MEASURING THE EFFECTS OF MONETARY POLICY INNOVATIONS IN NIGERIA: A STRUCTURAL VECTOR AUTOREGRESSIVE (SVAR) APPROACH

Chuku A. Chuku[1]
University of Uyo, Nigeria.
chukuachuku@gmail.com

ABSTARCT
Correctly identifying the effects of monetary policy innovations is necessary for good policy making. In this paper, we carry out a controlled experiment using a structural vector autoregression (SVAR) model to trace the effects of monetary policy shocks on output and prices in Nigeria. We make the assumption that the Central Bank cannot observe unexpected changes in output and prices within the same period. This places a recursive restriction on the disturbances of the SVAR. We conduct the experiment using three alternative policy instruments i.e. broad money (M_2), Minimum Rediscount Rate (MRR) and the real effective exchange rate (REER). Overall, we find evidence that monetary policy innovations carried out on the quantity-based nominal anchor (M_2) has modest effects on output and prices with a very fast speed of adjustment. While, innovations on the price-based nominal anchors (MRR and REER) have neutral and fleeting effects on output. We conclude that the manipulation of the quantity of money (M_2) in the economy is the most influential instrument for monetary policy implementation. Hence, we recommend that central bankers should place more emphasis on the use of the quantity-based nominal anchor rather than the price-based nominal anchors.

Keywords: Monetary innovations, structural vector autoregression, output effect, price effect.

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[1] Department of Economics, University of Uyo, P.M.B 1017, Uyo, Nigeria.

I. INTRODUCTION AND MOTIVATION

What are the actual effects of monetary policy shocks on output and prices? The answer to this question has exercised the minds of central bankers and academicians from the time of the Classical quantity theorists in the 20th century to the monetarists in the 1950's and 60's and until present day economists. The answers to this question has been highly idiosyncratic, depending on the structure of the economy under investigation, the approach being adopted, the choice of variables used and the identifying restrictions imposed on the models.

Correctly measuring and understanding what monetary policy can do (as well as what it cannot do) is essential for good policy-making and for choosing among alternative macro-economic frameworks. The empirical literature contains a preponderance of studies both in developed and developing countries that seek to measure the effects of monetary policy innovations (unanticipated shifts) on the business cycle (see for e.g. Cushman and Zha, 1997; Christiano et al., 1999; and Bernanke and Mihov 1998; Khan et al., 2002; Berument, 2007). Although these studies return puzzling results[2] from their analysis, there however seems to be a consensus about the impacts of monetary policy shocks on output and prices in developed economies as Christiano et al. (2002) discuss.

Interestingly, in a developing economy like Nigeria, the potentials for using monetary policy innovations to engender real economic effects are less clear. The ambiguity may stem from the inherent imperfections in the goods, money and labour markets, and the unsticky nature of prices among others. So that, monetary policy innovations may just pass quickly through to prices and have little or no real effects.

In the past, central bankers and academicians have tried to clarify the ambiguities in the effects of monetary policy innovations in Nigeria, using single-equation, simultaneous-equations and (or) the narrative approach (see for e.g. Balolgun, 2007; Odusola, 2005; Uchendu, 1996; Adamgbe, 2004 and Nnanna, 2001). This paper improves on previous studies by employing the structural vector autoregression model (SVAR) to measure the real and nominal effects of monetary policy innovations in Nigeria. We carry out the experiment using three most commonly used monetary policy instruments in Nigeria. That is, broad money, measured by M_2, the Minimum Rediscount Rate (MRR) and the real effective exchange rate (REER). Real economic effects are measured by the dynamics of the real Gross Domestic Product (RGDP) while nominal economic effects are captured by an index of consumer prices (CPI). We ask three crucial questions. (1) Does monetary policy in Nigeria follow the neutrality proposition? (2) If it does not, which is the most influential policy instrument? And (3), what is the speed of adjustment aftershocks?

[2] Nagel and Parker (2003) provide an extensive discussion of the various puzzles.

The remainder of the work is organized as follow; in Section 2, we review the literature and describe a baseline theoretical model to underpin our empirical investigation. In Section 3, we review the practice of monetary policy in Nigeria. Section 4 presents the methodology employed and the results are discussed in section 5. We explain the implications for policy and conclude the discussion in Section 6.

II. REVIEW OF LITERATURE

Two fundamental propositions about the effect of the quantity of money on the economy predate the emergence of monetary economics as a recognized discipline of study. The first is that increases in the quantity of money that is not associated with corresponding increases in real output will eventually lead to inflation, and the second is that a shortage of money can depress the volume of economic activity. A considerable literature has emerged, attempting to give credence or discordance to these propositions, using parsimoniously restricted multivariate time series models as Sims and Zha (2005) discuss.

