CENTRAL BANK OF NIGERIA

MODELING THE IMPACT OF MACROECONOMIC UNCERTAINTY ON THE CONDUCT OF MONETARY POLICY

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EXECUTIVE SUMMARY

Since the work of Keynes on "The General Theory of employment, Interest and Money in 1936", several theoretical and empirical studies have been devoted to the analyses of the impact of uncertainty shocks on the economy. Uncertainty has a considerable connection with questions of probability, volatility, expectations and stability (in both macroeconomic and financial variables) and plays a critical role in the transmission and effectiveness of monetary policy.

Central banks often set specific objectives such as the achievement of price and monetary stability, improved economic growth and sound and stable financial system. In achieving these objectives, the monetary authority sets targets for key monetary and financial variables and develops policy strategies that could influence the variables. Thus, central banks' predictions also take cognizance of the dynamic behaviours of these variables of interest which also affect the outcomes of monetary policy.

Uncertainty may be because policy-makers are unsure of the model that best fits the dynamics of the economy. It may also be with respect to understanding the prevailing exogenous conditions of the economy. In Nigeria, uncertainty about the transmission mechanism and incomplete understanding of the system has remained a major challenge for monetary policy (Uchendu, 2009).

Given the raging debate in the literature as to whether uncertainty dampens the path of economic growth or recovery and inflationary performance, there is the need to measure it in order to manage it. Understanding the implications and state of uncertainty in an economy and importing such into the model of monetary policy making will greatly enhance the appropriateness and timeliness of policy decisions.

This study, therefore, models the impact of macroeconomic uncertainty on monetary policy in Nigeria. A number of questions are germane to this study: first, are the effects of monetary policy shocks weaker when uncertainty is high? Is the effectiveness of monetary policy influenced by the prevailing degree of economic uncertainty? Proceeding from a fundamentally policy rule a la Taylor's rule, real and nominal uncertainties, monetary uncertainty, stock market uncertainty and other structural factors to reflect country-specific features such as the pocket of banking crises, oil price and exchange rate are also in the

basket of the possible sources of volatility that raises the complexity of monetary policy implementation were estimated within a VAR framework. The GARCH is applied to measure uncertainty using the conditional variance of the relevant indicator given that it allows splitting-up of the sources of uncertainty into anticipated and unanticipated changes which can be evaluated using a VAR.

This enabled us to determine the short-run and long-run impact multipliers as well as conduct historical decomposition with a view to evaluating the time-varying dimensions of the major sources of impact. This approach permits indicators of uncertainty, monetary policy variables and economic growth to depend on one another. Thus, it is possible to include an exogenous 'shock' to the uncertainty equation, and then observe how that affects other variables within the system, such as output, exchange rate and inflation. In addition, by way of prognosis, the impulse response functions and forecast variance decomposition were also conducted.

The findings revealed that macroeconomic uncertainty does not significantly undermine monetary policy effectiveness in Nigeria. For instance, inflation uncertainty does not harm the output growth performance while exchange rate uncertainty shock and oil price shock have immediate positive effects that do not last long on output in Nigeria. Similarly, inflation uncertainty shocks have positive effect on inflation but negative response and correlation with exchange rate and oil price uncertainties, respectively. Finally, macroeconomic uncertainty in inflation, exchange rate and oil price causes the exchange rate to depreciate. Consequently, the choice of appropriate monetary policy reaction functions must be guided by wide range of information set to deal with these issues for proper conduct of monetary policy in Nigeria.

Section One

1.0 Introduction

Since the work of Keynes on "*The General Theory of Employment, Interest and Money* in 1936"*, several theoretical and empirical studies (see Ulrich (2012), Aastveit, et al (2013), Baker, et al (2013) and Bloom (2013))* has been devoted to the analyses of the impact of uncertainty shocks on the economy. Uncertainty has a considerable connection with questions of probability, volatility, expectations and stability (in both macroeconomic and financial variables) and plays a critical role in the transmission and effectiveness of monetary policy.

According to Montes (2010), uncertainty is a feature of the real world that influences the decision-making process of economic agents and undermines the effectiveness of monetary policy. Insufficient knowledge of the economic system could deter policy actions from having the desired effects while poor understanding of the consequences of monetary policy would lead to mis-judgement and extremely levitate the costs of achieving policy goals (Ononugbo, 2012). Hence, macroeconomic uncertainty may affect policy actions (or inactions), while policy uncertainty – not knowing how the policy maker will act – can spook the financial market.

Central banks often set specific objectives such as the achievement of price and monetary stability, improved economic growth and sound and stable financial system. In achieving these objectives, the monetary authority often set targets for key monetary and financial indicators and develop policy strategies that could influence their outcomes. Thus, the predictive ability of central banks takes cognizance of the dynamic behaviour of these variables of interest which also affect the outcomes of monetary policy.

Uncertainty in the monetary policy space is usually gleaned from the traverse of key macroeconomic variables especially inflation, output growth, exchange rate and interest rate usually measured by the amplitudes of their variances. However, the volatility of a number of other variables such as oil prices, sovereign debt profile, socio-political climate, disasters, and so forth–that impact on the macroeconomic ambiance are crucial sources of uncertainty and need not be overlooked. The effects of these variables are more critical for the investment components of the aggregate demand, more so for economies that are

vulnerable to foreign capital flows (given the volatile nature of interest rate sensitive portfolio investments) and increases the speculative behaviour among agents.

In the literature, macroeconomic uncertainty appears to have a bifurcate interaction with monetary policy. On one hand, the design of monetary policy and the level of transparency and credibility of the central bank in the conduct of monetary policy are important for the evolution of uncertainty through its effect on the process of rational expectation. This is closely related to the problems of time-inconsistency exposited in the works of Kydland and Prescott (1977) and Barro and Gordon (1983), which highlighted the role of rational expectations and the sub-optimality of discretionary (as against *rule*-based) policies in maximising the social objective function. Hence, the unpredictability of monetary policy outcomes, illustrated by deviations of the expectations of market participants from policy-makers' actions results in an environment of uncertainty (Herro and Murray, 2011). On the other hand, the level of volatility and uncertainty inherent in the macroeconomy weighs on the mind of policy makers when taking monetary policy decisions. In many respects, the degree to which uncertainties are incorporated in the model of policy making determines the correctness of the decision therefrom as it moderates the adverse consequences associated with knowledge constraints. In fact, Brainard (1967) and Debelle and Cagliarini (2000) argued that policy decisions that attaches zero weight to uncertainty may induce overshot or incomplete actions as the policy-maker seeks to aggressively avoid 'worst-case' outcomes.

Given the raging debate in the literature as to whether uncertainty dampens the path of economic growth or recovery and inflationary performance; there is the need to measure it in order to manage it. Understanding the implications and state of uncertainty in an economy and importing such into the model of monetary policy making will greatly enhance the appropriateness and timeliness of policy decisions. Uncertainty in this regard, may be because policy-makers are unsure of the model that best fits the dynamics of the economy. It may also be with respect to understanding the prevailing exogenous conditions of the economy.

In Nigeria, uncertainty about the transmission mechanism and incomplete understanding of the system has remained a major challenge for monetary policy (Uchendu, 2009). The country had faced several shocks and uncertainties which were largely external: international oil price shocks, volatility of crude oil receipts,

shocks associated with terms of trade, weak foreign demand and high world food prices, among others. On the domestic front, the economy has suffered from the occasional capital market collapse, lack of adequate fiscal savings, pockets of banking failures, ethnic and political tensions and leakages. These are believed to contribute to volatility and slow economic growth in Nigeria (Batini, 2004; Balogun, 2007).

There is no gainsaying that several efforts have been made to address apparent uncertainties in the economy and enhance the efficacy of monetary policy. First, following the establishment of the Monetary Policy Committee (MPC), through MPC workshops and retreats, Monetary Policy Implementation Committee (MPIC) and Monetary Policy Technical Committee (MPTC) brainstorming sessions, a huge information set is processed in pre-MPC discussion meetings prior to taking decisions on the direction of policy stance. Second, to deal with uncertainties regarding the future path of relevant variables, a suite of models are now being used to implement future forecasts for inflation, output growth and other relevant indicators. A number of studies such as Herro and Murray (2011) have investigated the effects of monetary policy uncertainty on the macroeconomy.

In spite of efforts to minimize macroeconomic uncertainty, the complexity of economic relationships, the size and persistence of existing shocks and the prevailing economic conditions support the investigation of uncertainties in macroeconomic variables in a small open oil economy like Nigeria. To help our understanding of the impact of uncertainty on monetary policy, a number of questions are germane to this study: Are the effects of uncertainty shocks high on monetary policy? Is the effectiveness of monetary policy influenced by the prevailing degree of economic uncertainty?

In order to answer these questions, this study seeks to model the impact of macroeconomic uncertainty on monetary policy in Nigeria. Specifically, the study determines the degree of macroeconomic uncertainty, using proxies such as inflation, output growth and exchange rate uncertainties; assess the short- and long-memory of uncertainties; and determine the impact of uncertainties on monetary policy objectives. The paper is organised into six sections. Following the introduction, section two provides an exhaustive examination of the existing relevant literature both theoretical and empirical. Section three maps the stylised facts discernible for the Nigerian case. Our research methodology is detailed in section four while section five conducts the empirical analysis. Policy recommendations and conclusions are in section six.

Section Two

2.0 Literature Review

2.1 Conceptual Issues

In the literature, the concept of macroeconomic uncertainty remains one area that has been difficult to conceptualize. Evidently, several authors have tried to analyze macroeconomic uncertainty from different perspectives. Macroeconomic uncertainty in traditional economic parlance simply implies volatility in economic and financial conditions and variables. Economic theory predicates that macroeconomic uncertainty makes it problematic to predict the outcome of monetary policy (Kydland and Prescott, 1977). One way uncertainty affects policy choices is that central banks anchor expectations of what is likely to happen in the future based on scenarios. This alludes why macroeconomic uncertainty is regarded as countercyclical (Bloom, 2013).

Nevertheless, there are many schools of economic thought that have attempted to conceptualize the meaning of macroeconomic uncertainty as well as its impact on the conduct of monetary policy in the literature. Some economists view macroeconomic uncertainty from output and inflation variability and volatility perspective (Bredin and Fountas, 2005). Others attempted to conceptualize it from the countercyclical behavior of economies-business cycle perspective (Bloom, 2013). Macroeconomic uncertainty is also perceived from the dynamic characterization of the general banking environment. For instance, it is expected that if banks perceive the macroeconomic environment to be stable, they form expectations that borrowers will be better able to repay loans because of their improved ability to accurately predict income stream over the life of the loan (Whyte 2010).

The effects of macroeconomic uncertainty on monetary policy run through the asymmetric impact of macroeconomic volatility of critical variables on the conduct and performance of monetary policy. Usually, economic agents form expectations on current macroeconomic conditions to predict what the future conditions would look like. In most cases, if current stock market is low, speculators expect the future path to rise and could take actions that could affect the future returns on the investment. Economic agents also see inflation volatility as opportunity for low growth of future inflation and rise in output performance.

In the literature, there are ways of dealing with the issue of macroeconomic uncertainty. These include rules and discretion. Rule approach deals with setting appropriate but systematic body of rules and procedures that economic variables path would follow. Discretionary approach however, relates to the instinct of the policymaker used to confront the dynamics of economic variables to achieve optimal policy solution.

The literature is replete with the precise analytical distinction between policy rules and discretion on time consistency (Barro and Gordon, 1983). A policy rule refers to the optimal solution to a dynamic optimization problem, whereas discretionary policy refers to the inconsistent or shortsighted solution, even though it may be a "time-consistent" strategy.

Humphrey (1992) and Prescott (1977) contributions to the discourse on conducting monetary policy according to rules has a long history in economics. The importance of the debate highlights the behaviour of central banks in the conduct of monetary policy. A rule-like behaviour involves that the central bank will conduct policy systematically while refraining from manipulating expectations to achieve temporary gains in output. In a rule-based policy, the monetary authority seeks to maximize an objective function by designing an appropriate formula to be implemented over several periods. In contrast, discretionary policy entails making new decisions in each period.

In addition, if the monetary authority is a rational policymaker that is free to choose the best monetary policy, the time-consistent monetary policy is the one that the monetary authority selects to optimize each time it selects a policy, even though the optimal policy would be to select a plan or rule at the beginning and then adhere to it over time, which could make the action "time-inconsistent". Whereas time-consistent policy could yield significant short-run social benefits, economic agents would rely on period-by-period optimization and this will make policymakers to lose credibility.

2.2 Empirical Literature

Empirical evidence on the impact of macroeconomic uncertainty on monetary policy is relatively scarce in the literature. The few available studies focus on advanced economies of the UK, US and Japan. A cursory survey of the literature also indicates that different methodological approaches have been adopted in investigating the empirical relationship between macroeconomic uncertainty and performance.

The seminal attempts by Brainard (1967) to uncover the effects of uncertainty on monetary policy opened a vista of extensive discussion on the subject, which has become a major issue in modern central banking. Brainard vehemently argued that in case of uncertainty about the magnitude with which policy choices affect aggregate demand and inflation, it is optimal to move the policy instrument by a smaller amount than in the case of no uncertainty. In other words, where parameter uncertainty exists in a model, central banks should not behave as if the uncertainty does not exist. This concept was later described by Blinder (1999) as the "Brainard uncertainty principle". The principle asserts that uncertainty about a parameter is multiplied into the system as more and more of a policy is used by the central bank.

