

# ESTIMATING A MONETARY POLICY REACTION FUNCTION FOR THE CENTRAL BANK OF NIGERIA (1999 – 2007)

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## ABSTRACT

This study estimates a simple model of the Central Bank of Nigeria's "reaction function"— that is, the relationship between economic developments and the Bank's response to them vis-à-vis setting its Monetary Policy Rate (MPR). A Taylor-type reaction function is estimated for the Central Bank of Nigeria. Although this type of analysis is common for advanced economies in recent times (e.g. Clarida et al, 1997)<sup>2</sup>, relatively little work has been undertaken for developing countries, including Nigeria. In a system of behavioural equations including an aggregate demand (IS curve), aggregate supply (Phillips curve) and an uncovered interest rate parity equation, the Taylor-type reaction function is used in various scenarios to assess the efficacy of monetary policy in influencing macroeconomic variables. The results suggest that a Taylor-rule framework is a useful way to summarize key elements of monetary policy conduct in Nigeria. The results showed inflationary pressures played a significant role in the decisions taken by the Bank during the review period. In addition, the results uncover the role of output in determining the assessment of the Bank on the future path of interest rates. Given the importance of the monetary authorities' reaction functions in, for example, macro modelling, research in the topic is useful and contributes to econometric applications in the area of macroeconomic policy management, specifically monetary policy.

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<sup>1</sup>The views expressed in this paper belong to the author and do not represent the views of the Central Bank of Nigeria.

<sup>2</sup> Clarida, Richard, Jordi Gali, and Mark Gertler. 1997. "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory."  
Unpublished paper, Columbia University



# **ESTIMATING A MONETARY POLICY REACTION FUNCTION FOR THE CENTRAL BANK OF NIGERIA (1999 – 2007)<sup>1</sup>**

## **1 Introduction**

This paper presents and estimates a small new-Keynesian model for the Nigerian economy, which can be used to support monetary policy analysis, risk assessment and forecasting. Though the model is built based on the principle of parsimony, it is calibrated to capture economic realism as much as possible. It is a structural model as each of its equations has an economic interpretation, and causality as well as identification is coherent. Policy interventions have counterparts in changes in parameters or shocks, and their influence can be analyzed by studying the resulting changes in the model's outcomes. The model is general equilibrium as the main variables of interest are endogenous, depending on each other and random shocks affect each endogenous variable making it stochastic. It is possible to use the model to derive measures of uncertainty in the underlying baseline forecasts. The model incorporates rational expectations as economic agents cannot be fooled consistently.

The model contains three structural equations: A Phillips curve for CPI inflation, an aggregate demand curve for the output gap and an uncovered interest rate parity condition that relates the behaviour of domestic and foreign interest rates and the nominal exchange rate. The fourth equation in the model is an estimated reaction function (Taylor-type rule) for setting the Central Bank of Nigeria's anchor interest rate (Monetary Policy Rate – MPR). Notwithstanding the size of the model developed here, it is still possible to describe the main ingredient of the transmission mechanism in Nigeria, with the important advantage of its simplicity and clarity which should help to

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enhance the monetary policy communication strategy as well as its outcomes.

The model links the policy instrument (a short-term interest rate) and the nexus of output, inflation, and the exchange rate in a small-open economy. Key variables are expressed as deviations-from-equilibrium, and do not try to explain the underlying real equilibrium values. However, the model can address many policy issues that arise routinely in making decisions about monetary policy actions and communicating the reasons to the public as implied earlier. It is a trimmed down version of a generic quarterly prediction model (QPM) used in most inflation-targeting central banks with the objective of deciding on the appropriate level of the policy rate, given the inflation target and the current state of the economy. The model provides a helpful organizing framework for establishing near- and medium-term baseline forecasts, which encourages structured and transparent discussions of current policy issues at the central bank. Due to its ability to generate alternative scenarios, the model is a helpful tool for risks assessment in the baseline forecast in addition to analyzing the relative importance of various assumptions. The theoretical framework and part of the empirical specification of the model was based on the works of, Svensson (2000), Linde et al (2004), Monacelli (2005) and Berg et al (2006). The goal is therefore, to apply similar framework to the characteristics of the Nigerian economy and to develop a useful practical model that could support monetary policy analysis.

The analysis of the reactions of monetary authorities to macroeconomic outcomes and the impact of their actions on the entire economy are amongst key topics of monetary economics. Friedman and Schwartz's (1963) motivated the initial surge of interest in the latter aspect with their influential work, as well as the introduction of the Real Business Cycle models. Subsequently, Sims (1980) boosted the subject by introducing Vector

Autoregressions Modelling (VARs), which remains to date the dominant approach in the assessment of the impact of monetary authorities' actions on macroeconomic aggregates.

Although monetary policy<sup>2</sup> formulation and implementation has a standard format, country peculiarities exist. Whereas in other countries numerous studies exist on the subject of monetary authorities reaction to economic realisations in the decision making process, there is sparsely any literature on the CBN reaction function. The need to determine a rule on how the CBN takes decisions on its key interest rate and the interactions of such policies with other economic variables is overwhelming.

In addition, because of the role reaction functions plays in a wide variety of macroeconomic analyses, including in macroeconomic modelling and forecasting, and despite the fact that the explicit guidelines that central banks in developing economies ascribe to when taking their policy decisions would appear to be intractable, this study is useful. For obvious institutional reasons, empirical evidence could help determine the manner in which they implicitly react to key economic developments. The outcome of the study should provide a basis for macroeconomist and market participants to base assumptions on the monetary policy stance of the CBN.