Milton Friedman and Anna Schwartz (1963) inspired the campaign in their seminal work as they documented the strong time series correlation of monetary aggregates with both output and prices. They explain that these correlations did not primarily represent passive responses of monetary aggregates to development in the private sector, but instead mainly the effects on monetary policy shifts on the private sector (see Nagel and Parker, 2003 for a discussion). From their argument, it follows that innovations in monetary policy variables have the potential for stimulating the economy when it is sluggish or cooling it down when it overheats.

The literature has identified several factors that determine the capacity of central banks to use monetary policy innovations to achieve countercyclical objectives is the economy. One of such factors is the 'credibility' of monetary policy[3]. In this regard, credibility refers to the level of commitment of the central bank to following a set down monetary policy rule rather than following a discretionary approach. This is important because economic agents make their decisions based on the expected course of monetary policy as well as the current policy. Also, policy transparency which deals with the extent of policy disclosure and the timing of central bank communication are key success factors in evaluating the effectiveness of monetary policies as shown by Ehrmann and Fratzscher (2007) and Geraats (2005).

However, Bernanke and Mihov (1998) and Leeper et al. (1996) prefer to make the case for the choice of the monetary instrument used for intervention as the major determinant of the degree of impact. They both submit that the traditional approach of using changes in the money stock to stimulate or depress economic activity is inferior to the use of interest rates. This is because the growth rate of monetary aggregates depends on a variety of non-policy influences. Other authors like Cochrane (1998)

[3] Persson and Tabellini (1997) provide an extensive discussion on the credibility literature.

emphasize anticipation or non-anticipation by agents as the key factor. Whereas, Starr (2005) in the spirit of new Keynesianism, focused on the sticky and flexible nature of prices. No matter the opinion that different authors may hold about the major determinants of the effectiveness of monetary policy, it is certain that the effectiveness of monetary policy shocks, is a function of a compound set of variables.

In developed economies, such as the United States (U.S) and some core European countries, there is substantial evidence of the effectiveness of monetary policy innovations on real economic parameters (see for e.g. Mishkin, 2002; Christiano et al., 1999; Rafiq and Mallick, 2008 and Bernake et al., 2005). However, for developing countries like Nigeria, the evidence is weak and full of 'puzzles'. For example, Balolgun (2007) used simultaneous equation models to test the hypothesis of monetary policy ineffectiveness in Nigeria and find that, rather than promote growth; erstwhile domestic monetary policy was the source of stagnation and persistent inflation. Similar evidence was also found for The Gambia, Guinea, Ghana and Sierra Leone using the same models.

For middle-income economies, the empirical literature shows that monetary policy shocks have some modest effects on economic parameters. Ganev et al. (2002) for example, studied the effects of monetary shocks in ten Central and Eastern European (CEE) countries and find no evidence that suggests that changes in interest rates affect output, but find some indication that changes in the exchange rate does. In the same spirit, Starr (2005) using an SVAR model with orthogonalized identification find little evidence of real effects of monetary policy in five Commonwealth of Independent States (CIS) with the notable exception that interest rate have a significant impact on output in Russia.

The idiosyncratic evidence (inconsistent with theoretical expectations) returned from different investigations in different countries is what economist usually refer to as 'puzzles'. The three most common puzzles identified in the literature are; the liquidity puzzle, the price puzzle and the exchange rate puzzle. The liquidity puzzle is a finding that an increase in monetary aggregates is accompanied by an increase (rather than a decrease) in interest rates. While the price puzzle is the finding that contractionary monetary policy through positive innovations in the interest rate seems to lead to an increase (rather than a decrease) in prices. And yet, the most common in open economies is the exchange rate puzzle, which is a finding that an increase in interest rate is associated with depreciation (rather than appreciation) of the local currency.

In contemporary studies, researchers have devised convenient ways of eradicating these puzzles. Most of them now follow the framework set by Lucas (1972) who recommended the incorporation of rational expectations in the studies of the effects of monetary policy. Some recent investigations that follow this approach include: Khan et al. (2002); Brument and Dincer (2008); Cochran (1998); and Zhang (2009).

A. A Baseline Theoretical Framework[4]

The basic theoretical framework for analyzing monetary policy effects is the Keynesian IS-LM framework with a Philips curve superimposed on it to determine inflation. The mechanism is such that changes in monetary policy (usually specified as exogenous shifts in monetary aggregates) affect the money supply, which changes interest rate to balance the demand with supply. The changes in interest rates then affect investment and consumption which latter cause's changes in output and eventually prices.