Shuetrim and Thompson (1999) empirically examined the consequences of parameter uncertainty for optimal monetary policy and showed that parameter uncertainty could actually induce policy engagement following unanticipated shocks. Benchmarking this result with an open-economy framework model without parameter uncertainty, it was found that policy response differ, depending on the source of shock. They, however, cautioned that the results should be accepted with caution as parameter uncertainty implication depends on the type of shock as well as the model specification.

Ha (1999) examines the implications for monetary policy over uncertainty from two perspectives: the robustness of efficient inflation-forecast-based rules and the uncertainty about the length of the transmission lag. The results show that though less-aggressive and more forward-looking rules are more robust than more-aggressive and less- forward-looking rules, the later has higher absolute levels of inflation variability, making central banks to favour the less-robust rules, which are better at containing inflationary pressures. The results further indicate that under uncertainty about the transmission lag, it is better for central banks to assume that inflation is harder to curb and, thus, overestimate the transmission lag. This will enable them to receive warning signals of inflationary pressures and hence nib it in the bud in order to stabilize the economy.

Debelle and Cagliarini (2000) investigated the extent to which various forms of uncertainty affect the optimal path of interest rates or variability of the instrument of monetary policy in a simple Australian economy model. It was observed that the difference between the observed optimal policy outcome and those derived from the model could not be explained by the direct introduction of uncertainty. Similarly, while uncertainty about output sensitivity improved the degree of

smoothness of optimal policy, interest rate was rather influenced by different factors other than those observed.

Jordà and Salyer (2001) and Creal and Wu (2014) investigated the contribution of interest rate uncertainty to economic fluctuations and business cycles using term structure model to extract uncertainty from the volatility of yields as well as a VAR model to determine the impact on key macroeconomic variables. Results indicated that a shock to short term interest rate uncertainty reduced inflation, while a higher long-term uncertainty led to reverse results of higher inflation. In the context of a limited participation model, Jordà and Salyer (2001) showed that greater uncertainty about monetary policy usually resulted in a decline in nominal interest rates. Increased uncertainty was also found to dampen short-term maturity bonds yield as households improved their liquidity profile with the banking sector. Similarly, reduction in long-term maturity bonds yield was also noticed but that the decrease would result to a greater uncertainty on the nominal intertemporal rate of substitution.

Bredin and Fountas (2005) used a bivariate GARCH-M model to measure the effect of real (output growth) and nominal (inflation) uncertainty on inflation and output growth for the European Union (EU) countries, including all Eurozone countries by applying monthly data from 1962 to 2003. Testing for four economic theories associated with the Friedman (1968), the paper noted that inflation uncertainty had positive impact on output growth with evidence of associated cost; output growth uncertainty is mixed having a negative and positive effect in some countries.

Herro and Murray (2011) estimated the Taylor-type regression rule and a constant gain learning model to quantify the degree of effect of monetary policy uncertainty on levels of output growth, unemployment, inflation as well as the volatility of these variables in the U.S. economy. The paper observed that though uncertainty could not predict nor show evidence among the levels of variables, it nevertheless significantly exerted pronounced output, growth and unemployment volatilities.

From the banking sector lending behaviour perspective, Whyte (2010) used autoregressive distributed lag (ARDL) framework to investigate the response of credit to macroeconomic volatility or uncertainty in the Jamaican economy. Though the result could not confirm the existence of a long-run relationship between bank lending and indicators of macroeconomic uncertainty, interest

rate volatility was found to be the most important macroeconomic variable, owing largely to the interaction between monetary and fiscal policies in the economy in the short-run. Evidenced from the study was the positive effect of exchange rate and inflation uncertainties on bank lending in the short-run, while uncertainty associated with monetary policy had a negative effect. To sustain economic growth, the paper opined that policymakers should focus on building market confidence as well as correct the imbalances in the macro economy.

Examining the impact of macroeconomic uncertainty on banking activities, Baum et al (2004) and Talavera et al (2006), submitted that since banks must obtain costly information on borrowers before extending loans to new or existing customers, uncertainty about economic conditions (and the likelihood of loan default) would have clear effects on their lending behaviour and affect the allocation of available funds. Therefore, as uncertainty increased/decreased, the loan–to–asset ratios declined/increased as greater economic uncertainty hindered banks' ability to foresee the investment opportunities (returns from lending). Conversely, when uncertainty was reduced, incomes predictability was enhanced culminating to a higher loan-to-assets ratio, as managers took advantage of more precise information about different lending opportunities. Thus, the economic environment was a systematic risk component that affected every participant within the economy.

Section Three

3.0 Stylized Facts on Uncertainties and Macroeconomic Variables

This section covers the developments around key macroeconomic variables as well as the conduct of monetary policy in Nigeria. Over the past four decades, several episodes and developments propagated by many factors have been observed in the economy. These factors build in uncertainties in the behaviour of macroeconomic variables over time. For instance, macroeconomic uncertainty has been observed to emanate from banking crises, oil price crises and exchange rate crisis period in Nigeria. In the banking crisis period, the economy may be bedeviled by liquidity constraints and may undermine financial intermediation processes. In Nigeria, there has been period of banking crises with attendant effects on some economic and financial variables. During the period 1994, 2004 and 2009, Nigeria witnessed banking crises with some implications on liquidity, interest rates, and exchange rate.

The Nigerian oil and gas sector has been under pressure in the last two decades especially during and after the global financial crisis. Figure … show that prior to the GFC, the price of bonny light, Nigeria's crude oil price, strongly trended upward to peak at over US$120 per barrel in 2008. However, during the GFC crude oil price drastically dipped to a trough of US$40 per barrel in 2009 from a peak of US$147 per barrel in 2008. Associated implication ranged from significant collapse of financial institutions to losses in asset value/share price particularly of mortgage-related securities, stock market declines, speculative bubbles and currency crisis, among others. Similarly local currency depreciated from N118 to N145 per US dollar (official rate) in the same period. Stock prices have also witnessed significant bearish trends due to this crisis in the last quarter of 2008. In the post GFC era, oil price recovered to stabilize at an average of US$100 per barrel between 2010 and 2014. However, from the middle of 2014 oil price nose-dived to a five-year ebb of US$50 per barrel owing largely to supply glut in the international oil market, weak recovery in advanced and emerging economies and declining demand for Nigeria's crude oil, among others.

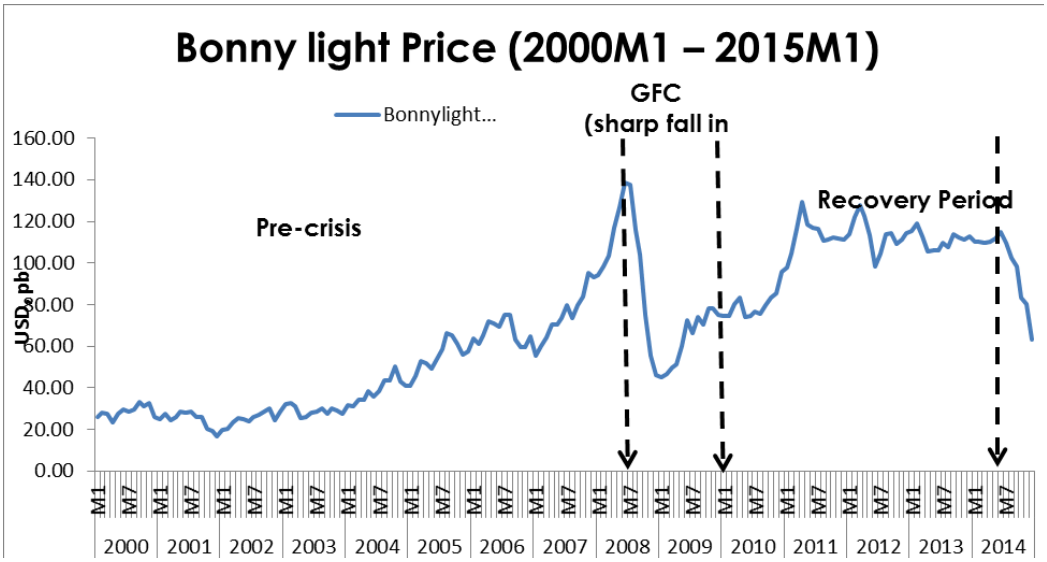
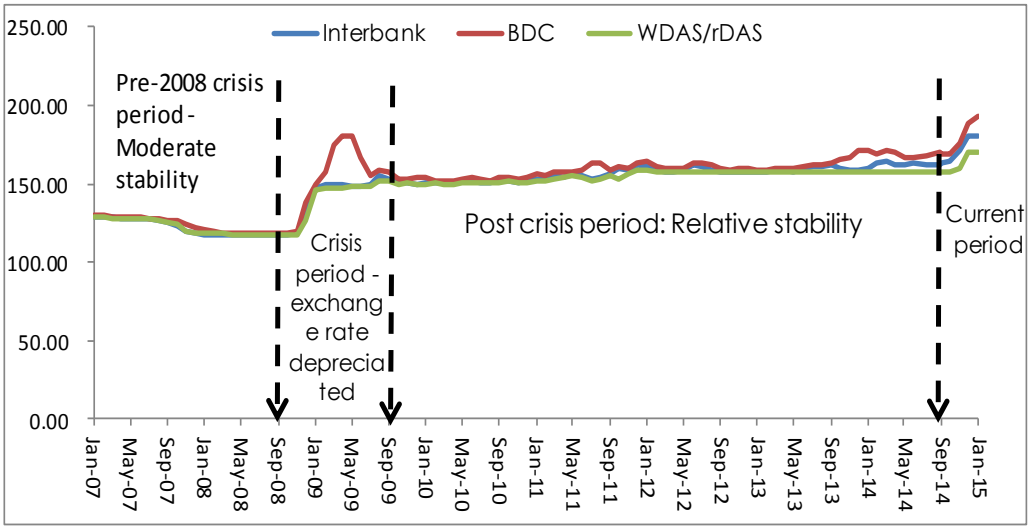


Figure 2 illustrates exchange rate movements in the different segments of the foreign exchange market over four periods; pre-2008 crisis period, crisis period, post-crisis period and the current period. Prior to the global financial crisis, exchange rate exhibited relative stability owing to the monetary policy stance. During the crisis period, macroeconomic uncertainty associated with the exchange rate caused the exchange rate to depreciate. It also highlights the direct link between exchange rate and oil price. Given the structure of our economy, oil price crisis also heightens undue pressure on the exchange rate.

During the post global financial crisis, macroeconomic uncertainty in the exchange rate was moderated due to the policy stance of the Central Bank of Nigeria. Exchange rate exhibited modest stability until the third quarter of 2014 when the economy plunged into a serious crisis due to oil price fall. In general it is evident that macroeconomic uncertainties can be extremely contagious. In other words, given the nature of our economy, oil price shocks can trigger exchange rate and banking crises which could underpin the behaviour of macroeconomic variables.


Interbank
BDC
WDAS/rDAS
Pre-2008 crisis period - Moderate stability
Crisis period - exchange rate depreciated
Post crisis period: Relative stability
Current period
250.00
200.00
150.00
100.00
50.00
0.00
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
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Section Four

4.0 Methdology

In the literature, various methods have been used in the measurement of uncertainty in macroeconomic time series. It is rather incontrovertible that many economic time series are characterised by time-varying variance and are subject to volatility clustering. In short, volatility clustering entails periods of high variances and low variances at some other periods. These levels of uncertainty definitely can make policy making very challenging if it is not clearly understood. Proceeding from a fundamentally policy rule a la Taylor's rule, real and nominal uncertainties were determined. In addition, monetary uncertainty, stock market uncertainty and other structural factors to reflect country-specific features such as the pocket of banking crises, oil price and exchange rate are also in the basket of the possible sources of volatility that raises the complexity of monetary policy implementation. The research agenda, as noted earlier, is to assess the implication of these different layers of uncertainty for monetary policy, in particular, on the objectives of monetary policy. Consequently, extracting the idiosyncratic uncertainties require robust tool-kit as found in the extant literature.
Originally, measures of uncertainty have been developed in the literature to model volatility in financial time series. Engle (1982) developed the Autoregressive Conditional Heteroscedasticity (ARCH) to measure plausible strong correlations between observations characterized by large distance apart and time varying. Several extensions to the pioneer ARCH model, includes Engle's, et al (1987), ARCH in Mean (ARCH-M), the Generalized ARCH (GARCH) by Bollerslev (1986). The different aspect of the GARCH model also includes the integrated GARCH (IGARCH) model by Engle and Bollerslev (1986), the multivariate GARCH models (MGARCH) by Baba, et al (1990) and extended by Engle and Kroner (1995) and asymmetric GARCH models [exponential GARCH (EGARCH) by Nelson (1991), GJR-GARCH by Glosten, et al (1993), and asymmetric power GARCH ((APGARCH) model by Ding, et al (1993)].

To achieve this, the Generalised Autoregressive Conditional Heteroskedasticity (GARCH) is applied to measure uncertainty using the conditional variance of the relevant indicator. This approach is usually preferred to some of the early measures of uncertainty such as the rolling standard deviation. In this regard, the GARCH approach has the advantage of allowing a split-up of the sources of

uncertainty into anticipated and unanticipated changes much more than variability, which is what the variance or standard deviation method yields.

