower and upper bounds at the 5 per cent level of significance, the null hypothesis of no cointegration could not be rejected in both equations of the exchange rate model. At the 10 per cent level, however, we fail to reject the null hypothesis of cointegration. Compared to the asymptotic critical values, however, the small sample (actual) indicates the null of no cointegration is rejected. For the second equation with interactive terms involving financial innovation presented in Table 4 (in Appendix), the results of the bounds test presented show that the null hypothesis of no cointegration is rejected both asymptotically and in finite sample at all standard levels of significance given that the F-statistics estimated is greater than the critical value at upper bound.

5.3 Symmetric Effect Test

Using Wald statistics, we tested for symmetry effects in the relationship between monetary policy shock and exchange rate without financial innovation and with financial innovation. Given the Wald statistics of 5.73 and p-value of 0.018, the null hypothesis of long run symmetry was rejected in favour of long run asymmetry in the response of exchange rate to monetary policy shock with financial innovation. In similar manner, the test for long run symmetry was conducted for the equation without financial innovation and the Wald Statistics and p-value estimated were
282.01 and 0.00, respectively. With a Wald statistics of 0.79 and p-value of 0.67, the null hypothesis of symmetry cannot be rejected for the model with financial innovation while the null of short run symmetry is rejected with respect to the equation without financial innovations (Wald statistics is 1.53 and p-value is 0.13) (see Tables 13 and 14 in the Appendix).

5.4 Bounds Test

In the economic growth models, the NARDL bounds test rejected the null of no cointegration in favour of cointegration with and without financial innovations.

The results are presented in Tables 7 and 8. However, the tests for long run symmetry conducted show that the null hypothesis of symmetry cannot be rejected in the model with and without financial innovations (see Tables 9 and10). The short run test for symmetry, on the other hand, indicated the existence of symmetry effect in the response of economic growth to monetary policy shocks without financial innovations but asymmetric effects with financial innovations (see Tables 11 and 12 in Appendix).

In view of the existence of asymmetry in response to monetary policy, we proceed to model the long run and short run asymmetric dynamics as presented in Tables 15, 16, 17 and 18 (see Appendix). The coefficients of the positive and negative components of the explanatory variable in the exchange rate model have statistically significant impact on exchange rate behaviour in the long run in both the model with and without financial innovations. It is important, however, to note that in the model with financial innovations, the magnitude of the impact is much smaller: a per cent increase in the MPR results in a near zero increase exchange rate.

On the other hand, with no financial innovations, a percent increase in MPR will lead to 4.9 per cent increase in the exchange rate, while a percent negative shock will decrease the exchange rate by close to 59 per cent.

Turning to economic growth model, the coefficients of the explanatory variable were not statistically significant in the model without financial innovations (Table 16 in Appendix). In other words, the explanatory variable was not a statistically important variable explaining the behavior of economic growth.
However, in the model with financial innovations, the coefficients of the explanatory variable were statistically significant. In other words, financial innovations enhance the impact of monetary policy on economic growth in the long run. A one per cent decrease in the monetary policy rate results in 0.00012 per cent increase in economic growth. However, contrary to expectation, even a one per cent increase in MPR with financial innovations tends to have positive impact on economic growth.

In Table 17, the short run asymmetric dynamics of the exchange rate model without financial innovations shows that negative swings in the MPR will lead to statistically significant increase in the exchange rate (depreciation) in the short run. A positive swing on the other hand will have positive impact in the immediate period but will turn negative in the first lag period. In line with a priori expectation, the error correction term (ECT) is negative and the speed of adjustment is 15 per cent. This implies that exchange rate adjusts by 15 per cent of the changes in the monetary policy shock (MPR) over the previous month. There is slow adjustment in this case. The short run symmetry in the model with financial innovations is not statistically significant. The ECT is negative and statistically significant, but with low adjustment coefficient of 3.6 per cent.