Contemporary studies on the effects of monetary policy now generally favour a more encompassing dynamic stochastic general equilibrium (DSGE) framework (see for e.g. Walsh, 1998; Goodfriend and King 1997 and the references therein). Here, we pursue a simple general-equilibrium framework, similar to that of Clarida et al. (2005) but different in the sense that we exclude the assumption of perfect price flexibility and stick to the sticky price assumption.

The analysis begins by fully articulating a model of the Nigerian economy, where the model details include (1) a statement of agents optimizing problems, (2) a mechanism of monetary non-neutrality and (3) a source of monetary shock imparting on the economy. The purpose is to show the central bank's objective function in maximizing the welfare of agents through policy choices. Rather than work through the details of the derivation, which are readily available elsewhere, (Walsh, 1998; Bernanke et al., 1998; Fuerst, 1998 and Clarida et al., 1999) we instead directly introduce the key aggregate relationships.

The model is as follows: let $\gamma_t$be the actual output, and z_t be the natural level of output both in logs. Let the difference between actual and potential output be called the 'output gap' x_t. Hence,

$$x_t \equiv \gamma_t - z_t \tag{2.0}$$

In addition, let π_t be the period t inflation rate, defined as the percent change in the price level from t-1 to t and let i_t be the nominal interest rate. Each variable is expressed as a deviation from the long-run trend.

It is then possible to represent the baseline model in terms of two equations: an IS curve that relates the output gap inversely to the real interest rate, and a Phillips curve that relates inflation positively to the output gap. Hence:

$$x_t = -\varphi[i_t - E_t\pi_{t+1}] + E_t x_{t+1} + g_t \tag{2.1}$$

[4] This sub-section draws enormously from Clarida et al. (1999)

$$\pi_t = \theta x_t + \beta E_t \pi_{t+1} + \mu_t \tag{2.2}$$

Where E_t is the expectations operator, $E_t\pi_{t+1}$ is the future expectation of inflation, $E_t x_{t+1}$ is future expectation of the output gap, $[i_t - E_t\pi_{t+1}]$ measures the real interest rate, φ measures the interest elasticity in the IS curve and g_t is a disturbance term. Equation (2.1) is obtained by log-linearizing the consumption Euler-equation that arises from the household optimal savings decision, after imposing the equilibrium condition that output equals consumption plus government expenditure (see Walsh, 1998 for a step by step derivation).

Equation (2.1) differs from the traditional IS curve mainly because current output depends on expected future output as well as the real interest rate. Higher expected future output raises current output. The reason is that individuals prefer to smooth consumption expectations of higher consumption next period (associated with higher expected output) which leads them to want to consume more today (Clarida et al., 1999). The negative sign of the coefficient of real interest rate on current output reflects the intertemporal substitution of consumption. Hence, the coefficient $-\varphi$ represents the intertemporal elasticity of substitution.

The disturbance g_t is a function of expected changes in government expenditure relative to expected changes in potential output. Changes in g_t correspond to shifts in the IS curve which can be referred to as demand shocks. This would have also been the case if we were abstracting using investments or private consumption.

To better understand how expectations about the future affects current aggregate activity within the framework, we iterate equation (2.1) forward to obtain:

$$x_t = E_t \sum_{i=0}^{\infty} \{-\varphi[i_{t+i} - \pi_{t+1+i}] + g_{t+i}\} \tag{2.3}$$

Equation (2.3) implies that the optimal gap depends not only on the real interest rate and demand shock, but also on the expected future paths of these two variables. It therefore follows that expected as well as current monetary policy (in this case, measured by changes in interest rate) can affect aggregate demand.

The Philips-curve depicted by equation (2.2) is simply a log-linear approximation of the steady state aggregation of individual firm's pricing decisions (see Clarida et al., 1998 for the derivation). The equation resembles the traditional expectations-augmented Phillips curve described by Blanchard (1997) because it relates the inflation rate with the output gap and expected inflation. However, it is different from the traditional specification in that expected future inflation $E_t\pi_{t+1}$, enters additively as opposed to expected current inflation $E_{t-1}\pi_t$. The implications of this distinction can be observed if we iterate equation (2.2) forward thus:

$$\pi_t = E_t \sum_{i=0}^{\infty} \beta[\theta x_{t+i} + \mu_{t+i}] \tag{2.4}$$

From equation (2.4) we observe that unlike the traditional Philips curve, inflation depends entirely on current and future economic conditions rather than lagged inflation expectations. The variable x_{t+i} captures movements in marginal costs associated with variations in excess demand. Whereas, the exogenous shock μ_{t+i} usually referred to as "cost push" captures anything else that may affect expected marginal costs.