4.1 Data

The study applies annualised quarterly data spanning, 2000:1–2015:1. These variables include inflation, real GDP growth, real M2 growth, oil price, growth in market capitalization (equities), changes in exchange rate and measures of money market activity. To derive the measures of uncertainty, a composite indicator of uncertainty for the money market is modelled using a multivariate GARCH, while the univariate GARCH is used to obtain inflation uncertainty, real output uncertainty, monetary uncertainty, stock market uncertainty and exchange rate volatility. The impact of these conditional variances on the objectives of monetary policy can, thus, be evaluated using a VAR.

4.2 Evaluation of Time Series Properties and ARCH Effects

In order to provide a prima facie evidence of the presence of ARCH effects, the time series is evaluated for the presence of unit root test using the augmented Dickey-Fuller statistic with the lag order selection based on the Akaike Information Criteria (AIC) and Schwartz Bayesian Criteria (SBC). The ARCH effects is examined by estimating a GARCH (1, 0**)** model of the form:

An ARCH (q) model has two equations, which are estimated simultaneously. The first equation is the mean equation, and the second is the variance equation. A simple ARCH (1) with an autoregressive first order mean equation and first order variance equation is expressed as follows,

$y_t = a_0 + a_1 y_{t-1} + \varepsilon_t$, where $\varepsilon \tilde{} D(0, h_t)$

$h_t = \omega + \alpha_1 \hat{\varepsilon}^2_{t-1}$ Since the variance represents the second moment of the process, it follows that the two equations constitute a system. In this case the mean is an AR (1) process and the variance process is also an autoregressive process of the first order. Generally, we have an ARCH process as:

$y_t = \mathrm{E}\{y_t \mid I_t\} + \varepsilon_t$, the mean process,

Where $\varepsilon_t \sim D(0, h_t)$

$h_t = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon^2_{t-i}$, the variance process, ARCH (q)

4.3 The Generalised Autoregressive Conditional Heteroscedasticity (GARCH)

For a more general specification, the variance process is modeled as a GARCH (p,q)

$$h_t = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i}$$

If there are no ARCH or GARCH effects the sum of the coefficients should be zero, $\sum_{i=1}^{q} \alpha \varepsilon_{t-i}^2 + \sum_{i=1}^{q} \beta_i h_{t-1} = 0$. It follows that the variable ω is the residual variance and $\omega = \sigma^2$. The sum of the coefficients $\sum \alpha_i + \sum \beta_i$ shows the long-run solution of the GARCH process. If the coefficients sum to unity, $\sum \alpha_i + \sum \beta_i = 1$, we talk about an Integrated GARCH (IGARCH) process.

In order to derive an indicator of money market uncertainty, this paper applies the more specific GARCH-M as it gives us the flexibility to have a composite indicator of a number of money market variables including interbank call rate, prime lending rate, and ratio of banking system liquid assets to total. The intuition for this selection is predicated on the need to capture the banking industry's ability to sustain intermediation over a long term.

$$Y_t = \mu + \sum_{i=1}^{p} \Gamma_i Y_{t-i} + \psi \sqrt{h_t} + \sum_{j=i}^{q} \Theta_j \varepsilon_{t-j} + \varepsilon_t \quad \text{Where } \varepsilon_t \square (0, \mathrm{H}_t)$$

(1)

$$H_t = \begin{pmatrix} h_{y,t} & h_{y\pi,\mathrm{t}} \\ h_{\pi y,\mathrm{t}} & h_{\pi,t} \end{pmatrix}$$

Where, $Y_t = \begin{pmatrix} y_t \\ \pi_t \end{pmatrix}; \varepsilon_t = \begin{pmatrix} \varepsilon_{y,t} \\ \varepsilon_{\pi,t} \end{pmatrix}; \sqrt{h_t} = \begin{pmatrix} \sqrt{h_{y,t}} \\ \sqrt{h_{\pi,t}} \end{pmatrix}; \mu = \begin{pmatrix} \mu_y \\ \mu_\pi \end{pmatrix}$

$$\Gamma_i = \begin{pmatrix} \Gamma_{11}^i & \Gamma_{12}^i \\ \Gamma_{21}^i & \Gamma_{22}^i \end{pmatrix}; \psi = \begin{pmatrix} \psi_{11} & \psi_{12} \\ \psi_{21} & \psi_{22} \end{pmatrix}; \Theta_j = \begin{pmatrix} \Theta_{11}^j & \Theta_{12}^j \\ \Theta_{21}^j & \Theta_{22}^j \end{pmatrix}$$

$$H_t = C_0^{*l} C_0^* + B_{11}^{*l} H_{t-1} B_{11}^* + A_{11}^{*1} \varepsilon_{t-1} \varepsilon_{t-1}^l A_{11}^* + D_{11}^{*l} \xi_{t-1} \xi_{t-1}^l D_{11}^*$$

(2)

Where $C_0^* = \begin{pmatrix} c_{11}^* & c_{12}^* \\ 0 & c_{22}^* \end{pmatrix}; \mathrm{B}_{11}^* = \begin{pmatrix} \beta_{11}^* & \beta_{12}^* \\ \beta_{21}^* & \beta_{22}^* \end{pmatrix}; A_{11}^* = \begin{pmatrix} \alpha_{11}^* & \alpha_{12}^* \\ \alpha_{21}^* & \alpha_{22}^* \end{pmatrix};$

$$D_{11}^* = \begin{pmatrix} \delta_{11}^* & \delta_{12}^* \\ \delta_{21}^* & \delta_{22}^* \end{pmatrix}; \xi_t^2 = \begin{pmatrix} \xi_{y,t}^2 \\ \xi_{\pi,t}^2 \end{pmatrix}$$

4.4 Structural Vector Autoregression

4.4.1 Vector Autoregression

To analyse the impact of macroeconomic uncertainty on monetary policy, the estimates of measures of uncertainty and indicators of the objectives of monetary policy were undertaken by adopting a Vector Autoregression (VAR) framework. This enabled us to determine the short-run and long-run impact multipliers as well as conduct historical decomposition with a view to evaluating the time-varying dimensions of the major sources of impact. This approach permits indicators of uncertainty, monetary policy variables and economic growth to depend on one another. Thus, it is possible to include an exogenous 'shock' to the uncertainty equation, and then observe how that affects other variables within the system, such as output, exchange rate and inflation. In addition, by way of prognosis, the impulse response functions and forecast variance decomposition will also be conducted.

4.4.2 Structural Identification

The study identified the restrictions on structural parameters as shown in equation..., where εrY, εhinf, εiber, εhinf_un, εiber_un and εolp_un represent structural shocks relating to each variable in the SVAR. The long run restriction is over-identification with six (6) degrees of freedom.

$$\begin{bmatrix} 1 & c_2 & 0 & c_7 & c_{11} & 0 \\ 0 & 1 & c_4 & c_8 & 0 & 0 \\ 0 & 0 & 1 & c_9 & c_{12} & c_{14} \\ c_1 & c_3 & 0 & 1 & 0 & 0 \\ 0 & 0 & c_5 & c_{10} & 1 & c_{15} \\ 0 & 0 & c_6 & 0 & c_{13} & 1 \end{bmatrix} \begin{bmatrix} ry \\ h\inf \\ iber \\ h\inf\_un \\ iber\_un \\ olp\_un \end{bmatrix} = V(L) \begin{bmatrix} ry \\ h\inf \\ iber \\ h\inf\_un \\ iber\_un \\ olp\_un \end{bmatrix} + \begin{bmatrix} \varepsilon_{ry} \\ \varepsilon_{h\inf} \\ \varepsilon_{iber} \\ \varepsilon_{h\inf\_un} \\ \varepsilon_{iber\_un} \\ \varepsilon_{olp\_un} \end{bmatrix} \quad (3)$$

From the equation, it is assumed that aggregate output (rY) reacts to contemporaneous change in inflation (hinf), and uncertainties in inflation (hinf_un) and exchange rate (iber_un) and inflation prices (hinf) only react immediately to innovations in exchange rate (iber) and inflation uncertainty (hinf_un). The first two rows of equation () does not support the idea that the reaction of the real sector (aggregate output and prices) to shocks in the monetary sector. The third row represents the exchange rate equation. Exchange rate, being an asset price, reacts immediately to all uncertainty shocks. The inflation uncertainty shocks response to output and inflation.

Section Five

5.0 Empirical Results

5.1 Discussion

The conditional variances of inflation, exchange rate and oil price are derived in a univariate GARCH and the estimates were used to conduct block exogeneity/Granger causality tests. Consequently, the causality relationships were examined to inform data consistent ordering in the unrestricted VAR.

The estimated coefficients of the conditional variance equations are reported in Tables 1a-d. The parameters sufficiently satisfy the GARCH conditions. The residual diagnostics also shows that the GARCH models of the conditional means and conditional variances describe the joint distribution of the disturbances well.

A plot of the conditional volatility for inflation, exchange rate and oil price are reported in Figures 1a-d. The conditional volatility of exchange rate (Figure 1a) was high in March 2007 at the onset of the global financial crisis and there were also occasions of some short-memory rises over the sample period. The sharp increase in international oil prices contributed to the extreme volatility of the oil price in 2008 and occasional rise in the latter months. The period of the global financial crisis was also characterized by strong monetary uncertainty as a result of monetary easing that came with the stimuli of the domestic economy through banks, in particular, the expanded discount window facility and the injection of over N620 billion. The conditional volatility of the inflation (Figure 1c) showed considerable uncertainty between 2001 and 2005, but narrowed since 2006 at relative levels of stability over the estimation sample.

Table 1a: Univariate GARCH Model of Headline Inflation

Dependent Variable: Headline Inflation

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	1.07	0.05	20.19	0.000
HINF(-1)	0.91	0.00	231.37	0.000
	Variance Equation			
C	-0.031	0.007	-4.631	0.000
RESID(-1)^2	0.057	0.024	2.383	0.017
GARCH(-1)	0.939	0.019	49.381	0.000

Table 1b: Univariate GARCH Model of Exchange Rate

Dependent Variable: Inter-bank Exchange Rate

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	10.250	1.046	9.804	0.0000
IBER(-1)	0.952	0.004	225.120	0.0000
HINF	0.082	0.013	6.196	0.0000
PLR	-0.233	0.034	-6.948	0.0000
MA(1)	0.315	0.049	6.440	0.0000
	Variance Equation			
C	0.489	0.131	3.736	0.0002
RESID(-1)^2	2.100	0.328	6.396	0.0000
GARCH(-1)	-0.009	0.012	-0.791	0.4291

Table 1c: Univariate GARCH Model of Oil Price

Dependent Variable: Oil Price

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.560	0.732	0.765	0.4442
OLP(-1)	0.995	0.010	103.990	0.0000
	Variance Equation			
C	2.046	1.479	1.384	0.1664
RESID(-1)^2	0.305	0.132	2.309	0.0210
GARCH(-1)	0.649	0.133	4.875	0.0000

Table 1d: Univariate GARCH Model of Oil Price

Dependent Variable: Real Monetary Growth

Variable	Coefficient	Std. Error	z-Statistic	Prob.
RMG(-1)	0.954	0.008	118.018	0.0000
MA(1)	-0.290	0.070	-4.160	0.0000
	Variance Equation			
C	22.388	6.159	3.635	0.0003
RESID(-1)^2	0.815	0.208	3.911	0.0001
GARCH(-1)	0.151	0.111	1.366	0.1719