The paper is structured as follows. In the next section a short background of the Nigerian economy and the conduct of monetary policy by the CBN were presented. Section 3 presents the estimated model structure, data set and calibration as well as the underlying assumptions used to estimate values for inflation, output, interest rates, and the exchange rate. Section 4 describes

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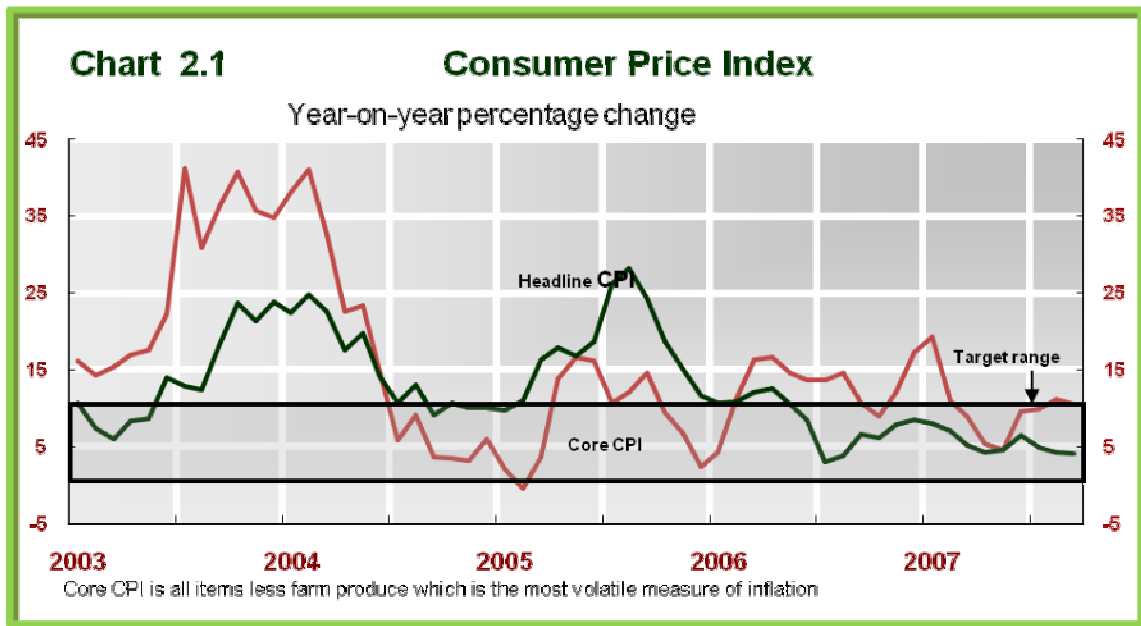
<sup>2</sup>Monetary policy is the use of instruments at the disposal of a central bank to influence the availability and cost of credit/ money with the ultimate objective of achieving price stability. Monetary policy influences movements in economic aggregates and provides an enabling environment for the attainment of broad macroeconomic objectives. The central bank is charged by national governments with the conduct of monetary policy and may be mandated to attain a single objective or multiple objectives. In most developing economies, the central bank is initially mandated with two objectives - those of price stability and economic growth.

the applied estimation method, the model's baseline forecast and estimation results. Section 5 concludes.

## **2 A Brief Background on the Economy and Conduct of Monetary Policy in Nigeria**

### **2.1 Background on the Nigerian Economy**

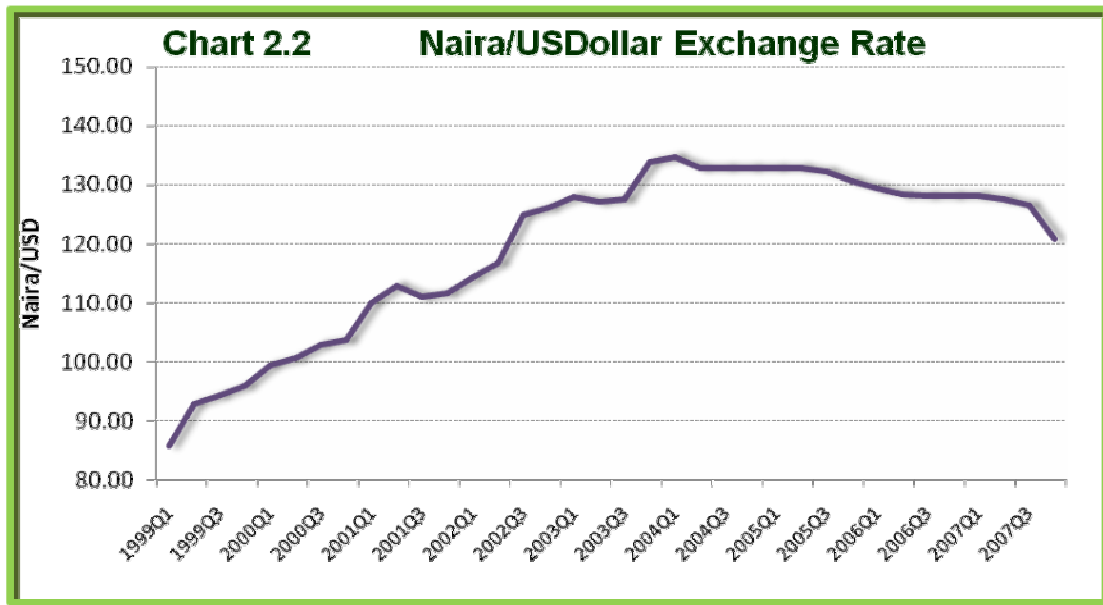
During the estimation period (1999 to 2007) the Nigerian economy's real and nominal sides experienced several major changes. Another important development was the prolonged structural change in the financial sector as banking services and innovations in the sector grew rapidly. Macroeconomic conditions in Nigeria have been benign in recent years. Inflation has fallen to single digits due to a disinflation process that occurred in Nigeria. From 1999 to 2007 average inflation measured by the year-on-year (y-o-y) change in the consumer price index (CPI) was 10.3 per cent. On the other hand, the economy grew (GDP) at an average of 6.2 per cent between 2002 and 2007. In addition, a major development was the transition to a more flexible exchange rate regime, from a fixed peg regime to a managed floating regime. This regime shift resulted in the eventual depreciation on the national currency from the fixed price to a market determined one. The event increased the sensitivity of the exchange rate to external shocks, which eventually affected imported prices, and consequently, increased the sensitivity of the exchange rate to the interest rate. Hence, the effectiveness of the interest rate as an instrument of stabilizing the inflation and the output gap was enhanced.