Putting this framework in context, and focusing on the nominal interest rate as the choice variable of monetary policy, the above framework provides a reasonable description of the operating procedures of the Central Bank of Nigeria. With sticky prices, innovations in the nominal interest rate immediately affects the real interest rate which causes agents to adjust their expectations and actions in such a way that output and prices are affected in the direction specified in the IS and LM equations.

To sum up, we introduce the Central Bank's objective function which converts the behavior of the target variables into a welfare measure to guide policy choices. Following contemporary practice, we assume the Central Bank's objective function is over an inflation target π_t and an output target x_t and takes the form:

$$\max \; -\frac{1}{2} E_t \left\{ \sum_{i=0}^{\infty} \beta[\alpha x_{t+i}^2 + \pi_{t+i}^2] \right\} \tag{2.5}$$

Where the parameter α is a relative weight assigned to the output deviations. Since $x_t \equiv \gamma_t - z_t$, the objective function takes the potential output of the economy z_t as the target output and implicitly takes zero as the target inflation rate. The appropriate weight to be assigned to the parameter α has generated a lot of controversies among monetary policy practitioners and researchers. However, there now seems to be a growing convergence to the consensus that the primary emphasis of monetary policy should be to control inflation and not to target output as Bernanke and Mishkin (1997) argue. We nurse our reservations about the appropriateness of placing the emphasis on inflation targeting especially in a developing country like Nigeria that requires enormous and sustained stimulation of aggregate demand to engender development.

III. MONETARY POLICY IN NIGERIA

The Central Bank of Nigeria (CBN) is mandated by the CBN act of 1958 to promote and maintain monetary stability and a sound financial system in Nigeria. Just like other central banks, the CBN has the "end" of achieving price stability and sustainable

economic growth through the "means" of monetary policy. Embedded in this twin objectives are (1) the attainment of full employment, (2) maintaining stability in the long-term interest rates and (3) pursuing optimal exchange rate targets. To achieve these multiplex objectives, the CBN operates through a system of targets. These are; the operational targets, the intermediate targets and the ultimate target (Ibeabuchi, 2007).

The Central Bank uses its operational target (unborrowed reserves), over which it has deterministic control to influence the intermediate target (broad money) which eventually affects the ultimate targets (inflation and output). In setting its targets, the CBN considers an information set that is feed into by contemporaneous and lagged values of real Gross Domestic Product (GDP), real investment prices, real wages, labour productivity, fiscal operations and balance of payments performance, among others. Depending on the relative importance attached to the various information elements, the CBN sets its target parameters for its quantity-based nominal anchor and its price-based anchors.

The bank generally implements its monetary policy programmes using the market-based and rule-based techniques. When implementing monetary policy using the rule-based technique, the CBN uses direct instruments like selective credit controls, direct regulation of interest rates and moral suasion. While indirect instruments like the Open Market Operation (OMO), discount rate and the reserve requirements are used when implementing monetary policy programmes using the market-based approach.

Since its inception, the CBN has implemented monetary policy using various combinations of these two techniques with more or less emphasis on the one. Depending on the emphasis that is placed on either of the techniques, the evolution of monetary policy in Nigeria can be classified into two phases: (1) the era of direct controls (1959-1986) and (2) the era of market-based controls (1986-date).

The era of direct controls was a remarkable period in monetary policy management in Nigeria, because it coincided with several structural changes in the economy; including the shift in the economic base from agriculture to petroleum, the execution of the civil war, the oil boom and crash of the 1970s and early 1980s respectively and the introduction of the Structural Adjustment Programme (SAP). During this period CBN's monetary policies focused on fixing and controlling interest rates and exchange rates, selective sectoral credit allocation, manipulation of the discount rate and involving in moral suasion. Reviewing this period, Omotor (2007) observe that monetary policy was ineffective particularly because the CBN lacked instrument autonomy and goal determination, being heavily influenced by the political considerations conveyed through the Ministry of Finance.

Progressively, the implementation of the SAP programme which commenced in 1986, ushered in a new era of monetary policy implementation with market-friendly techniques in Nigeria. The capacity of the CBN to carry out monetary policy using

market friendly techniques was letter reinforced by the amendments made to the CBN Act in 1991 which specifically granted the CBN full instrument and goal autonomy. Using this technique, the CBN indirectly influences economic parameters through its Open Market Operations (OMO). These operations are conducted wholly on Nigerian Treasury Bills (TBs) and Repurchase Agreements (REPOs), and are being complimented with the use of reserve requirements, the Cash Reserve Ratio (CRR) and the Liquidity Ratio (LR). These set of instruments are used to influence the quantity-based nominal anchor (monetary aggregates) used for monetary programming.