Figure 1a: Conditional Volatility of Interbank Exchange Rate

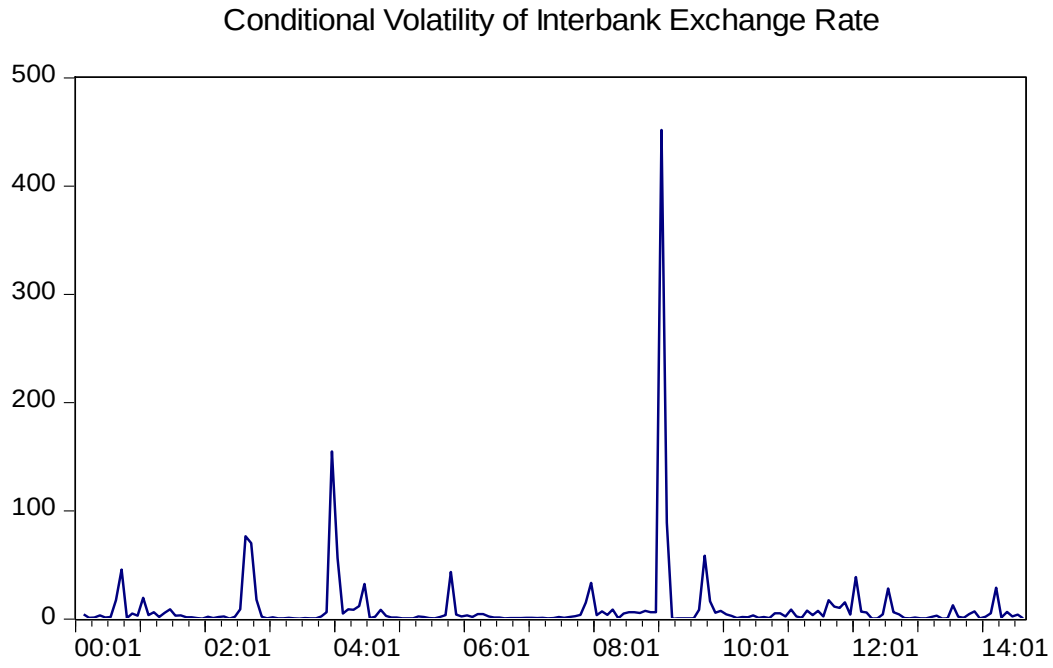


Figure 1b: Conditional volatility of Oil Price

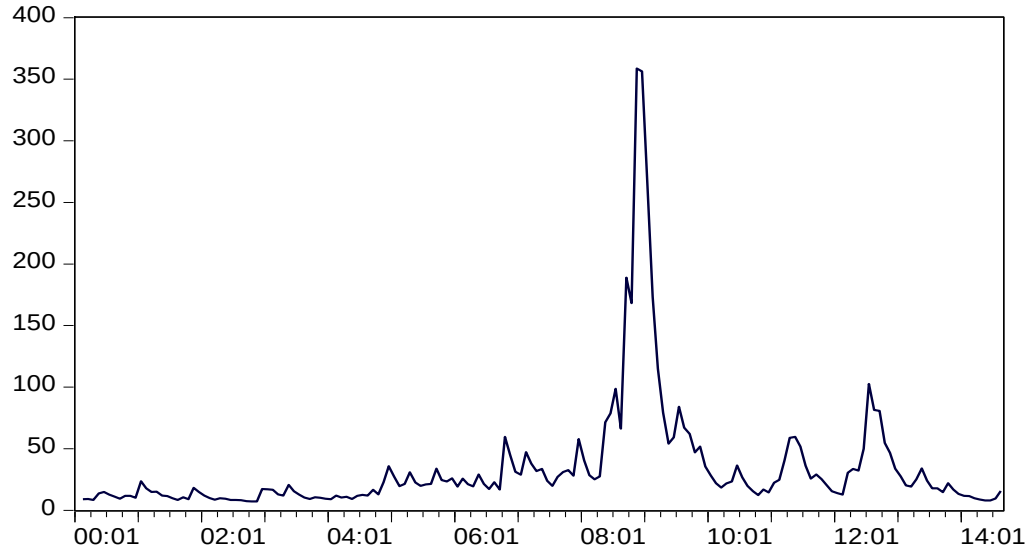


Figure 1c: Conditional Volatility of Inflation

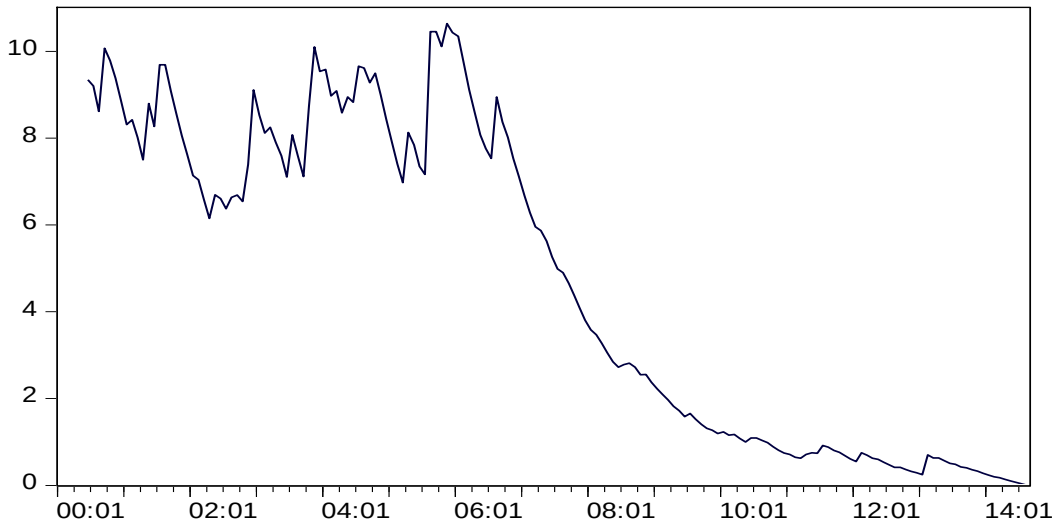
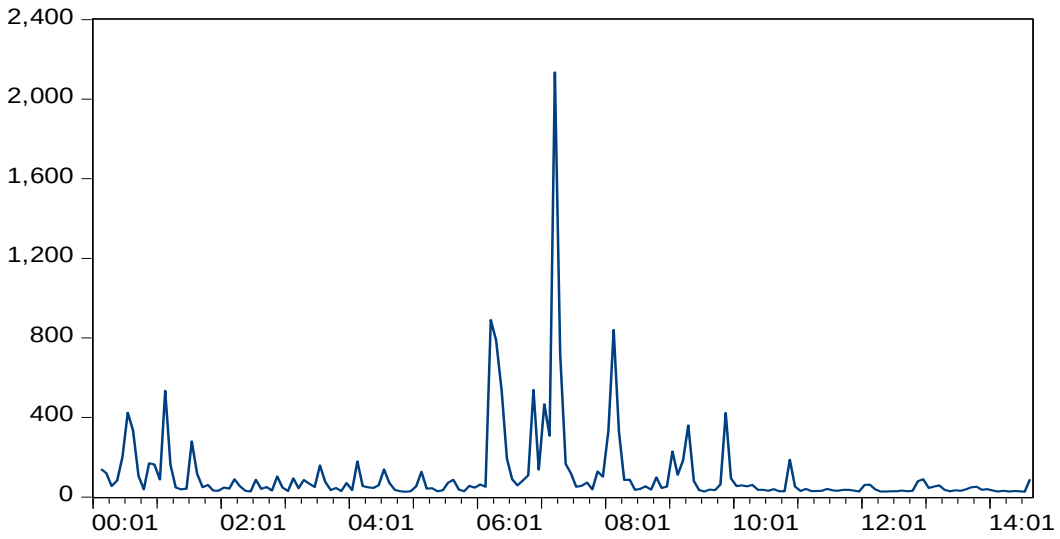


Figure 1d: Conditional Volatility of Real Money



In order to conduct structural factorization of the VAR, the unrestricted VAR was estimated with a lag specification of order of 2 based on an appropriate lag order selection criteria. The VAR was found to be stable with no root lying outside the unit circle (see Table 2). The variables entering the VAR were ordered based on a Block Exogeneity test.

Table 2: Stability Tests

Roots of Characteristic Polynomial

Endogenous variables: RY HINF IBER HINF_UN IBER_UN OLP_UN

Exogenous variables: C OLP

Root	Modulus
0.960016 - 0.040253i	0.960859
0.960016 + 0.040253i	0.960859
0.854411 - 0.067396i	0.857065
0.854411 + 0.067396i	0.857065
0.489534 - 0.152524i	0.512744
0.489534 + 0.152524i	0.512744
0.209624 - 0.409063i	0.459646

0.209624 + 0.409063i	0.459646
-0.219615 - 0.274025i	0.351170
-0.219615 + 0.274025i	0.351170
-0.085414	0.085414
0.026284	0.026284

No root lies outside the unit circle.

VAR satisfies the stability condition.

5.1.1 Long-run Structural Vector Autoregression (SVAR) Estimates

$$\begin{bmatrix} 1 & -7.22^{*} & 0 & -2.77^{*} & 0.71 & 0 \\ 0 & 1 & -0.23 & 12.4^{*} & 0 & 0 \\ 0 & 0 & 1 & -23.17^{*} & -41.51 & -53.15^{**} \\ -11.32^{*} & 1.09 & 0 & 1 & 0 & 0 \\ 0 & 0 & 45.97^{*} & 5.85^{*} & 1 & 16.69 \\ 0 & 0 & 140.4^{*} & 0 & 48.02 & 1 \end{bmatrix} \begin{bmatrix} ry \\ h\inf \\ iber \\ h\inf\_un \\ iber\_un \\ olp\_un \end{bmatrix} \quad (4)$$

From equation 4, * and ** indicate significance at 1%, 5% and 10% levels, respectively. Obviously, although, the structural identification indicated over-identification, with six (6) of the coefficients insignificant they can safely be said to be statistically not different from zero. Thus, inflation and inflation uncertainty shocks are the major drivers of the output growth. Inflation is generally driven from this finding by idiosyncratic inflation uncertainty shocks which can well represent the role of inflation expectations. The inter-bank exchange rate is majorly influenced by inflation uncertainty and oil price uncertainty shocks. This evidence brings to bear, the role of oil price volatility in the stabilization of the exchange rate if there is a positive shock to it. The inflation-growth nexus is underscored with growth shocks playing a significant role in the determination of inflation uncertainty shocks, while inter-bank uncertainty shock is largely influenced by shocks to exchange rate and inflation uncertainty. These pieces of evidence fit Nigeria's data as a strong correlation between oil price and exchange rate appreciation has been observed. Over the years, when oil price rises, external reserves are accumulated, while the appreciation of the exchange rate reduces the pass-through to domestic prices as the cost of food imports becomes cheaper, keeping inflation subdued.

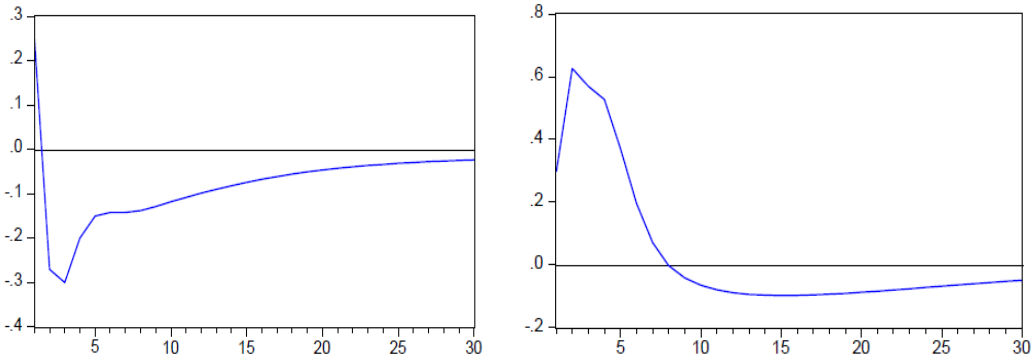
5.1.2 Impulse Response Functions

5.1.2.1 Response of Output Growth to Inflation, Exchange Rate and Oil price Uncertainties Shocks

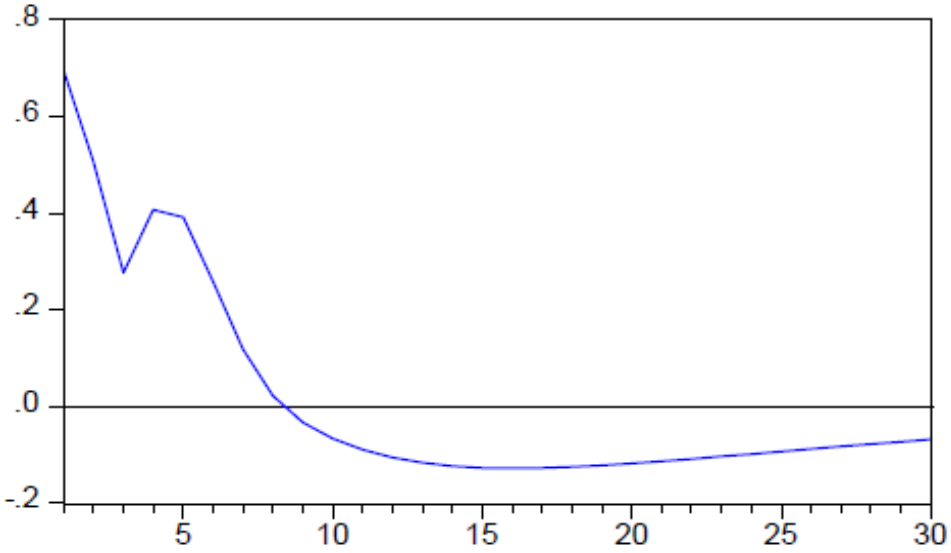
Contrary to expectations, inflation uncertainty does not harm the output growth performance in Nigeria. In the short run, we find evidence of a positive effect of inflation uncertainty on growth, thus supporting Dotsey and Sarte (2000) and contradicting Friedman (1977). Thus, uncertainty about inflation is not detrimental to growth in Nigeria. Therefore, on the basis of these results, it is observed that the Central Bank of Nigeria may need to complement its price stability objective with the growth objective by incorporating output uncertainty in its monetary policy objective.

A one standard deviation shock to exchange rate uncertainty leads to instantaneous increase in real output, peaking at the seventh period before decelerating gradually to the steady state in the eighth month. Thereafter, output slows down and remains persistent throughout the observed period. Thus, exchange rate uncertainty shocks improve macroeconomic performance in the short run i.e., raise output growth.