On the fiscal side, an oil-price-based fiscal rule which was introduced helped control government spending for consistent macroeconomic management and stability. The financial markets developed as the inter-bank foreign exchange market deepened and the maturity structure of the domestic sovereign bonds became longer, developments which augur well for monetary policy implementation. In addition, foreign investor interest in Nigerian assets spurred increased capital inflows in the review period. Government's debt profile was enhanced as the country exited both the Paris and London club of creditors list of debtors. This buoyed the Balance-of-Payments position of the country overtime.

However, due to the rapid developments in the financial market, the money demand function has become increasingly unpredictable. This has adversely affected the relationship between money and prices, further complicating forecasts of money demand. Thus, the conduct of monetary policy using the monetary targeting approach became more difficult. In view of the above,

the CBN announced its intention to adopt inflation targeting (IT)<sup>3</sup>, with its explicit implementation from January 2009.



## 2.2 Conduct of Monetary Policy in Nigeria

Depending on prevailing circumstances, the conduct of monetary policy by the Central Bank of Nigeria has been articulated to achieve overriding objectives, contemporaneously. In this regard, when designing monetary policy, the CBN reviews developments in the economy over a period, reviews the major pressure points and risk to price stability and output growth and then formulates a framework to guide its monetary policy implementation. Hence, the conduct of monetary policy in Nigeria has been usually confronted with the challenge of managing exchange rate, capital inflows, excess liquidity and rapid credit expansion as is common to most resource endowed economies.

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<sup>3</sup> Most recently, however, as a result of the overriding concern for inflation, many central banks have increasingly concentrated on the objective of price stability even where they are expected to pursue multiple objectives.

The 1958 Act establishing the Central Bank of Nigeria gives it the following policy mandates: issuance of legal tender currency notes and coins in Nigeria; maintenance of Nigeria's external reserves to safeguard the international value of the legal currency; promotion and maintenance of monetary stability and a sound and efficient financial system in Nigeria; and acting as banker and financial adviser to the Federal Government. In line with this mandate, the Bank is charged with the responsibility of conducting monetary policy in Nigeria.

Monetary policy in Nigeria has passed through two major phases, the era of direct monetary control and that of the current regime, indirect monetary control. At inception, the monetary policy framework of the Central Bank of Nigeria was formulated on the basis of a fixed exchange rate, which was supported by an arsenal of trade and exchange controls. With the introduction of the Structural Adjustment Programme (SAP) in 1986, direct controls were de-emphasised as the naira was floated and trade and exchange controls were liberalized. After painstaking preparations, indirect monetary controls were introduced in 1992. The delay in transiting to indirect monetary control was on account of the underdevelopment of the financial markets and the need to undertake prior activities to establish an enabling environment for effective implementation of a market based system.

Specifically, between 1958 and 1986, the need to ensure price stability, provide an enabling environment for economic growth and development as well as gainful employment, while ensuring external sector viability was dictated by the application of the "visible hand", in the form of direct control, in the determination of the exchange rate and the allocation of domestic credit as well as foreign exchange for international payments. Some of the direct monetary control instruments were credit ceilings, selective credit controls, administered interest and exchange rates, cash reserve requirements and special deposits. The CBN was persuaded that it

was necessary to deliver credit to end-users at low interest rates to stimulate output while the exchange rate should also be pegged and prevented from sustained depreciation. This was to reduce the incidence of imported inflation as the economy needed imports of raw materials and capital goods for improved industrial output. After designing a monetary programme, the Bank issued credit, trade and exchange guidelines which stipulated the sectoral allocation of credit by banks to the private sector, interest rate regime, the trade policy as well as quantitative restrictions on imports and foreign exchange modalities. The sectoral distribution of bank credit by the CBN was reflected in its annual guidelines. The control of interest rates at relatively low levels was done mainly to promote investment and growth. Furthermore, special deposits were imposed to reduce the amount of free reserves and credit-creating capacity of banks. Minimum cash ratios were stipulated for the banks in the mid-1970s on the basis of their total deposit liabilities; but they were not very effective since they were lower than those the banks on their own maintained with the CBN.

From 1986 onwards, the difficulties encountered with implementing direct monetary controls led to the introduction of indirect controls in 1992. Under the system, the use of the "invisible hand" or market forces was to be encouraged. Open Market Operation (OMO) was introduced, complemented by reserve requirements and discount window operations. In order to improve macroeconomic stability for the effective implementation of OMO, efforts were directed at the management of excess liquidity and strengthening monetary and fiscal policy coordination. A number of measures introduced to reduce liquidity included the reduction in the maximum ceiling on credit growth allowed for banks; the recall of the special deposits requirements against outstanding external payment arrears to CBN from banks; abolition of the use of foreign guarantees/currency deposits as collaterals for naira loans and the withdrawal of public sector deposits from

banks to the CBN. Moreover, from August 1990, the use of stabilization securities for purposes of reducing excess liquidity in banks was re-introduced.