With respect to the economic growth model without financial innovations, the short run asymmetric dynamics of the model shows that negative swings have significant impact only after two lags while positive swings do not impact at all in the short run (Table 18). The error correction term is negative and statistically significant. In the economic growth model with financial innovations, both positive and negative swings have significant impacts. Positive swings do not have immediate important impact - it only matters in the first and second lags. Negative swings, on the other hand, have immediate positive significant impact on economic growth and no significant impact until the seventh lag. The error correction term is negative and significant. The implications are that financial innovations enhance the impact of monetary policy shock on economic growth and ease the transmission process of monetary policy in the economy.

Long run Multipliers

Figures 3 to 6 depicts the cumulative multipliers for the four models examined in this study. The cumulative dynamics of economic growth and exchange rate with respect to a 1 per cent increase (positive shock) in monetary policy with and without financial innovations is represented by the upper solid line while the lower dashed solid line denotes the effect of 1 per cent negative shock (decrease) in monetary policy. The thick red dashed line between the 95 per cent confidence intervals represents the difference between positive and negative responses. Figure 3 depicts that positive component of monetary policy drives the asymmetry in relation to exchange rate. Thus, the response of exchange rate during periods of high monetary policy rate outweighs the response of exchange rate during periods of decline in monetary policy rate. However, in Figure 4 with financial innovations, there is a balance between the positive and negative components of monetary policy and the net impact is neutral or non-asymmetric. In the growth model, the long run multipliers chart shows that the asymmetry is initially driven by negative components and later by positive components. However, with financial innovation introduced into the model, the Figures 7 and

8 show the results of the cumulative sum of residual for test of model stability. As can be seen from the two figures the models are stable as the cumulative sum of residuals lies within the 95 per cent confidence interval in both cases.

6.0 Conclusion and Policy Recommendation

This study provides empirical inputs into the debate on the role of financial innovations in asymmetric impact of monetary policy shocks. First, we developed a model to examine the existence or otherwise of the asymmetric impact of monetary policy on output and exchange rate. Second, we examined the existence or otherwise of a relationship between the asymmetric effects of monetary policy shocks and financial innovations. We leveraged on the nonlinear autoregressive distributed lag (NARDL) model of Shin, Yu, and Greenwood (2014) and established that asymmetric effects exist and that financial innovations substantially eliminates such asymmetric effects of monetary policy shocks in Nigeria. The key policy implication of these findings is that financial innovation plays a major role in the monetary policy transmission. Specifically, it highlights the important role of financial innovations in the transmission of monetary policy impulse during economic recession.

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Appendix

Table 1: Phillips-Perron unit root test at Level

Variables	Unit Root			t-Stat at level
	1%	**5%**	**10%**	
M3	-4.0461	-3.4524	-3.1517	-2.4766
m2	-4.0461	-3.4524	-3.1517	-2.8809
fn1	-4.0461	-3.4524	-3.1517	1.4945
fn2	-4.0461	-3.4524	-3.1517	0.4358
Dd	-4.0461	-3.4524	-3.1517	-2.1156
Ibr	-4.0461	-3.4524	-3.1517	-8.1803***
Mpn	-4.0461	-3.4524	-3.1517	1.3837
cpi	-4.0461	-3.4524	-3.1517	0.2655
inf	-4.0461	-3.4524	-3.1517	-1.8337
ibexc	-4.0515	-3.4549	-3.1532	-2.0924
ngdp	-4.0461	-3.4524	-3.1517	-2.7 652
rgdp	-4.0461	-3.4524	-3.1517	-3.9255**
mpr	-4.0461	-3.4524	-3.1517	-1.8774

Source: Author's computation, * (**) (***) denotes significance at 10%, 5% and 1% respectively