Figure 2: Responses of Real Output Growth to Selected Uncertainty Shocks
Response of RY to Inflation Uncertainty Shock Response of RY to Exchange Rate Uncertainty Shock



Response of RY to Oil Price Uncertainty Shocks

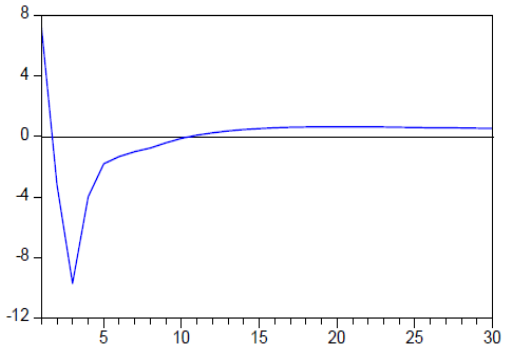


5.1.2.2 Response of Exchange Rate to Inflation, Exchange Rate and Oil price Uncertainties Shocks

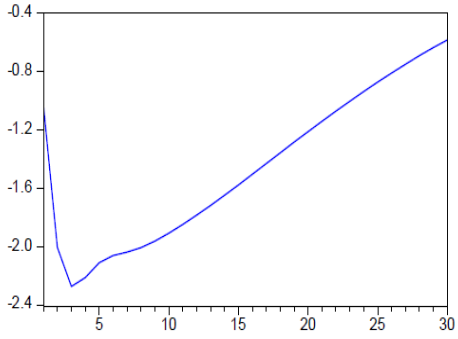
Ostensibly, although, the CBN seeks to stabilize the price level and support strong output growth, it understands that this can only be achieved if the naira exchange rate is not subject to extreme misalignment. Consequently, interventions in the foreign exchange market are used as a tool to keeping the exchange rate devoid of volatility arising from macroeconomic uncertainty. In line with a-priori expectation, inflation uncertainty leads to a depreciation of the naira. Furthermore, idiosyncratic uncertainty in the exchange rate also contributes to the dynamics of the naira exchange rate. In economic parlance, when economic agents expect the exchange rate movement to vary in the near to medium to term, it builds in uncertainty around the exchange rate. The impact showed long memory of oil price uncertainty on the level of exchange rate.

Figure 3: Responses of Exchange Rate to Selected Uncertainty Shocks

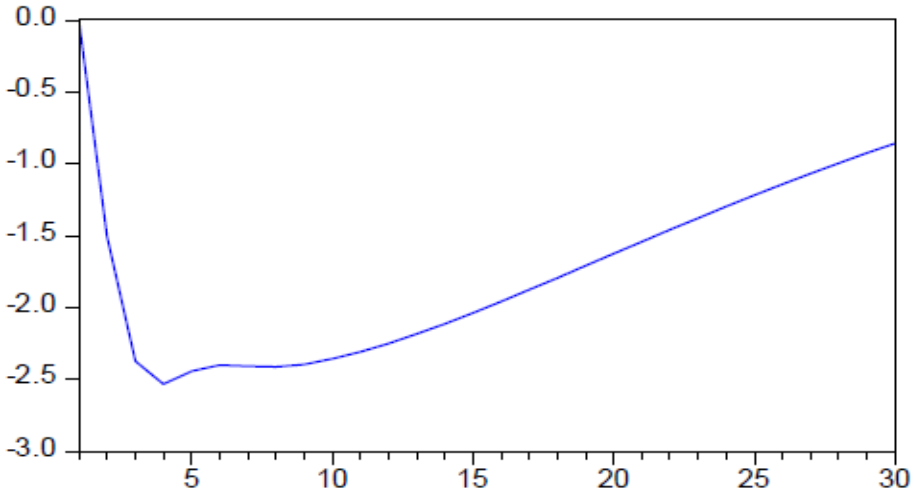
Response of IBER to Inflation Uncertainty Shock



Response of IBER to Exchange Rate Uncertainty Shock



Response of IBER to Oil Price Uncertainty Shock



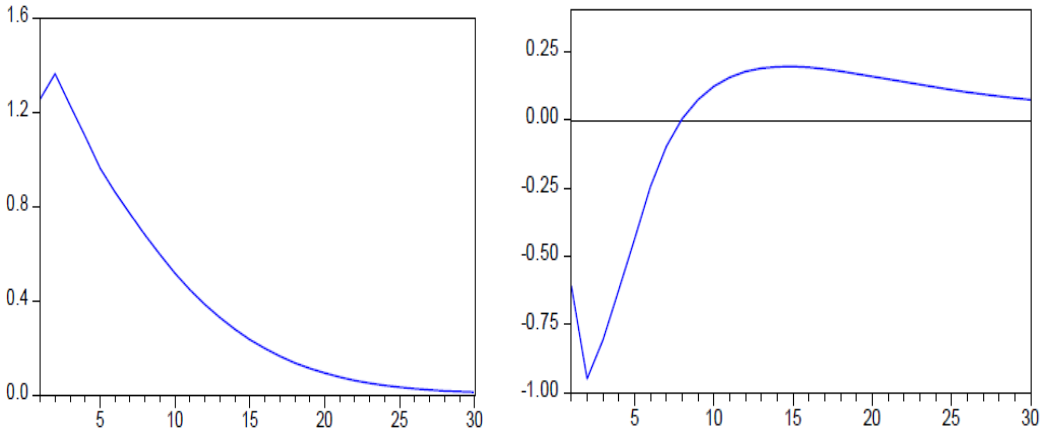
5.1.2.3 Response of Inflation to Inflation, Exchange Rate and Oil price Uncertainties Shocks

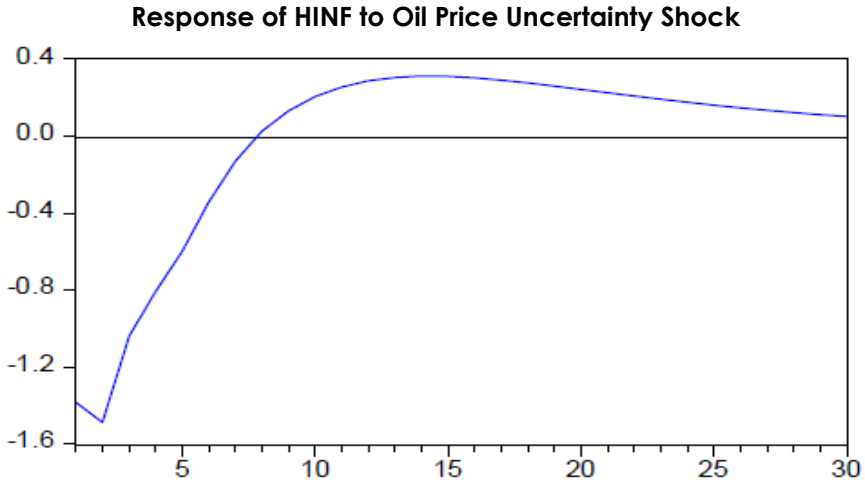
Inflation uncertainty shows an instantaneous positive effect on inflation, declining gradually through the sample horizon. This is likely since most investment decisions are undertaken in a normal and stable period. Investors are not likely to invest during the turbulent time, but rather hold on and wait when environment are conducive. Thus, with reduction in inflation it is expected that interest rate will decline, thereby boosting investment leading to higher output growth. Similarly, inflation uncertainty seems to raise inflation, as predicted by Cukierman and Meltzer (1986).

Similarly, inflation responds instantaneously and negatively to exchange rate uncertainty shock reducing inflation in the first six month, and thereafter, became positive, peaking at the eight month. A swift response from the monetary authority aimed at moderating monetary growth explains the intuition for the positive response appreciates the exchange rate and lowers the pressure on inflation.

Historically, within the estimation sample, Nigeria has faced periods of positive oil price shocks in spite of the upward and downward swings that characterized oil prices internationally. Consequently, there has been an observed negative correlation between inflation and oil prices uncertainty, indicating a dampening effect of oil price pass-through to aggregate price level. This finding confirms this relationship as the impact of oil price uncertainty shock shows a dampening of inflation. An earlier result confirms that an oil price uncertainty shock appreciates the exchange rate and this obviously has a subduing pass-through effect on domestic prices. While it is necessary to note that for Nigeria, the impact of oil price shock is symbiotic, as the country export crude oil and at the same time import processed petroleum products, in a low inflationary regime, the positive impact of the oil price uncertainty is seemingly the most dominant.

Figure 4: Responses of Inflation to Selected Uncertainty Shocks Response of HINF to Inflation Uncertainty Shock Response of HINF to Exchange Rate Uncertainty Shock



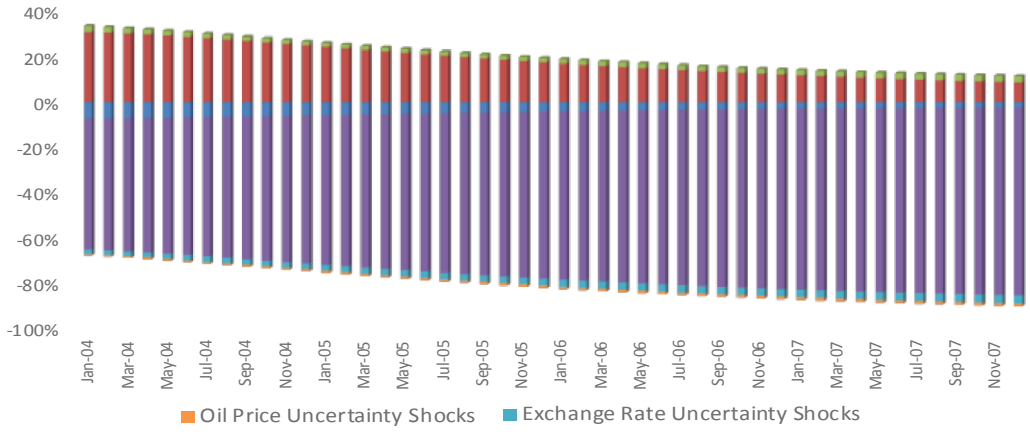


5.1.3 Historical Variance Decomposition

5.1.3.1 Responses of Real Output

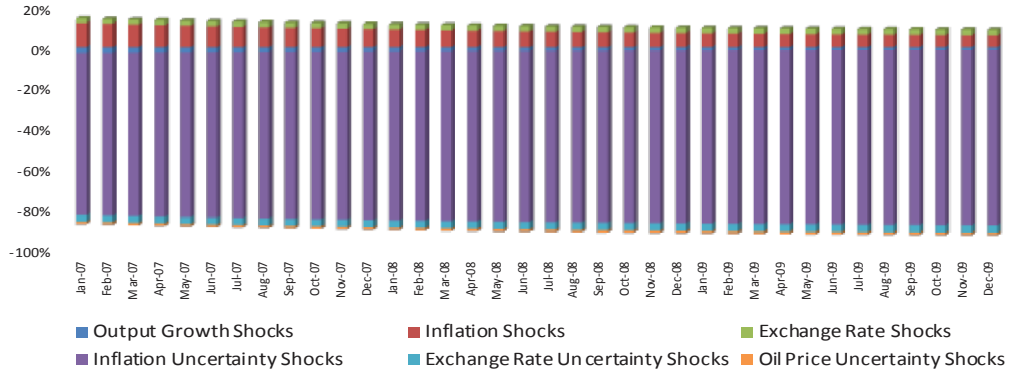
The impact of macroeconomic uncertainty on real output growth in the years preceding the global financial crisis was generally dampening. Results show that much of the deceleration was accounted for by inflation uncertainty shock, though in a receding manner. The negative effect of exchange rate uncertainty and oil price uncertainty widened marginally as global financial crisis period approached. Meanwhile, inflation and oil price shocks exhibited positive contribution to output growth, though in a declining pattern. The dampening contribution of growth shocks to itself decays over the period.

Figure 5: Response of Real Output Growth (2004 - 2007)



Inflation uncertainty, exchange rate uncertainty and oil price uncertainty shocks cumulatively dampen real output growth during the global financial crisis with inflation uncertainty shock taking the lead. These results are not unexpected given the counterproductive economic environment prevalent at the time of the crisis. Though inflation and exchange rate shocks contributed moderately to buoy output growth, this was, however, slower compared with the period prior to the global financial crisis.

Figure 6: Responses of Real Output (2007-2009)



The effect of uncertainty on the performance of real output growth after the global financial crisis was persistently negative with inflation uncertainty shock accounting for most of the effect. This is followed by the exchange rate uncertainty shock while the margin of exchange rate and inflation shocks positive contributions widened during the recovery period. The contribution of output shock to itself thinned out throughout the period of analysis.