In order to give banks more leverage in the allocation of credit, sectoral credit distribution targets were merged into four sectors in 1986, and further reduced to two in 1987. From October 1996, the authorities abolished all mandatory credit allocations. The commercial and merchant banks at the time were subjected to equal treatment since their operations were found to produce similar effects on the monetary process. Areas of perceived disadvantage to merchant banks were harmonized in line with the need to create conducive environment for their operations.

As preconditions for the introduction of OMO could not all be met at once, it was necessary to undertake its implementation in phases. Thus, from September 1, 1992, the CBN lifted credit ceiling on individual banks that met CBN specified criteria in respect of statutory minimum paid-up capital, capital adequacy ratio, cash reserve and liquidity ratio requirements, prudential guidelines, sectoral credit allocation and sound management. However, the use of stabilization securities to mop up excess liquidity in banks was intensified while three discount houses commenced operations from March 1993. The CBN commenced OMO in treasury securities with banks through discount houses on a weekly basis in June, 1993.

Under the general framework of deregulating the economy in 1986, to enhance competition and efficient allocation of resources, the Central Bank of Nigeria introduced a market-based interest rate policy in August 1987. While it was generally agreed that low interest rates, which were likely to accompany deregulation, might stifle investment, the deregulation of interest rates allowed banks to determine their deposit and lending rates according to market conditions through negotiation with their customers. However, the minimum rediscount rate (MRR), which should influence other interest rates

continued to be determined by the Central Bank in line with, changes in overall economic conditions. The MRR, which was 15.0 per cent in August 1987, was reduced to 12.75 per cent in December 1987 with the objective of stimulating investment and growth in the economy. In 1989, the MRR was raised to 13.25 per cent in order to contain inflation. To further liberalize interest rate management, the cap on interest rate was lifted in 1992 and re-imposed in 1994 when inflationary spiral could not be contained.

However, in October 1996, interest rates were fully deregulated, with the banks given freedom to determine the structure of interest rates in consultation with their customers. The CBN, however, retained its discretionary power to intervene in the money market to ensure orderly developments in interest rates. The policy of interest rate deregulation has been retained since 1997. In December 2006, the MRR was replaced with the Monetary Policy Rate (MPR). The MPR was brought down to 10.0 per cent from 14.0 per cent (MRR), with a lending rate of 13.0 per cent and a deposit rate of 7 per cent. This summed up to a corridor of 600 basis points and was a standing facility intended to stem volatility in interest rates, especially inter bank rates. The Bank continued to apply the tools of reserve requirements and discount window operations. However, under the standing facility, discount window operations became less prominent. Subsequently, the corridor was abolished as the overnight standing deposit facility became unremunerated. The MPR became more effective than the MRR in steering interest rates and signalling a commitment to only lend to banks as a last resort. In order to further strengthen the money market, deepen it and ensure that treasury instruments were fully priced in the market place without moral hazard for the CBN; primary dealers were appointed to trade in such securities and underwrite them as situations demand. This action effectively broke the monopoly of discount houses in the primary market for treasury securities.

The institutional framework for monetary policy has also been reviewed over the years to ensure a more robust outcome. The Bank introduced a Monetary Policy Committee (MPC) in 1999. The MPC deliberates on the Bank's monetary programme, reviews developments in the economy, especially the state of the money and foreign exchange markets, undertakes an assessment of the risks to price stability, decides whether to adjust interest rate or not, and agrees on the measures to be taken to contain unfavourable price developments. When the MPC was constituted in 1999, the major problem was the management of the naira and it met daily to address issues relating to effectiveness of the foreign exchange market and discussed monetary policy issues.

The monetary policy process is becoming more transparent and accountable since the MPC was introduced. At the end of every MPC meeting, a communiqué is issued and the public is able to assess the monetary policy stance of the Bank. The press makes comments on the monetary policy process and this feedback to the monetary policy process. The periodic reporting of the activities of the Bank to the National Assembly has also contributed to the intensified public scrutiny of the Bank's monetary policy process. The monetary policy communication process would still require fine tuning for more robust outcome. Transparency, accountability and effective communication will become more relevant on transition to inflation targeting. The Bank will be required to make public its inflation target, its operating instrument and publicly explain the reasons for its inability to meet the target in case such a situation arises. The reforms in the monetary policy process are ongoing.

Overtime the framework for conducting monetary policy in Nigeria had witnessed some transformation. This included the shift from the use of direct monetary policy control to indirect (market-based) monetary management, and the switch from short-term framework to a two-year medium-term

framework in the conduct of monetary policy. Although the objectives of monetary policy remained basically the same and monetary aggregates remained the intermediate target to achieve the ultimate objective of inflation during these periods, there were some fundamental changes in the strategies and instruments employed in the conduct of monetary policy in order to cope with the evolving financial environment. These changes are usually analyzed under two major phases, namely, the period before the Structural Adjustment Programme (SAP) that witnessed direct control method and post-SAP era when market instruments were employed.

The recent reforms in the conduct of monetary policy by the CBN have continued to yield fruitful results. However, the evolving financial and economic environment has brought new initiatives, challenges and prospects which must be marched by effective measures in a bid to manage the macroeconomic environment satisfactorily. The need to capture the interrelationship between various macroeconomic variables and sectors of the economy and the ability predict there future path is essential for attaining such laudable objectives of the central bank.