Table 2: Phillips-Perron unit root test at First Difference

Variables	Unit R oot			t-Stat at First
	1%	**5%**	**10%**	**Difference**
M3	-4.0469	-3.4528	-3.1519	-10.1381***
m2	-4.0469	-3.4528	-3.1519	-12.3822***
fn1	-4.0469	-3.4528	-3.1519	-14.3433***
fn2	-4.0469	-3.4528	-3.1519	-17.7025***
Dd	-4.0469	-3.4528	-3.1519	-13.2457***
Ibr	-4.0506	-3.4545	-3.1529	-7.9639***
Mpn	-4.0469	-3.4528	-3.1519	-14.1860***
Cpi	-4.0469	-3.4528	-3.1519	-6.9445***
Inf	-4.0469	-3.4528	-3.1519	-11.1937***
Ibexc	-4.0505	-3.4545	-3.1529	-7.1098***
Ngdp	-4.0469	-3.4528	-3.1519	-5.1547***
Rgdp	-4.0469	-3.4528	-3.1519	-4.4726***
mpr	-4.0469	-3.4528	-3.1519	-9.9241***

Source: Author's computation, * (**) (***) denotes significance at 10%, 5% and 1% respectively

Table 3: Summary of Results for Cointegration Test

F-Bounds Test		Null Hypothesis: No level s relationship		
Test Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**
			Asymptotic: n=1000	
F-statistic	3.618030	10%	2.63	3.35
K	2	5%	3.1	3.87
		2.5%	3.55	4.38
		1%	4.13	5
			Finite Sample:	
Actual Sample Size	96		n=80	
		10%	2.713	3.453
		5%	3.235	4.053
		1%	4.358	5.393

Table 4: Summary of Results for Cointegration Test (MFN)

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**
			Asymptotic: n=1000	
F-statistic	4.5493 96	10%	2.63	3.35
K	2	5%	3.1	3.87
		2.5%	3.55	4.38
		1%	4.13	5
			Finite Sample:	
Actual Sample Size	96		n=80	
		10%	2.713	3.453
		5%	3.235	4.053
		1%	4.358	5.393

Table 5: Summary of Results of Wald Test of MPR with Financial Innovations

Test Statistic	Value	df	Probability
t-statistic	-2.392737	101	0.0186
F-statistic	5.725193	(1, 101)	0.0186
Chi-square	5.725193	1	0.0167
Null Hypothesis: $\omega_2^{+} = \omega_2^{-}$			
Null Hypothesis Summary:			
Normalized Restriction (= 0)		Value	Std. Err.
$\omega_2^{+} - \omega_2^{-}$		-2.41E-08	1.01E-08

Restrictions are linear in coefficients.

Table 6: Summary of Results of Wald Test of MPR without Financial Innovations

Test Statistic	Value	Df	Probability
t-statistic	16.79342	101	0.0000
F-statistic	282.0191	(1, 101)	0.0000
Chi-square	282.0191	1	0.0000
Null Hypothesis: $\omega_2^+ = \omega_2^-$			
Null Hypothesis Summary:			
Normalized Restriction (= 0)		Value	Std. Err.
$\omega_2^+ - \omega_2^-$		50.22180	2.990564

Restrictions are linear in coefficients.

Table 7: Summary of Results of Bound Test with Financial Innovations

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**
		Asymptotic: n=1000		
F-statistic	16.19567	10%	2.63	3.35
K	2	5%	3.1	3.87
		2.5%	3.55	4.38
		1%	4.13	5
		Finite Sample:		
Actual Sample Size	99	n=80		
		10%	2.713	3.453
		5%	3.235	4.053
		1%	4.358	5.393

Table 8: Summary of Results of Bound Test with Financial Innovations

F-Bounds Test		Null Hypothesis: No levels r elationship		
Test Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**
		Asymptotic: n=1000		
F-statistic	10.99395	10%	2.63	3.35
K	2	5%	3.1	3.87
		2.5%	3.55	4.38
		1%	4.13	5
		Finite Sample:		
Actual Sample Size	99	n=80		
		10%	2.713	3.453
		5%	3.235	4.053
		1%	4.358	5.393

Table 9: Summary of Results of Wald Test Long run Symmetry Without Financial Innovations

Test Statistic	Value	df	Probability
t-statistic	0.852128	104	0.3961
F-statistic	0.726122	(1, 104)	0.3961
Chi-square	0.726122	1	0.3941
Null Hypothesis: $\omega_2^+ = \omega_2^-$			
Null Hypothesis Summary:			
Normalized Restriction (= 0)		Value	Std. Err.
$\omega_2^+ - \omega_2^-$		18164.70	21316.87

Restrictions are linear in coefficients.