Figure 7: Responses of Real Output (2010 - 2012)

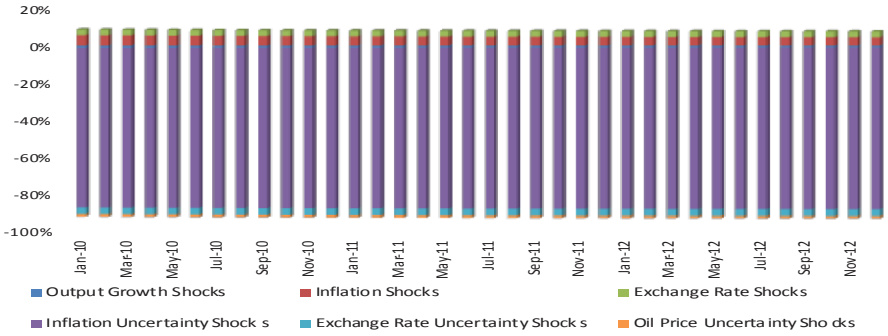
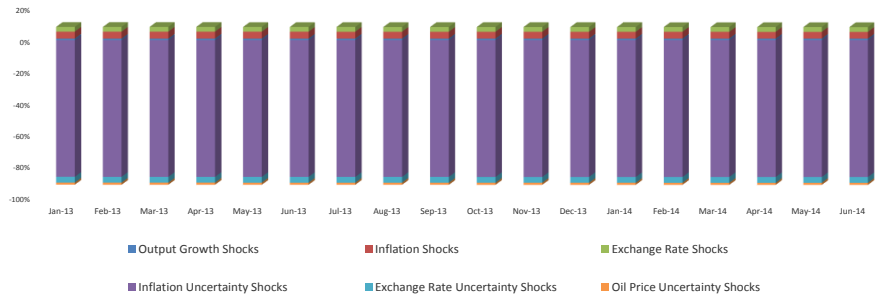


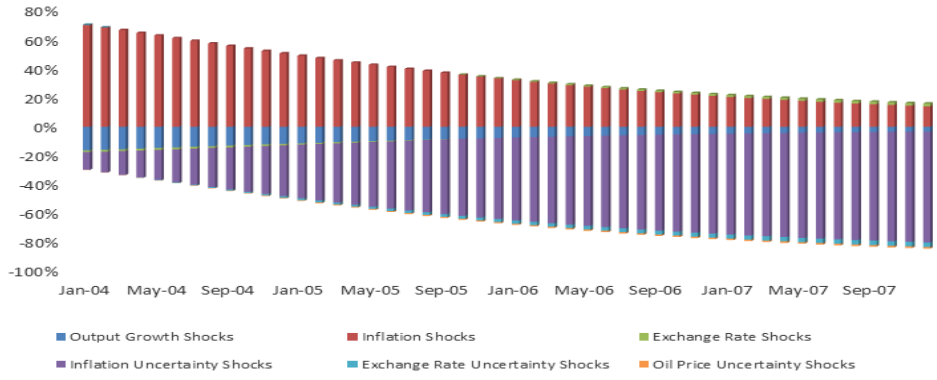
Figure 8: Responses of Real Output Growth (2013 - 2014M6)



5.1.3.2 Responses of Exchange Rate

Historically, the response of exchange rate to the various shocks is quite revealing and it varies over time. From the period 2004-2007 (banking consolidation period), inflation shocks and exchange rate shocks had dominant positive effects on exchange rate while inflation uncertainty shocks and output shocks had dampening negative impact on exchange rate during the period. Furthermore, the variables have countercyclical effects as evident in figure 2. Specifically, the beginning of consolidation in 2004, witnessed the dominance of inflation shocks due to mistrusted expectations but insulated as it tilt towards the end of the consolidation exercise in 2007. Similarly, as the consolidation exercise gained momentum, inflation uncertainty shocks continued to accentuate adverse impact on exchange rate. A clearer intuition here is that exchange rate behaviour during the period was underlined by the positive shocks in inflation during the consolidation exercise.

Figure 9: Responses of Exchange Rate (2004 - 2007)



During the post consolidation and the global financial crisis (2007-2009), exchange rate response to shocks changed dramatically. Figure 2 indicated that inflation shocks and exchange rate shocks maintained non-negligible but relative small effects on the exchange rate during the period. On the other hand, the persistence and dominating negative impact of inflation uncertainty shocks remained evident throughout the crisis period. Again, exchange rate uncertainty shocks and oil price shocks do not have substantial impact on exchange rate behaviour. This implied that macroeconomic uncertainty does not have significant impact on monetary policy.

Figure 10: Responses of Exchange Rate (2007 - 2009)

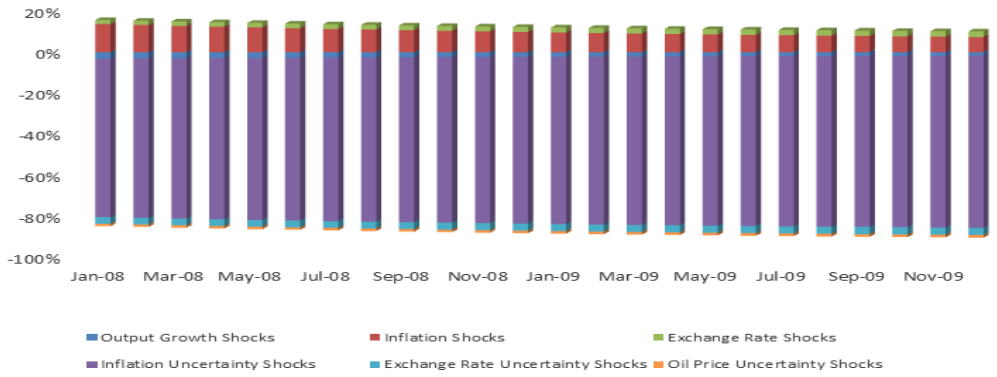


Figure 3 also indicates that inflation uncertainty shocks, oil price shocks and output shocks have persistent negative impact on exchange rate during the period 2010-2012. However, inflation shocks and exchange rate shocks had positive impact on exchange rate. The effects of both shocks reduced overtime. Intuitively, the period coincided with the recovery period supported by modest capital flow across developing and emerging economies including Nigeria. Thus, it is evident that inflation shock and exchange rate shocks do not have substantial impacts on exchange rate dynamics in Nigeria.

In the same vein, both the inflation shocks and exchange rate shocks have declining but positive impact on the exchange rate during the period 2013-2014M6. This is not unexpected given that inflation rate moderated significantly to a single digit while exchange rate witnessed modest stability. Thus, the impacts of the shocks of these variables are expected to decline. The economic implication of this revelation is that macroeconomic uncertainty proxied by macroeconomic variable uncertainty shocks does not have any significant impact on exchange rate except the shocks to the variables which has to do with the expectations

formed by rational economic agents. Similarly, this result corroborates the findings of Bredin, (2007) but refutes the results of Herro and Murray (2011) in the literature. For instance, Bredin (2007) showed that macroeconomic uncertainty does not affect o **Figure 10: Responses of Exchange Rate (2007 - 2009)** while Herro and Murray, (2011) macroeconomic uncertainty is associated with macroeconomic performance in output growth and unemployment.

Another striking revelation is that exchange rate response to some of these shocks was high during the banking consolidation and the global crises period until it moderated in the post-crises period. This suggests that the shocks are largely reflected in the expectations formed by rational economic agents rather than the anticipated exogenous shocks.

The policy implication of above is that monetary policy response anchored on managing expectations is largely required to direct the behaviour of exchange rate. In other words, such policy must be a type that has the ultimate target of underpinning inflation. As revealed by the influence of global financial crisis and banking system consolidation, the central bank must tighten monetary stance so as to curtail the economy from the spillover of capital movement which puts inflation and exchange rate expectations from unnecessary slidings.

Figure 11: Response of Exchange Rate (2010 - 2012)

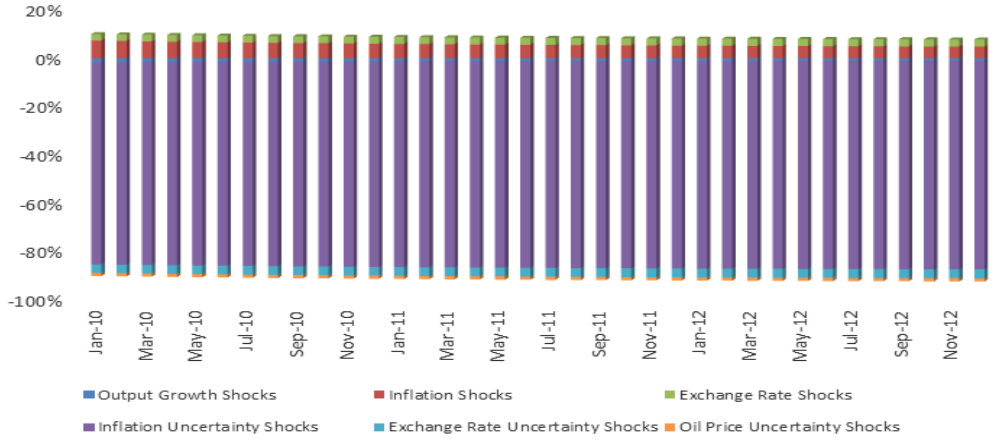
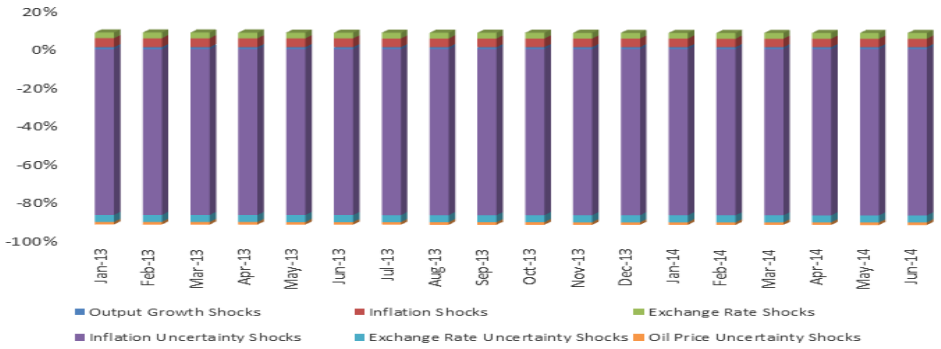


Figure 12: Responses of Exchange Rate (2013 - 2014M6)



5.1.3.3 Responses of Inflation

Prior to the period of global financial crisis from 2004 – 2007, the result from the analysis of the historical decomposition indicated that inflation uncertainty shock has the highest pull effect on inflation throughout the period of analysis. It trended upwards continuously from -42.4 per cent in January 2004 through -65.4 per cent in February 2006 to close at -59.0 per cent in December, 2007. This shock dominates among other shocks. The influence of inflation shock was next in terms of dampening factor on inflation. The least reducing factors on inflation, of all the shocks were exchange rate and oil price uncertainty shocks while exchange rate and output growth shocks had positive impact to response of inflation, even though the impact dies out over the horizon. Thus, from policy perspectives, inflation uncertainty and inflation shock needs to be closely monitored by the monetary authority as they have helped to stabilise inflation response to these shocks over the period of analysis.

Figure 13: Responses of Inflation (2004 - 2007)

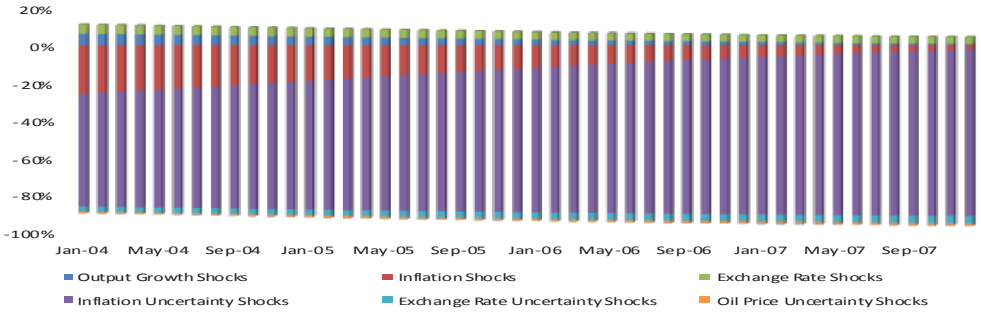


Figure 14: Responses of Inflation (2008 - 2009)

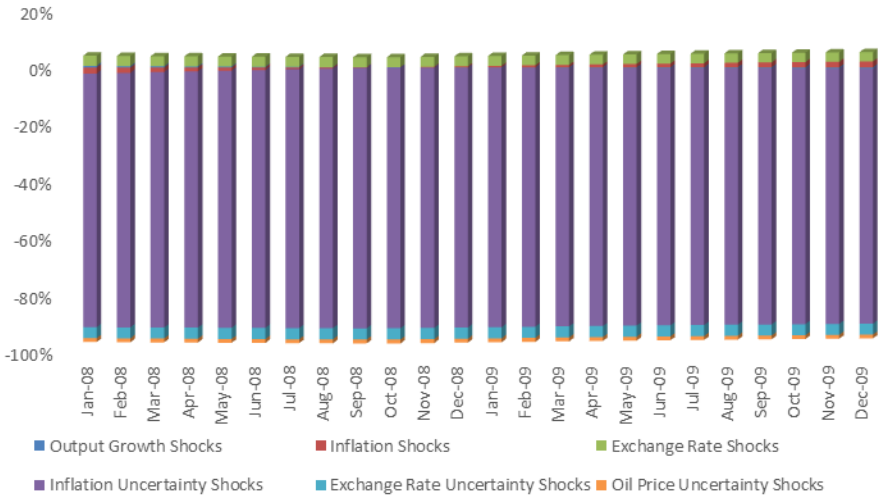
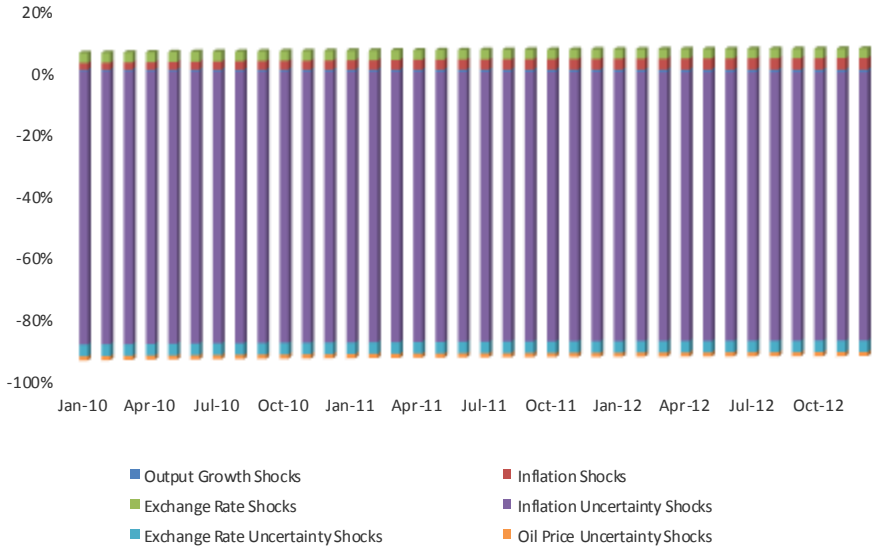


Figure 15: Responses of Inflation (2010 - 2012)



The responses of inflation to all the shocks considered during (2008 – 2009) and post-global financial crisis 2010 – 2012) showed the same pattern. The historical decomposition covering the period during and post-global financial crises depicts that inflation uncertainty shock has the highest overwhelming dampening

effect on inflation. The other striking factor observed is the persistence of equal proportions over the three-year horizon. This implies that it had helped to tapers inflation response to this shock and curtails inflation from exploding. The other indicators of macroeconomic uncertainty such as exchange rate and oil price contributed negatively to inflation response, albeit marginally. The inhibiting impacts of these shocks were not significant. Thus, going by the findings, monetary authority needs to note that inflation uncertainty improve macroeconomic performance, as it is associated with a lower inflation rate during and post-global financial crisis period.