### **3.1 The Model**

The model described below is largely based on Svensson (2000), Linde et al. (2004) and Berg et al. (2006). At several stages deviation from other formulations is made, in order to adjust the model to the peculiar characteristics of the Nigerian economy. Furthermore, for completeness and in order to highlight the meaning of the structural parameters that we estimate, we shall present the main stages of the model's development. For more background on the formulations the reader should refer to the papers mentioned above. The model estimation technique is based on a simple gap model, while more complicated versions of it may be found working in many central banks all around the world. The model consists of four core equations, namely:

1. Aggregate demand (IS curve)
2. Aggregate supply (Phillips curve)
3. Uncovered Interest Rate Parity
4. Monetary Policy Rule

### 3.1.1 Aggregate demand

The aggregate demand equation corresponds to the open economy type of the traditional IS curve and is of the form:

$$\hat{Y} = a_1 \hat{Y}_{t-1} - a_2 r\hat{m}c_t + a_3 \hat{Y}^* + u_t \quad (1)$$

Where  $\hat{Y}$  is the deviation of the log of output from its gap level, i.e., the output gap;  $r\hat{m}c$  is the real monetary condition index, defined as deviations of the long-term real interest rate from its steady state level,  $\hat{r}$ , and deviations of the real exchange rate from level,  $\hat{z}$ ; while  $\hat{Y}^*$  is the foreign output gap,  $u$  is an aggregate demand shock. The coefficients  $a_1$ ,  $a_2$ , and  $a_3$  capture the persistence of output; the impact of monetary conditions on real economic activity; and the impact of foreign environment, respectively.

### 3.1.2 Aggregate supply

The aggregate supply relationship, i.e., the Phillips curve is defined as follows:

$$\pi_t = b_1 (b_2 \pi_{t-1} + (1 - b_2) E_t \pi_{t+1}) + (1 - b_1) (\pi_t^{\text{imp}} - \Delta \bar{z}) + b_3 \hat{Y}_t + \eta_t \quad (2)$$

where  $\pi$  is the annualized quarterly change of CPI, i.e., inflation;  $E_t$  denotes model-consistent inflation expectations;  $\pi^{\text{imp}}$  is import price inflation;  $\Delta \bar{z}$  is the trend change in the real exchange rate that reflects country's economic convergence vis-à-vis its trading partners; and  $\eta$  is an aggregate supply shock. Inflation pressures come from the output gap, the exchange rate gap and expected and lagged inflation.

The supply relationship encompasses multi-period, overlapping nominal contracts, extended for a direct impact of import prices, as the latter is an important feature, since small open economies usually have potent

exchange rate channel of monetary transmission. The coefficient  $1 - b_1$  approximates the weight of imported goods in the consumer basket. Second, inflation in emerging-market economies partly results from the income convergence process — each percentage point of real income convergence corresponds to one percentage increase in the price level. The trend increase in the price level caused by appreciation of the real exchange rate, was approximated by the  $\Delta \bar{z}$  in the Phillips curve.

Expectations are properly captured to model both forward-looking and backward looking agents in the economy using model consistent expectations,  $E_t$ . Economic agents who are assumed to be fully forward-looking comprise  $1 - b_2$  of the population and  $b_2$  agents follow the rule of thumb of past inflation. Another way of thinking about this parameter is the persistence of inflation—the more persistent inflation, the higher is  $b_2$ . The coefficient  $b_2$  captures for the influence of the output gap on inflation (the slope of the Phillips curve), measuring the level of trade-off between output and inflation.

Import prices are often lagged and are calculated simply as the sum of foreign inflation and change in the nominal exchange rate:

$$\pi_t^{imp} = d_1 \pi_{t-1}^{imp} (1 - d_1) (\Delta s_t + \pi_t^*) + \vartheta_t. \quad (3)$$

This is important as it represents the direct exchange rate channel and reflects the speed of the exchange-rate pass-through.

### 3.1.3 Uncovered Interest Rate Parity

The relationship with the world is captured by the uncovered interest rate parity condition that relates the behaviour of domestic and foreign interest rates and the nominal exchange rate, while the nominal exchange rate may exhibit some persistence:

$$\Delta s_{t+1} = e_1 \Delta s_t + (1 - e_1) (i_t - i_t^* - prem_t) + v_t, \quad (4)$$

where  $\Delta s$  is the change of the nominal exchange rate;  $i$  is the domestic nominal interest rate;  $i^*$  is the foreign nominal interest rate;  $prem$  is the risk premium; and  $v$  is an exchange rate shock. The coefficient  $e_1$  determines the level of exchange rate persistence—the higher its value the less sensitive is the exchange rate to changes in interest rates. It could be that the country has a deep FOREX market and thus a more stable exchange rate (Bulíř, 2005) or that the central bank intervenes heavily in the FOREX market (the more heavily the central bank intervenes, the higher the value of  $e_1$ ).

The long-term version of the uncovered interest rate parity is better expressed in real variables, binding together the trend values for real exchange rate appreciation (either due to the Balassa-Samuelson effect or some “convergence inflation” as in Čihák and Holub (2003)) and the trend values of domestic and foreign real interest rates:

$$\Delta \bar{z}_{t+1} = \bar{r}_t - \bar{r}_t^* - prem_t. \quad (5)$$

The steady-state values for  $\Delta z$ ,  $r$  and  $r^*$  are set as parameters in this model, requiring prior assessment of these trend values, while the risk premium is calculated endogenously, assuring the existence of a consistent steady state. We assume that the Nigerian economy would have an equilibrium real appreciation to the tune of about 4 per cent annually. Alternatively, the central bank uses FOREX interventions actively (and the exchange rate channel) to meet the inflation target.

### 3.1.4 Policy Rule

Notwithstanding the level of attention given to modelling the impact of monetary policy on macroeconomic aggregates, macroeconomists are also interested in modelling the central banks' reaction to developments in the economy. These responses which are prompted by various economic realisations in addition to the particular objective of price stability are captured in econometric models commonly referred to as “monetary policy reaction functions”. The analysis of the monetary authorities' reactions,

although a sensibly researched topic (Khoury, 1990), was sparsely undertaken until recent interest was (mainly) motivated by Taylor (1993). The Taylor rule was formulated explicitly for determining the short-term interest rate of the central bank and states that “keep the real-short-term interest rate constant as a neutral policy stance, and make a surcharge (discount) when the output gap is positive (negative) and/or inflation is above (below) a target rate”.