On the other hand, the Minimum Rediscount Rate (MRR) is being used as the price-based nominal anchor to influence the direction of the cost of funds in the economy. Changes in this rate give indication about the monetary disposition of the Bank, whether it is pursuing a concessionary or expansionary monetary policy. This rate has generally been kept within the range of 26 and 8 percent since 1986. As a companion to the use of the MRR, the CBN latter introduced the Monetary Policy Rate (MPR) in 2006 which establishes an interest rate corridor of plus or minus two percentage points of the prevailing MPR. Since 2007, this rate has been held within the band of 10.25 and 6 percent.

Despite the empirical evidence found for the efficacy of monetary policy with market-based techniques, the effectiveness or otherwise of monetary policy during this era is still an issue in debate. Though we take a position on this issue at the conclusion of the work, we recognize that monetary policy in Nigeria is confronted with several challenges. Some of them include; fiscal dominance and non-synchronization of fiscal and monetary policies, the existence of a large informal sector, debt and liquidity overhang, data inconsistencies and lateness, and the cash-in-hand nature of the economy. These peculiar characteristics of the economy place a special emphasis on the dynamism of monetary policy in Nigeria.

IV. METHODOLOGY

We start by first specifying the a priori expectation of our model. We follow the arguments set out in the standard Mundell-Fleming-Dornbush model[5] which assumes *a priori,* that expansionary monetary policy reduces interest rates, depreciates the real exchange rate and increase prices, money supply and the level of real output (Rafiq and Mallick, 2008). To observe the effects of monetary policy innovations in Nigeria, we adopt the Structural Vector Autoregression (SVAR) approach with a recursively-orthogonalized identifying restriction to take care of the underlying assumptions we make.

We follow the approach initially developed by Sims (1980), refined in the ensuing literature by Christiano et al. (1999) and implemented by Starr (2005). We estimate a

[5] This model simply extends the standard IS-LM model.

reduced form VAR and identify monetary-policy innovations through specification about variable ordering. Specifically, the reduced form VAR is thus:

$$Y_t = B_0 + B_1 Y_{t-1} + \cdots + B_k Y_{t-k} + \mu_0 \tag{4.0}$$

Where Y_t is a vector of our policy and non-policy variables,[6] B_0 is a vector of constants, B_{t-j} is a matrix of coefficients on the variables lagged j periods, μ_t is a vector of serially uncorrelated disturbances that have zero mean and variance co-variance matrix Σ_μ^2 and k is the number of lags. We make the usual assumption that the Central Bank cannot respond instantaneously to developments in the real economy.[7] This assumption imposes a recursive restriction on the reduced form disturbance Σ_μ^2. This restriction helps to identify and interpret the relationship between the residuals of the SVAR model and the underlying innovations in monetary policy variables. It is only when the innovations have been correctly identified that the estimated SVAR can be used to generate impulse response functions that describe the time-dynamic effects of monetary innovations on the non-policy variables. This process is usually referred to as the Choleski decomposition.

Specifically, our assumption implies that monetary policy innovations are determined based on knowledge of contemporary and past values of the non-policy variables, whereas, the non-policy variables respond to changes in the policy variables with a lag and not vice-versa. This approach has several advantages. First, it provides a basis for characterizing the relationship between the policy variables and the non-policy variables and second, it enables us to compare our results with findings in sister countries.

Because we are also interested in the answer to the second research question about the most influential monetary policy variable, we estimate the SVAR model including three popular measures of monetary policy. Hence, we use five variables in the model, three policy related variables and two non-policy variables. Money supply measured by M_2, The Minimum Rediscount Rate (MRR) and the real effective exchange rate (REER) are the policy variables. While output measured by real GDP and prices measured by the Consumer Price Index (CPI) are the non-policy variables.

We order the policy variables in the SVAR after the non-policy variables with output coming first, based on the assumption that it adjusts most sluggishly. This ordering technique is an aberration from the usual ordering used for developed economies where prices are assumed to be most sluggish, and hence, entering first (see for e.g. Starr, 2005). Nonetheless, reversing this order is likely to me more appropriate for Nigeria where prices are relatively flexible and the rigidity of production techniques makes output more inelastic.

[6] We have fully describe all the variables in Section 4.3.
[7] This is due to the time lag required for the collection of the required data used for policy formulation.