5.1.4 Dynamic Correlation Analysis

The figures below depict the dynamic correlations with reference to real output growth, inflation and exchange rate. Panel (a) plots the inter-temporal co-movements of inflation, exchange and oil price uncertainties on one end and inflation, exchange rate and output growth shocks on the other, with output growth rate as the reference variable. The plots reveal that inflation uncertainty exhibits upward trend and positive correlation through the lags to leads period. This implies that an increase in inflation uncertainty spurs output growth rate.

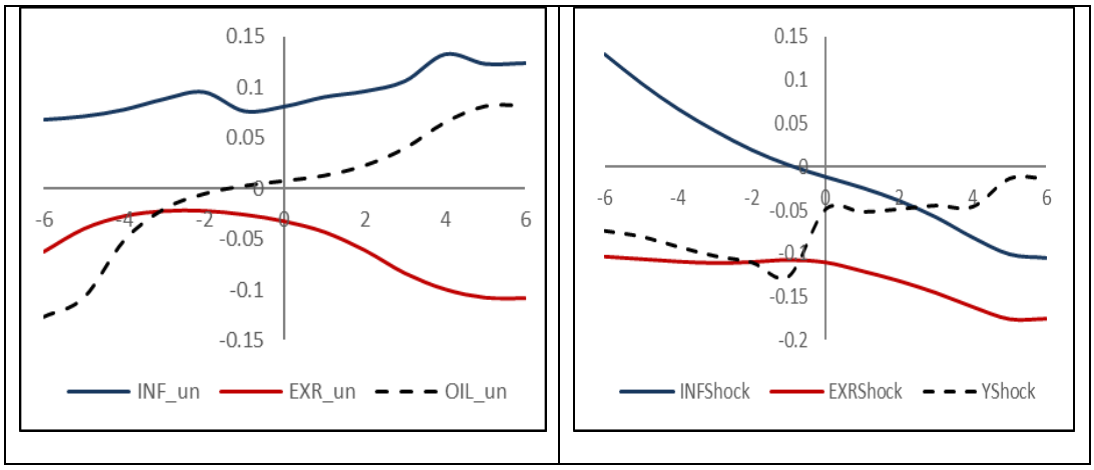
Oil price uncertainty and real output growth rate similarly exhibits mixed correlations from lags to leads. Oil price uncertainty, in contrast, show negative correlation with real output growth in the lag region while its trajectory trended upwards later in the leads region, indicating initial deceleration in real output growth but thereafter, recorded increasing trends. The co-movements between inflation shocks and real output growth can be perceived as mixed given the positive coefficients observed in the lagged region and negative coefficients in the lead region. This supports the sacrifice ratio hypothesis. However, exchange rate and real output growth shocks maintained a negative coefficient both in the lag and lead regions. Intuitively, this implies that exchange rate depreciation could trigger output loss.

Panel (b) presents the co-movements between inflation rate, exchange rate and oil price uncertainties on one end and inflation, exchange rate and output growth shocks on the other, with inflation as the reference variable. An upward trend is observed between inflation uncertainty and inflation from lag to lead therefore, implying that an increase in inflation uncertainty results to an increase in inflation. Exchange rate uncertainty and oil price uncertainty both exhibit downward trend. Therefore, an increase in these uncertainties both in the lag and lead region would tend to dampen inflation.

The second part of panel (b) shows a generally upward trend between inflation shock and exchange rate shock with inflation. However, while the correlation between inflation shocks and inflation exhibits both positive and negative coefficients, exchange rate shocks and inflation exhibits only positive coefficients. Output shocks also maintained positive correlation coefficients from lag to lead suggesting that an increase in real output growth shocks would initially lead to rise in inflation before dying off six months ahead.

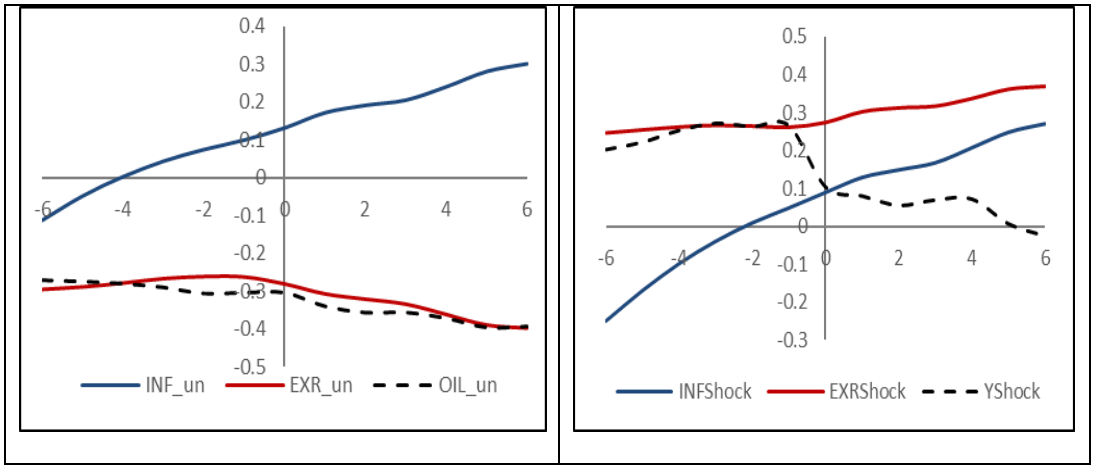
Panel (c) depicts the graphical representation of the dynamic correlation coefficients between various uncertainty shocks as well as variable shocks and the exchange rate. Evidently, the plots show that the correlation coefficients between all uncertainties – inflation, exchange rate and oil price – and exchange rate trend upwards from lag to lead region, and they all stabilise up to six-month ahead over the period of analysis. Specifically, while inflation and exchange rate uncertainties initially showed negative coefficients in the lag region, there was a turnaround from lag 3 where positive coefficients are observed. This is expected as an increase in both exchange rate and inflation uncertainty leads to further exchange rate depreciation. Oil price uncertainty, despite the upward trend, maintained negative coefficients throughout. The second part of panel (c) reveals a downward trend in the correlation between inflation shocks and exchange rate. This is contrary to that between output growth shocks and exchange rate. The correlation between exchange rate shocks and exchange rate can be seen to be relatively stable however, negative coefficients were recorded from the lag to the lead.

Figure 16: Correlation between Selected Uncertainty Shocks, Variable Shocks and Real Output Growth



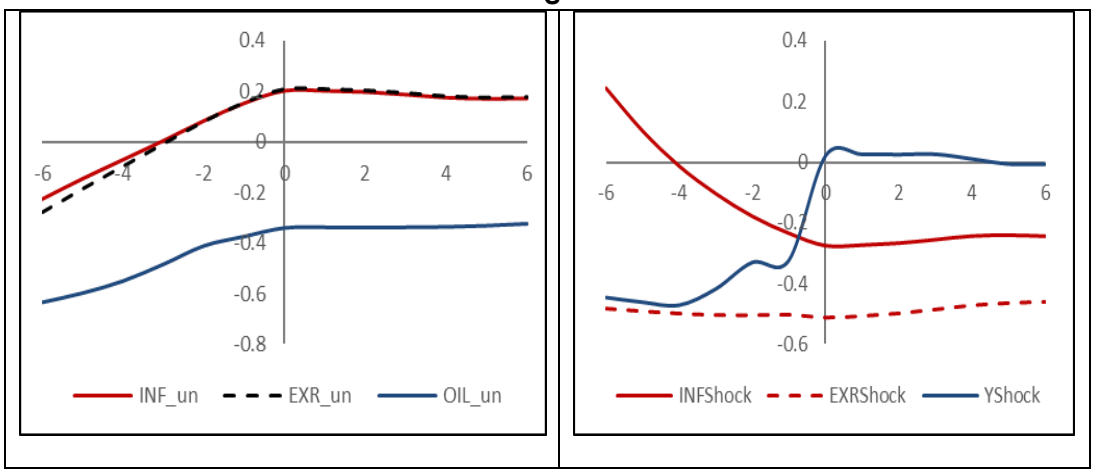
(a) Output Growth

Figure 17: Correlation between Selected Uncertainty Shocks, Variable Shocks and Inflation



(b) Inflation

Figure 18: Correlation between Selected Uncertainty Shocks, Variable Shocks and Exchange Rate



(c) Exchange Rate

Figure 22 explains that oil price uncertainty shocks significantly drives output growth shocks in the Nigerian economy in the lag region while exchange rate uncertainty shocks drives the output growth shocks in the lead region. It is imperative to state that both variables could influence output performance in Nigeria since oil price dynamic bears direct relationship with exchange rate behaviour in Nigeria.

Figure 19: Which Uncertainty Shock Drives Output Growth Shocks?

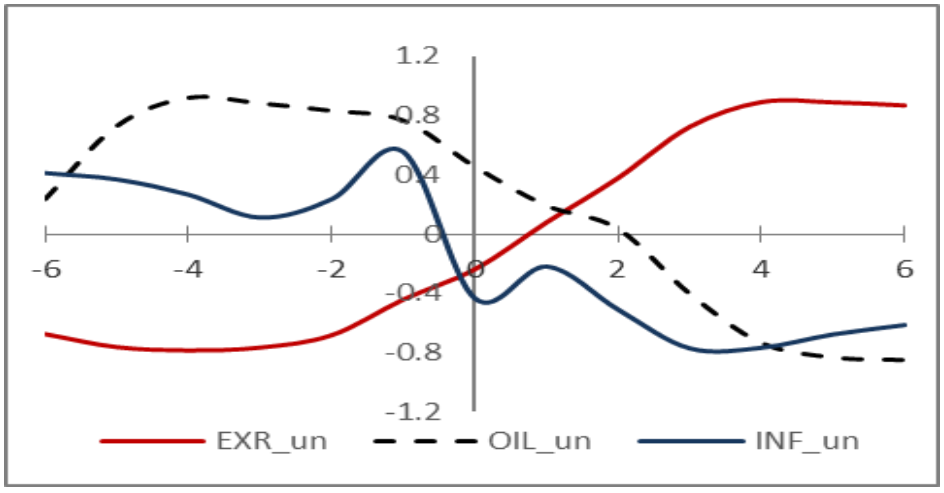
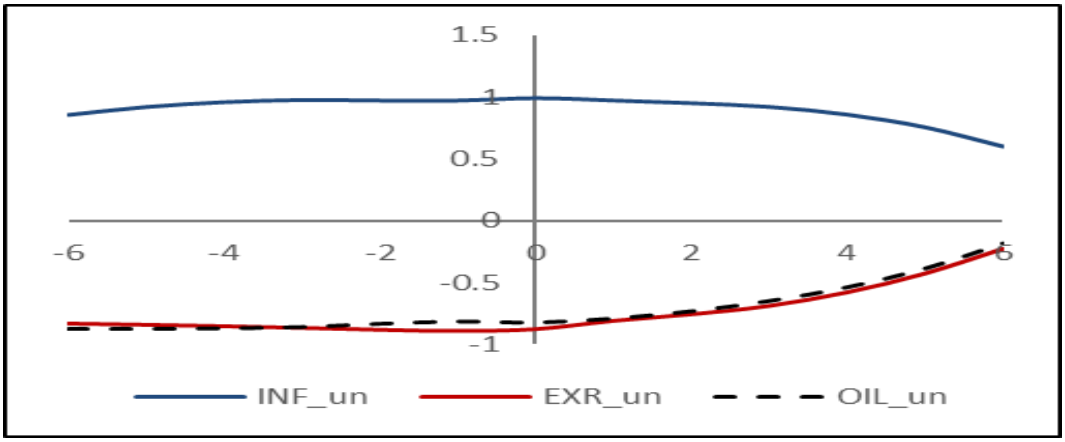