The model is closed by a policy reaction function of the monetary authority (a Taylor rule, Taylor, 1993). For simplicity, we take the three-month interest rate to be the instrument of monetary policy, and the authority is assumed to respond to deviations of next-period inflation from its target and to the output gap. The last-period policy stance may also affect the current policy stance:

$$i_t = f_1 i_{t-1} + (1 - f_1)(i_t^n + f_2(E_t \pi_{t+1} - \pi^T) + f_3 y_t) + \varepsilon_t, \quad (6)$$

Where,  $i$  is the domestic short-term nominal interest rate and  $\varepsilon$  is a policy shock. The monetary authority is fully forward-looking and uses model-consistent inflation expectations,  $E_t \pi_{t+1}$ . The policy-neutral rate,  $i_t^n$ , is such that keeps the output gap unchanged. We calculate it as a sum of the trend real interest rate and model-consistent inflation expectations:

$$i_t^n = \bar{r} + E_t \pi_{t+1}. \quad (7)$$

For the sake of simplicity and representative of the current interest rate structure in Nigeria, only the three-month interest rate is used, neglecting and no long-term interest rates.

### 3.2 Model Calibration

The baseline version of the model is based on “reasonable” values for all the parameters, however, the model exhibits comparatively low persistence. The model expresses each variable in terms of its deviation from equilibrium, though attempt is not made to elucidate on movements in equilibrium real exchange rate, real interest rate, real output and the inflation target. The

calibration process was split in two parts. First, the calibration of the trend variables which determines the steady-state levels of the model, and second the calibration of individual equations parameters, determining the business-cycle properties of the model.

### **3.2.1 Assumptions and Calibration on Equilibrium Values**

The calibration of the long-term parameters ensures that the model converges. These adjustments are made for the trend values of the domestic and foreign real interest rates, real exchange rate, and risk premium as the values are imposed via parameters. In addition, the targets for domestic and foreign inflation are set as parameter, since the choice of an inflation target predetermines that the forecasted inflation converges to the target. The model structure above (from equations (1) to (7)), determines some important long-run relationships. The nominal interest rate converges to the neutral rate that in turn equals to the sum of the trend real interest rate and inflation target in the long-run trends “steady-state” of inflation expectations equal the inflation target. The steady-state change in nominal exchange rate comes out as the sum of steady-state inflation differential vis-à-vis the world and steady-state real exchange rate appreciation. The risk premium is calculated endogenously given the parameterization of domestic and foreign real interest rate and the change in the real exchange rate. On the one hand, this is one way to keep the model simple. On the other hand, this simplification also keeps the trend values in (5) on a consistent path. The results of the model depend on the assumed equilibrium values. Six long-run parameters are set in the model:

- a. Inflation target – A fundamental assumption is that the CBN sets interest rate similar to an inflation targeting regime. This assumption is based on the trend of actual inflation up till 2005 as described in Berg et al. (2006). The assumed target is 8.5 per cent, which is the higher end of the single digit target as prescribed under the West African Monetary

Zone convergence criteria on inflation, at target the Bank has subscribed to meet since 2004.

- b. Foreign long-run inflation (or foreign inflation target) – this is based on an assumed target for inflation by the Federal Reserve Bank of the United States, given the trend of inflation over a similar period as above. The assumed target is 3 per cent.
- c. Domestic trend real interest rate – the level is assumed to be 5 per cent amounting to a risk premium of about 5 per cent.
- d. Foreign trend real interest rate – this is set at 4.75 per cent
- e. Equilibrium real exchange rate appreciation/depreciation – It is assumed that the national currency is under valued by about 5 per cent in the model. This assumption is based on the level of intervention of the monetary authority in the foreign exchange market over the recent past. However, the level of intervention has reduced over time, especially in the last two years under consideration (2006-2007), as the inter bank foreign exchange market and other autonomous sources have become the main supplier of foreign exchange in the market.
- f. Potential output growth – this level of potential growth of the economy is set by a trend estimated at an average of 7.6 per cent. Though oil GDP has decelerated over the recent past, growth in the non-oil sector should make up for the potential output growth in the Nigerian economy.

### **3.2.2 Business Cycle Properties**

The business cycle properties are as follows:

- a. **Output gap persistence** - varies between 0.1 (extremely low persistence) to 0.95 (high persistence). An OLS regression of a log of output on its lagged value and a trend was used to estimate the parameter values.
- b. **Pass-through from monetary conditions to real economy.** The value varies between -0.1 (low impact) to -0.5 (high impact) in the model calibration. The higher the parameter the more responsive is the output

gap to changes in monetary policy. This implies policy reactions need to be less pronounced as the parameter is adjusted upward. An expert assessment was applied to obtain the value.