Table 10: Summary of Results of Wald Test Long run Symmetry With Financial Innovations

Test Statistic	Value	df	Probability
t-statistic	1.348463	104	0.1804
F-statistic	1.818352	(1, 104)	0.1804
Chi-square	1.818352	1	0.1775
Null Hypothesis: $\omega_2^+ = \omega_2^-$			
Null Hypothesis Summary:			
Normalized Restriction (= 0)		Value	Std. Err.
$\omega_2^+ - \omega_2^-$		9.69E-05	7.18E-05

Restrictions are linear in coefficients.

Table 11: Summary of Results of Wald Test for Short run Symmetry Without Financial Innovations

Test Statistic	Value	df	Probability
F-statistic	1.294081	(13, 74)	0.2360
Chi-square	16.82305	13	0.2075

Table 12: Summary of Results of Wald Test for Short run Symmetry With Financial Innovations

Test Statistic	Value	df	Probability
F-statistic	3.083173	(13, 74)	0.0011
Chi-square	40.08124	13	0.0001

Table 13: Summary of Results of Wald Test for Short run Symmetry between Economic Growth and the interactive Variable (MFN)

Test Statistic	Value	df	Probability
F-statistic	0.787701	(13, 71)	0.6704
Chi-square	10.24011	13	0.6742

Table 14: Summary of Results of Wald Test for Short run Symmetry With Monetary Policy Rate

Test Statistic	Value	df	Probability
F-statistic	1.527929	(13, 71)	0.1288
Chi-square	19.86308	13	0.0987

Table 15: Summary of Results for Long Run Asymmetric Relationship: Exchange Rate

Exchange Rate Model	With Financial Innovations		Without Financial Innovations	
Variable	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Constant	107.0071	0.000	140.460	**0.000**
MFN_POS	-2.03E-07	0.055		
MFN_NEG	-3.51E-07	0.031		
MPR_POS			4.903	0.007
MPR_NEG			-58.722	0.000

Note: MFN_POS and MFN_NEG denote positive and negative shocks in the interactive variable; while MPR_POS and MPR_NEG denote positive and negative shocks in the monetary policy rate.

Table 16: Long Run Asymmetric Relationship: Economic Growth

Economic Growth Model	With Financial Innovations		Without Financial Innovations	
Constant	41671.66	0.0003	30351.020	0.228
MFN_POS	0.00008	0.024		
MFN_NEG	0.00012	0.028		
MPR_POS			-782.662	0.856
MPR_NEG			4171.134	0.736

Table 17: Short Run Asymmetric Relationship: Exchange rate

Exchange Rate Model Without Financial Innovations				
Variable	**Coefficient**	**P-value**	**Coefficient**	**P-value**
D(IBEXC(-1))	0.69	0.08	8.32	0.00
D(IBEXC(-2))	-0.41	0.09	-4.56	0.00
D(IBEXC(-3))	0.25	0.09	2.86	0.01
D(IBEXC(-4))	-0.10	0.07	-1.47	0.15
D(MPR_POS)	5.28	1.10	4.80	0.00
D(MPR_POS(-1))	-2.89	1.18	-2.45	0.02
D(MPR_NEG)	-1.78	2.02	-0.88	0.38
D(MPR_NEG(-1))	7.54	2.70	2.79	0.01
D(MPR_NEG(-2))	7.53	2.70	2.79	0.01
D(MPR_NEG(-3))	7.54	2.70	2.79	0.01
D(MPR_NEG(-4))	10.17	2.70	3.77	0.00
D(MPR_NEG(-5))	6.46	2.86	2.26	0.03
D(MPR_NEG(-6))	7.91	2.77	2.86	0.01
D(MPR_NEG(-7))	-9.47	2.77	-3.42	0.00
ECM(-1)	-0.15	0.04	-4.06	0.00
	Exchange Rate Model With Financial Innovations			
D(IBEXC(-1))	0.810	0.096	8.403	0.000
D(IBEXC(-2))	-0.497	0.115	-4.308	0.000
D(IBEXC(-3))	0.232	0.096	2.412	0.018
ECM(-1)	-0.036	0.015	-2.358	0.020