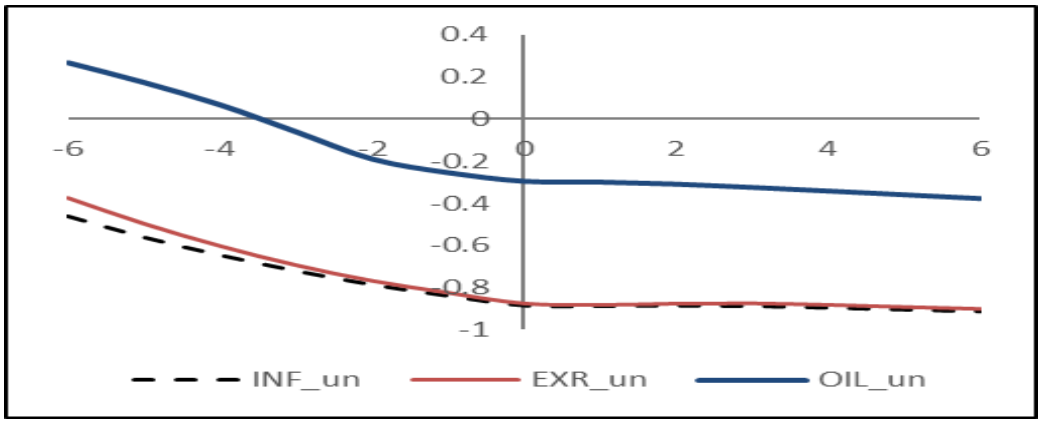
Figure 20 revealed that inflation uncertainty shocks drive inflation shocks. This is evident given the positive coefficients recorded in the lag and lead region. On the other hand, exchange rate and oil price uncertainty shocks recorded negative correlation coefficients with inflation shocks.

Figure 20: Which Uncertainty Drives Inflation Shocks?



The dynamic correlation analysis also reveals that exchange rate shocks in Nigeria are generally driven by oil price uncertainty shocks in the lag region. This is expected given the degree of oil proceeds that accounts for Nigeria's foreign exchange earnings. In the lead region, inflation uncertainty shocks and exchange rate uncertainty shocks obviously drives exchange rate shocks as a result of the pass-through from oil price uncertainty shocks in the lag region.

Figure 21: Which Uncertainty Drives Exchange Rate Shocks?



Section Six

6.0 Policy Recommendation and Conclusion

6.1 Policy Recommendations

- The Monetary Policy Committee members should incorporate inflation uncertainty in their decision making tool-kit, when considering various options of policy as the result indicates that inflation uncertainty could culminate into an appreciation of exchange rate which could further enthrone price stability and boost output in the long-run.

- The findings that inflation uncertainty is not detrimental to output growth in Nigeria suggest that the Bank's effort at stabilising prices should be sustained.

- With a positive effect of inflation uncertainty on growth, it is germane for proper conduct of monetary policy in Nigeria to factor in its impact when considering growth drivers among risk components as it is evident that it is not all risks elements are harmful.

- The significant and immediate positive effects of exchange rate uncertainty shock and oil price shock in the short-run have potential influence in business cycle fluctuations. Given the crucial role of exchange rate and oil price to the Nigerian economy, it is germane for the monetary authority to select appropriate choice of monetary policy reaction functions guided by wide range of information set to deal with these issues for the conduct of monetary policy in Nigeria.

- Monetary policy response should be anchored on managing expectations as it was evident from the study that it largely influence the behaviour of exchange rate during the period of analysis. Hence, the monetary authority should tighten monetary stance in order to insulate the economy from the spillover effect of capital flight which could further put pressure on inflation and exchange rate.

- Inflation uncertainty and inflation shocks needs to be closely monitored by the MPC members as they have helped to stabilise and tapers inflation response to these shocks over the period of analysis.

6.2 Conclusion

Recently, the concept of macroeconomic uncertainty has been given much attention, both by policymakers and in the academic literature. This is not unconnected with the prominent role it plays in monetary policy design and implementation. Much of the debate has been motivated by concerns that sustained uncertainty might force economic agents to take decisions are inimical to rationality. It also has serious implication for the conduct of monetary policy and monetary policy performance.

This study attempted to examine the impact of macroeconomic uncertainty on the conduct of monetary policy in Nigeria by developing a model within the framework of GARCH built in a structural vector autoregressive mechanism. The sources of uncertainty were derived from selected key macroeconomic indicators such as real output growth, inflation rate, exchange rate and oil price. Our empirical findings indicate that macroeconomic uncertainty does not significantly undermine monetary policy effectiveness in Nigeria. For instance, inflation uncertainty does not harm the output growth performance while exchange rate and oil price uncertainties shocks have immediate positive effects on output that do not last long in Nigeria. Similarly, inflation uncertainty shocks have positive effect on inflation but negative response and correlation with exchange rate and oil price uncertainties, respectively. Finally, macroeconomic uncertainties in inflation, exchange rate and oil price cause the exchange rate to depreciate. Consequently, monetary authorities are confronted with a range of information set that enable them to conduct effective monetary policy in Nigeria by endogenizing uncertainty in the formulation and conduct of monetary policy in Nigeria.

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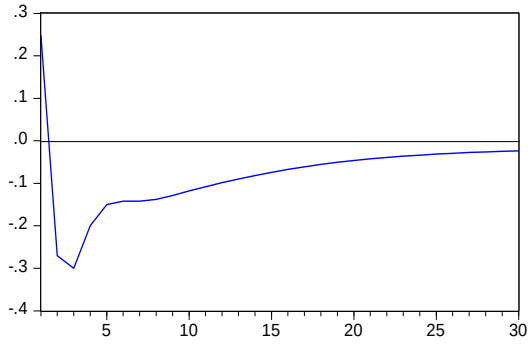
APPENDIX 1

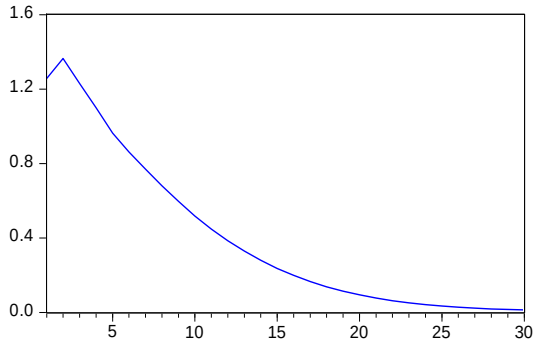
Inflation Uncertainty Shocks

Response to Structural One S.D. Innovations

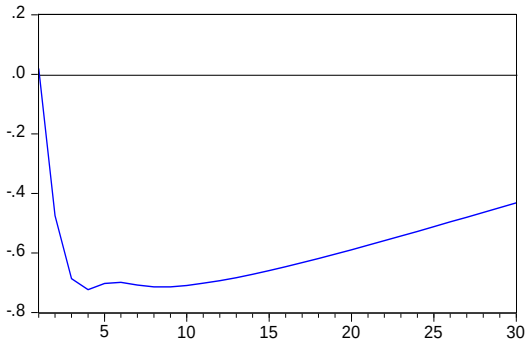
Response of RY to Shock4



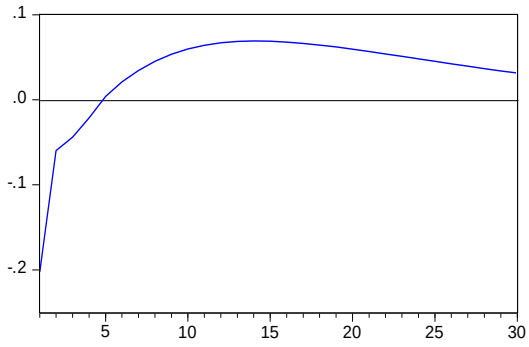
Response of HINF to Shock4



Response of IBER to Shock4



Response of HINF_UN to Shock4



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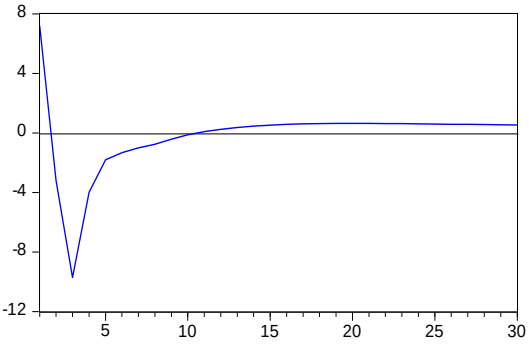
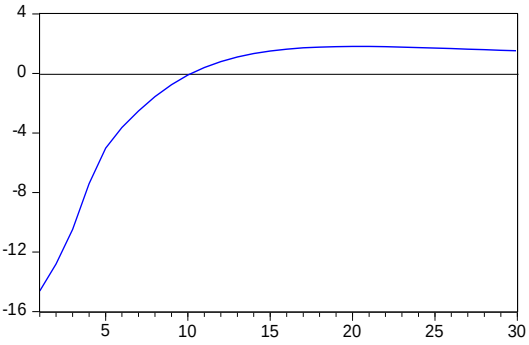
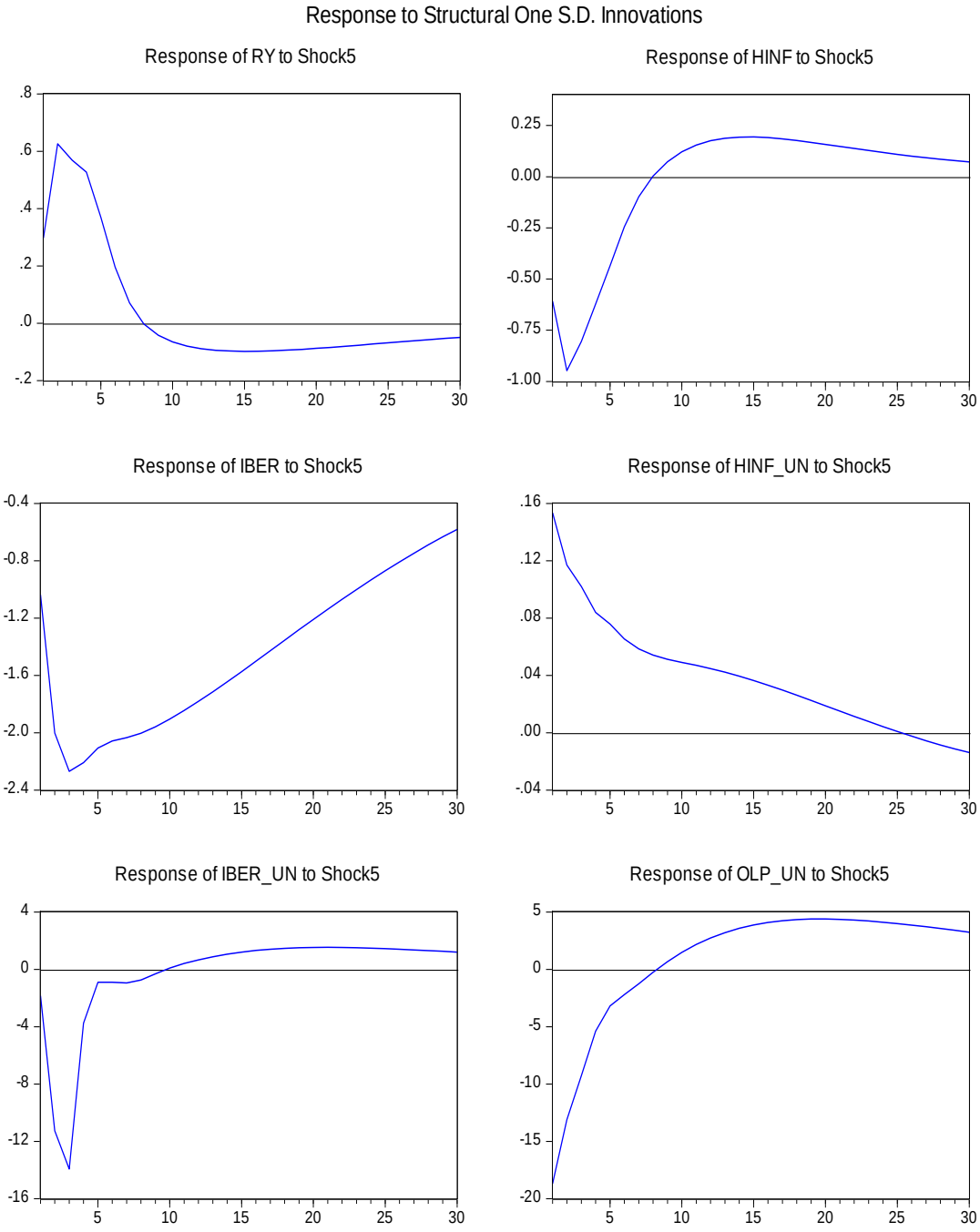


Response of OLP_UN to Shock4



Exchange Rate Uncertainty Shocks



Oil Price Uncertainty Shocks