Within the policy related block, we follow Starr (2005) by ordering the variables thus; money supply first, followed by the Minimum Rediscount Rate and then the real effective exchange rate to reflect their respective likely degrees of endogeniety. We estimate the SVAR taking the true lad length to be two.

V. PRELIMINARY DIAGNOSTICS

Since we are using times series data sets for the analysis, it is important that we first scan the data sets for stationarity properties. It follows that if some of the variables are stationary and others are non-stationary, then the latter should be incorporated into the SVAR model in their first-differences to avoid problems of spurious regression. Hence, to examine the stationarity properties of the data sets, we use a variety of units root tests. The motivation behind the assortment of tests is to obtain reliable and consistent results. Thus, in addition to the traditional tests of Dickey-Fuller and Phillips-Perron, we also employ the Ng-Perron (NP) test and the Kwiatkowski, Phillips, Schmidt and Shin's (KPSS) test designed to overcome the problems of low power and size distortions inherent in the traditional tests (see Madalla and Kim, 1998; for a discussion). Depending on the order of integration of the variables, we feed them into the SVAR model at their levels or first-differences.

A. Data and Measurement

The data sets used for this analysis is the quarterly series of the selected variables from 1986:1 to 2008:4. The choice of this period is to enable us focus strictly on the era of market-based monetary regime in Nigeria. The data was extracted from the 50th Anniversary Statistical Bulletin of the Central Bank of Nigeria and whenever necessary, we supplemented with our computations.

The data set and measurement of variables used in the model are as follows: (1) quarterly data of real GDP (RGDP) served as the measure of real economic activity, (2) quarterly data on the Consumer Price Index (CPI) captured nominal price changes, (3) broad money measured by the quarterly data series of M_2 served as a quantity-based monetary policy variable, (4) the Minimum Rediscount Rate (MRR) functioned as a price-based monetary policy variable and (5) the real effective exchange rate[8] which was computed as a trade-weighted index with inflation differential incorporated served as another price-based monetary policy variable.

The variables RGDP, CPI, and M_2 are incorporated into the model in their natural logs. This is to enable us index all the variables and to aid interpretation of results.

[8] The real effective exchange rate acts as a "pass-through" channel, that is, a component of the cost of imported items and helps to capture the traditional interest rate paradigm, where monetary policy has the immediate effect of changing the returns on assets denominated in other currencies.

B. Results from Preliminary Diagnosis

Table 1, summarizes the results obtained for each variable from the various techniques used to test the hypothesis of unit root or no unit root as the case may be. We use the 5% level of significance as our decision criteria.

Table 1 Summary of Results of Stationarity Tests

Variables	Test Techniques				Remarks
	ADF	PP	KPSS	NP	
RGDP	I(1)	I(1)	I(1)	I(1)	Differenced in model.
CPI	I(1)	I(1)	I(1)	I(1)	Differenced in model.
M_2	I(1)	I(1)	I(1)	I(1)	Differenced in model.
MRR	I(1)	I(0)	I(0)	I(0)	Incorporated at levels.
REER	I(1)	I(1)	I(1)	I(1)	Differenced in model.

With the exception of the Minimum Rediscount Rate (MRR), all other variables possess unit roots and became stationary only after we transformed them to their first differences. For the MRR, we obtained inconsistent stationarity results. The ADF test did not reject the hypothesis of the presence of a unit root in the levels. However, the PP, KPSS and NP tests gave results that suggest stationarity at the series level. Our inconsistent results for MRR are not surprising, given the known computational difficulties of distinguishing between non-stationary and stationary data sets with short time spans (see Madalla and Kim, 1998).

The unit-root test results provide us with a reliable guide on how to incorporate the variables into the SVAR analysis. Following our results, we feed RGDP, CPI, REER, and M_2 into the model at their first-differences, while MRR enters at its level as stated in the *Remarks* column of Table 1.

C. Estimated Effects of Monetary Innovations on Output and Prices

In this sub-section, we demonstrate the estimated effects of innovations in monetary policy variables on output and prices. The coefficients of our model are numerous (50) and not readily subject to interpretation. Hence, the interpretation follows from the path of the impulse response functions generated from the recursively-orthogonalized SVAR estimated residuals. The impulse responses show the path of output and prices when there are innovations in the policy variables.