Table 17: Short Run Asymmetric Relationship: Economic Growth

Economic Growth Model Without Financial Innovations				
D(RG(-1))	1.127	0.197	5.708	0.000
D(RG(-2))	1.059	0.159	6.647	0.000
D(RG(-3))	0.594	0.164	3.634	0.001
D(RG(-4))	0.783	0.144	5.441	0.000
D(RG(-5))	0.643	0.113	5.680	0.000
D(RG(-6))	0.178	0.116	1.534	0.129
D(RG(-7))	0.302	0.100	3.008	0.004
D(MPR_NEG)	57843.720	56434.240	1.025	0.308
D(MPR_NEG(-1))	7810.089	56802.130	0.137	0.891
D(MPR_NEG(-2))	161242.900	55347.870	2.913	0.005
ECM(-1)	-1.712	0.237	-7.232	0.000
Economic Growth Model With Financial Innovations				
D(RG(-1))	1.22941	0.16847	7.29766	0.00000
D(RG(-2))	1.07423	0.15144	7.09346	0.00000
D(RG(-3))	0.58311	0.14601	3.99358	0.00010
D(RG(-4))	0.84970	0.12402	6.85147	0.00000
D(RG(-5))	0.48084	0.09671	4.97207	0.00000
D(RG(-6))	0.31988	0.09357	3.41853	0.00100
D(RG(-7))	0.33621	0.08163	4.11892	0.00010
D(MFN_POS)	-0.00013	0.00016	-0.80420	0.42380
D(MFN_POS(-1))	-0.00039	0.00017	-2.35238	0.02120
D(MFN_POS(-2))	-0.00038	0.00019	-2.05363	0.04340
D(MFN_NEG)	0.00140	0.00023	6.20620	0.00000
D(MFN_NEG(-1))	-0.00015	0.00026	-0.59267	0.55510
D(MFN_NEG(-2))	0.00029	0.00027	1.07894	0.28400
D(MFN_NEG(-3))	-0.00024	0.00026	-0.91557	0.36280
D(MFN_NEG(-4))	-0.00002	0.00026	-0.07918	0.93710
D(MFN_NEG(-5))	0.00019	0.00025	0.79000	0.43200
D(MFN_NEG(-6))	-0.00037	0.00023	-1.58631	0.11680
D(MFN_NEG(-7))	0.00056	0.00024	2.34090	0.02180
ECM(-1)	-1.75128	0.20575	-8.51177	0.00000

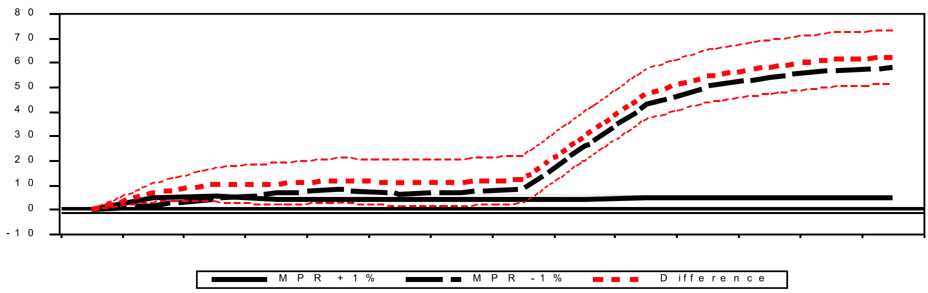

Figure 3: Long run Multiplier for Exchange Rate Model without Financial Innovations