- c. **Impact of foreign demand on the output gap** typically varies from 0.1 to 0.5 and is based on the export-to-GDP ratio.
- d. **Ratio of domestically produced goods in the consumer basket** – varies between 0.95 (closed economy) to 0.3 (fairly open economy). Based on the share of imported goods in the CPI basket, the parameter is set at 0.65.
- e. **Inflation persistence** – determines the share of forward-looking versus backward-looking agents on the goods markets. The value which varies between 0.4 (low persistence) and 0.9 (high persistence), is set in favour of backward-looking agents as pertains in the Nigerian economy and more pronounced policy reactions are required for a given disinflation goal. An OLS regression of the rate of inflation (quarter-on-quarter) on its lagged value and complement with expert assessment.
- f. **Exchange rate persistence measures FOREX market flexibility.** The value varies between zero (forward-looking FOREX market) to 0.9 (either backward-looking FOREX agents or a central bank intervening on the FOREX market). Though interventions stabilize the exchange rate it does not violate the steady-state consistency of the model — e.g., the exchange rate will never appreciate as long as there is positive inflation differential on the FOREX market ( $r - r^*$ ). Expert Assessment is applied.
- g. **Policy rate persistence in the Taylor rule.** The value varies between zero (no persistence in policy setting) to 0.8 ("wait-and-see" policy). Taylor-rule is applied via an OLS regression of the policy rate on its lagged value and complement with expert assessment.

- h. **Weight put by the policy maker on deviations of inflation from the target** in the policy rule. Expert assessment used to determine the value.
- i. **Weight put by the policy maker on output gap in the policy rule.** The linear homogeneity condition:  $3 f > 0$ , otherwise the model becomes explosive and is adjusted vis-à-vis an expert assessment.

### **3.3 Data Source and Methodology**

#### **3.3.1 Data Source**

Quarterly time series data covering 1999Q1 to 2007Q4 have been used for the estimation. Basically, data for the estimation and analysis are Gross Domestic Product (GDP) at 1990 constant basic prices, the Composite Consumer Price Index (CPI) 2003 base year, Monetary Policy Rate (MPR)/Minimum Rediscount Rate (MRR) of the Central Bank of Nigeria and the 91-day Treasury bill rate for the Domestic economy. On the other hand, data for the foreign economy was based on the United States economy which is a major trading partner of Nigeria and was obtained from the International Financial Statistics (IFS) of the International Monetary Fund (IMF). Data for the Nigerian economy were sourced from various editions of the Central Bank of Nigeria, Annual Reports and Statistical Bulletin, and Statistical Bulletin of the National Bureau for Statistics. The CPI and GDP are seasonally adjusted using the Census X12 methodology. Lambda is set at 1600 for the Hodrick-Prescott filter process.

A historical database, which provides initial conditions, is necessary to run the model forward. As a minimum, the database has values for all variables that appeared with a lag in the model structure. Thus, for a forecast starting in the first quarter of 2007, we need initial conditions for the fourth quarter of 2006 for all variables with the lag of order one.

The output gap and inflation gaps are all generated automatically via the read function applied in the Matlab software used for the modelling. Similarly,

other gaps in exchange rate and interest rates are also generated automatically. The study limits estimation of the monetary policy reaction function for the CBN to the technique adopted in the Taylor approach. Other variables and the level of discretion considered by the MPC for decision making on the MPR were not included in the modelling process.

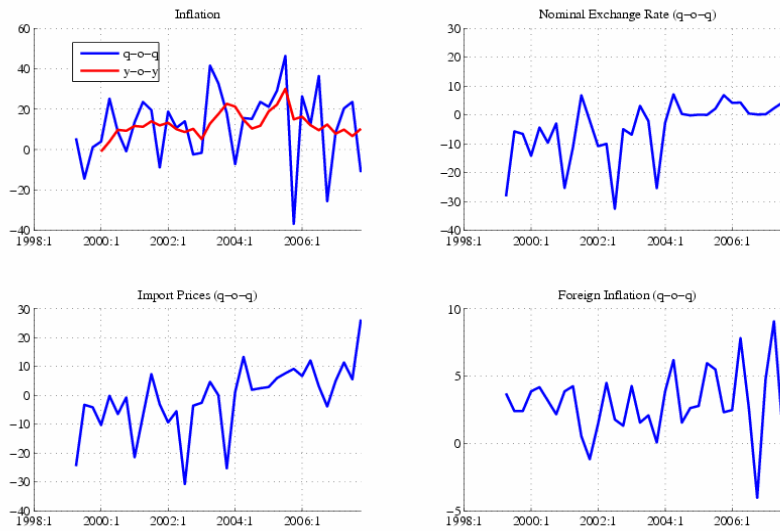
## Stylized Facts

### Inflation

Nigeria - Stylized Facts

2008-02-04 04:57:26

Inflations



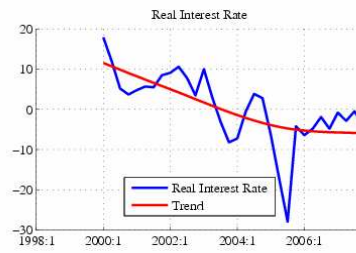
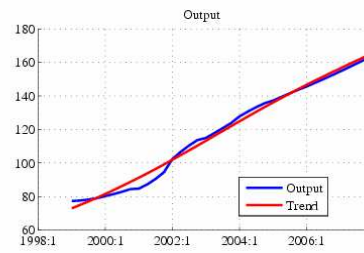
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## Trends

Nigeria - Stylized Facts

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Trends



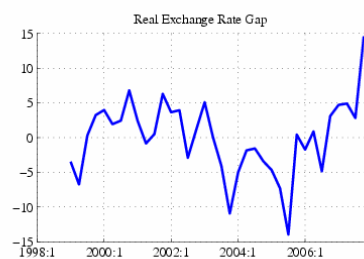
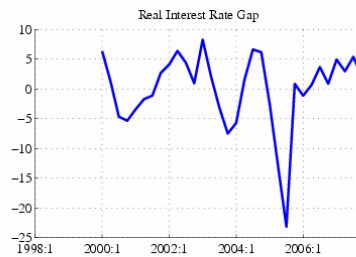
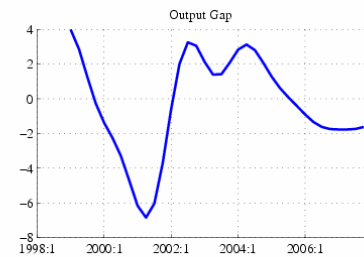
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## Gaps