Figure 1 Response of Output and Price to Monetary Innovations

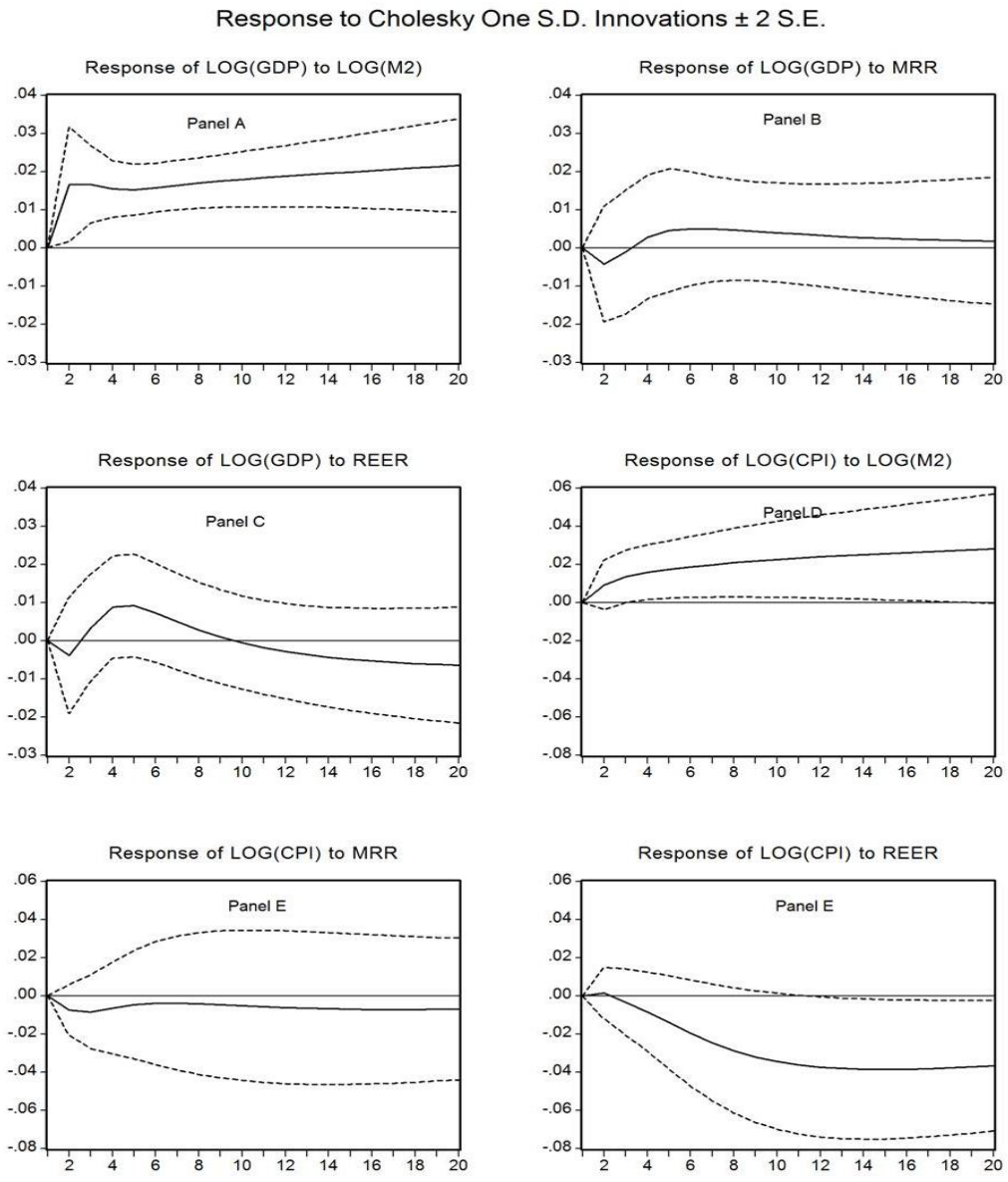

Figure 1, shows six panels of impulse response graphs indicating how innovations in respective monetary policy variables affect output and prices in Nigeria over a period of 20 quarters (5 years). Each panel illustrates the response of the non-policy variable to a one standard deviation innovation (corresponding to a positive shock) in the policy variable.

A value of zero means that the monetary shock has no effect on the non-policy variable and the variable continues on the same path it would have followed had there been no monetary shock. A positive or negative value indicates that the shock would cause the variable to be above or below its 'natural' path as the case may be. The solid lines depict the estimated effects, while the dashed lines show the boundaries of a 95% confidence interval.

Panel A of Figure 1 shows the response of real GDP to an expansionary shock in the money supply measured by M_2. Here, output rises quickly and significantly within the first three quarters, slows down and then stabilizes at the new level. This response is consistent with our *a priori* expectation as presented in the traditional Keynesian IS-LM model and the Mundell-Fleming-Dornbusch model. However, the time dynamics are startling, especially when we consider the rigid nature of the production techniques used in the economy. Normally, economic agents are expected to adjust their spending and investment habits moderately and gradually in response to the increased supply of funds rather than immediately. Therefore, it follows that this quick response may not reflect the usual marginal adjustment to the policy innovation. Rather, it measures the concurrence of significant changes in output during the period preceding the monetary innovation.