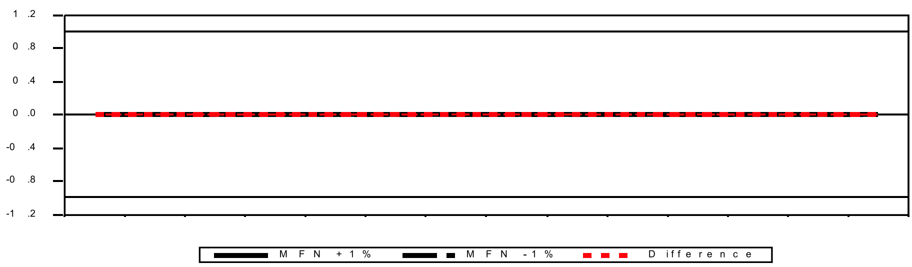

Figure 4: Long run Multiplier for Exchange Rate Model with Financial Innovations

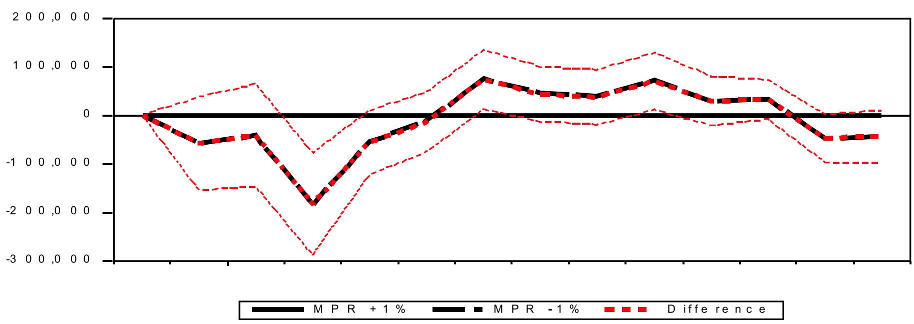

Figure 5: Long run Multiplier for Economic Growth Model without Financial Innovations

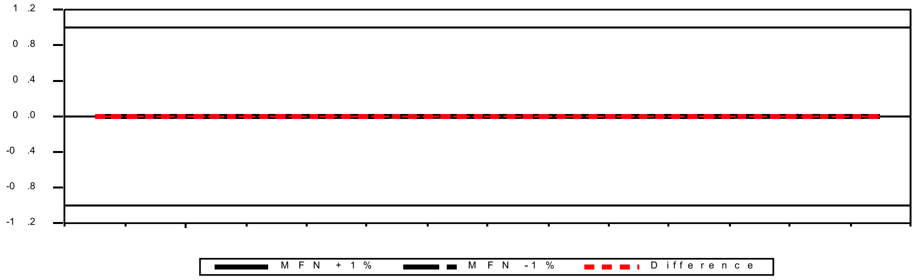

Figure 6: Long run Multiplier for Economic Growth Model with Financial Innovations

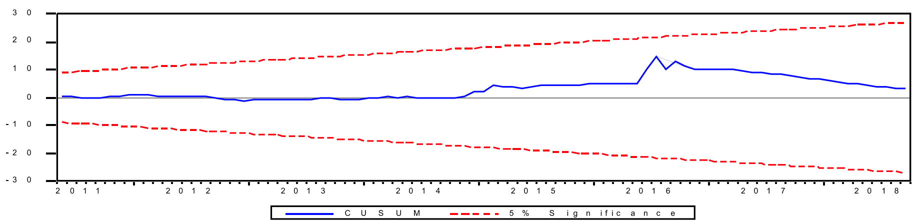

Figure 7: Model Stability Test for Exchange Rate Model

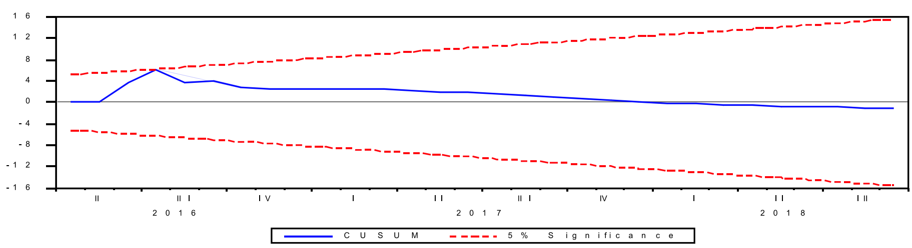

Figure 8: Model Stability Test for Economic Growth Model