Our results are similar to those found by Ghosh (1996) for Ukraine (a developing economy) in that the real effects of monetary policy are quick and transitory. Conversely, our results are unlike those found for the U.S (a developed economy) with monetary innovations having hump-shaped responses on real variables after a lag of about three quarters and petering out after about three years (Christiano et al., 2002).

In Panel B, we observe that a positive innovation in the Minimum Rediscount Rate, which corresponds to a concessionary monetary policy, has an insignificant choking effect on real GDP in the first two quarters and then it fizzles out in the third quarter with output returning to its natural path. Again, this response is consistent with theoretical expectations. The insignificant effect of the interest rate shock on real GDP is simply a confirmation of the thin nature of the credit markets in the economy.

Also, a positive shock in the real exchange rate (i.e. a real depreciation) increases real output with the positive effects commencing in the fourth quarter and petering out in the eight quarter as shown in Panel C. This response is theoretically consistent especially for an open economy with many trading partners like Nigeria.

Measuring the price effects of monetary innovations in Nigeria, Panel D shows that an increase in the monetary aggregate (M_2) instantly leads to sustained increase in prices. This corresponds to the finding by Akinlo (2007) that money supply and prices have a very strong correlation in Nigeria; it also lends credence to the conclusions of the quantity theory of money. The quick response suggests that prices are relatively

flexible, hence the sticky price assumption for the basic Keynesian IS-LM models may not be effective in Nigeria.[9]

Panel E reveals that the Minimum Rediscount Rate has no significant effect on prices. This evidence rules out the likely existence of the price puzzle in Nigeria. It further reinforces the conclusion derived from Panel B that credit markets are thin and relatively inaccessible. Our result is similar to that of Berument (2007) for Turkey and Kahn et al. (2002) for Israel, but very different from that of Rafiq and Mallick (2008) for Germany, France and Italy, Eichenbaum (1992) for the U.S and Sims (1992) for OECD countries in that they find evidence that suggest the existence of the prize puzzle.

Panel F shows that when there is depreciation in the real exchange rate, prices fall quickly and start recovering after about 15 quarters. Theoretically and practically, this is startling because depreciation of the real exchange rate should make local tradable goods more competitive globally and hence increase the demand for the local commodities. This increased demand should put an upward pressure on prices eventually. This abnormality can be explained by the week production capacity for tradable[10] goods in Nigeria.

Policy Implication

The results from this work provide a reliable guide for good monetary policy implementation in Nigeria and other developing economies that share similar characteristics. First, we observe that monetary innovations are not all neutral in the short-term, depending on the monetary policy instrument used. Since M_2 proved to have the most influential impact on output and prices, central bankers should place more emphasis on the quantity-based nominal anchor (M_2) for managing the economy. This implies that effective monetary policy should focus on manipulating instruments like the liquidity ratio, reserve ratio, and transaction on Treasury Bills and REPOs which directly affects the monetary aggregate M_2. Less emphasis should be placed on the use of interest rates (like MRR and MPR) and exchange rates to manage the economy. This is because they have virtually neutral and insignificant effects on output.

VI. CONCLUSION

In this paper, we carry out a controlled experiment using a structural vector autoregresion (SVAR) approach to trace the effects of monetary policy shocks on output and prices in Nigeria. We make the assumption that the Central Bank cannot observe unexpected changes in output and prices within the same period. This places a recursive restriction on the disturbances of the SVAR and help to generate impulse

[9] The dependence of the economy on the petroleum sector with its attendant volatilities may be an explanation for price flexibilities.
[10] Any good produced domestically that can be exported or imported is called a tradable good

response functions that track the effects of monetary policy innovations on output and prices.

Overall, we find evidence that monetary policy innovations have both real and nominal effects on economic parameter depending on the policy variable selected. Our results are of the view that price-based nominal anchors (MRR and REER) do not have a significant influence on real economic activity. Whereas, innovations in the quantity-based nominal anchor (M_2) affects economic activities modestly. It therefore follows that monetary policy shocks have been a modest driver of business cycle fluctuations in Nigeria.

We note that monetary policy implementation in a developing country like Nigeria faces additional challenges that are not present in developed economies; such has fiscal dominance and the treat of currency substitution. Therefore, to better understand the impacts of monetary policy shocks on output and prices, it will be instructive for future research in this field to include fiscal policy variables in the analysis.

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