Nigeria - Stylized Facts

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Gaps



3

## 4 Empirical Analysis and Results

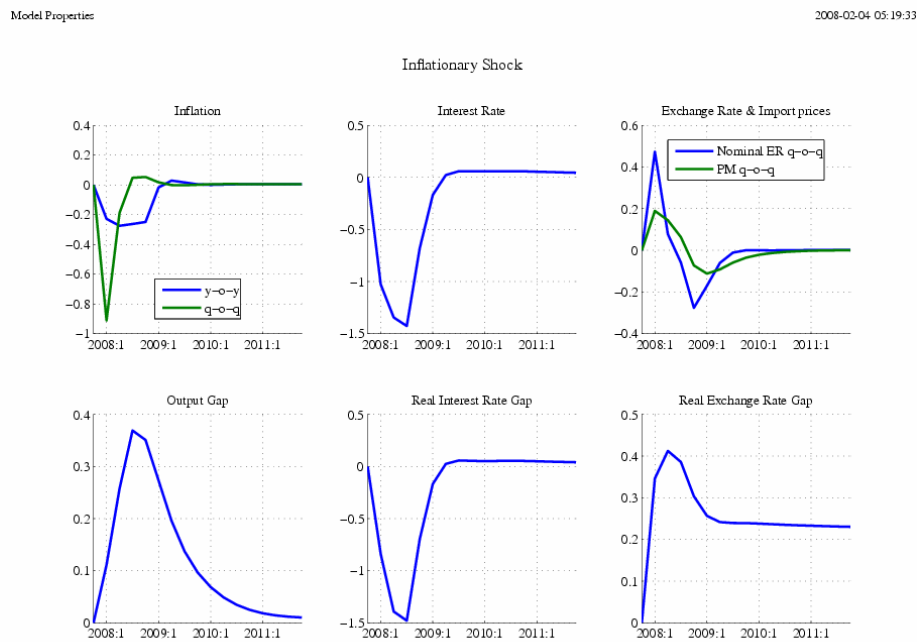
### 4.1 Baseline Forecast

In this section shows how the model can be used for forecasting and policy analysis purposes. The first part discusses how the baseline forecast scenarios can be created, while the second section discusses some risks assessment applications to the baseline scenario when the policy reaction function of the central bank is manipulated. The process is related to how a forecasting policy team can provide forecasts and analyse other trends for the Bank.

The model is applied in preparing a baseline forecast. Since the model is a simplified representation of the economy, it best used to frame discussions on the baseline forecast.

### Model Properties

#### Inflationary Shock

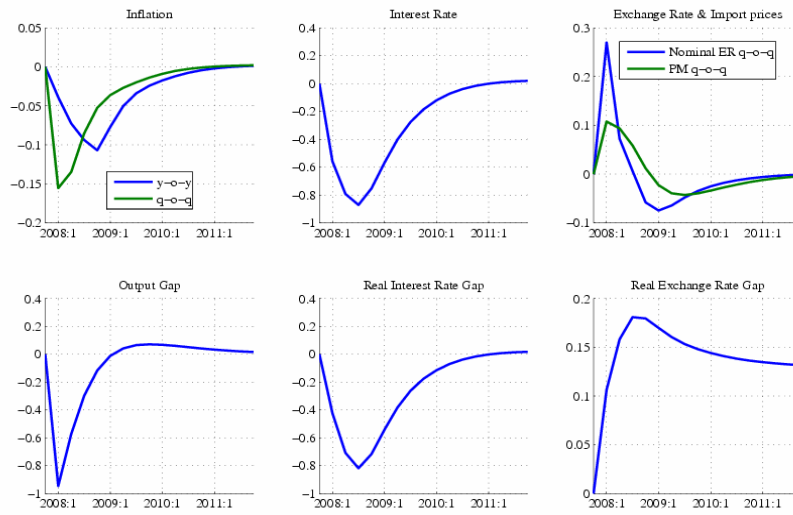


# Aggregate Demand Shock

Model Properties

2008-02-04 05:19:33

Aggregate Demand Shock



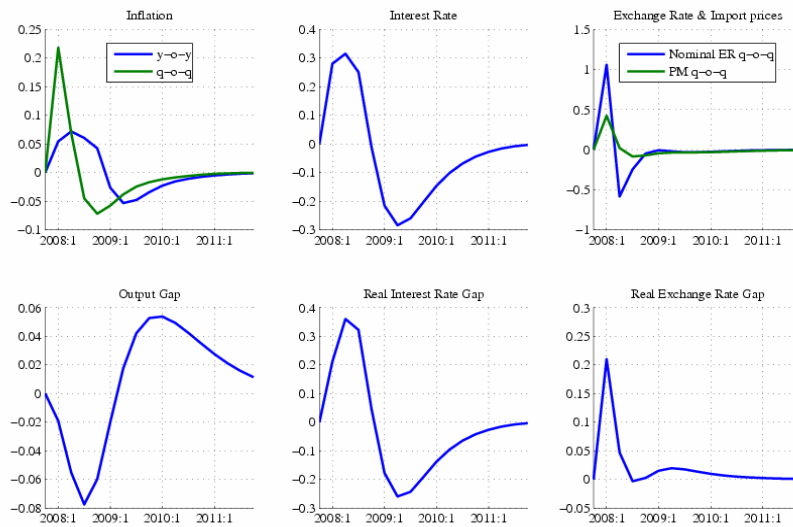
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# Exchange Rate Shock

Model Properties

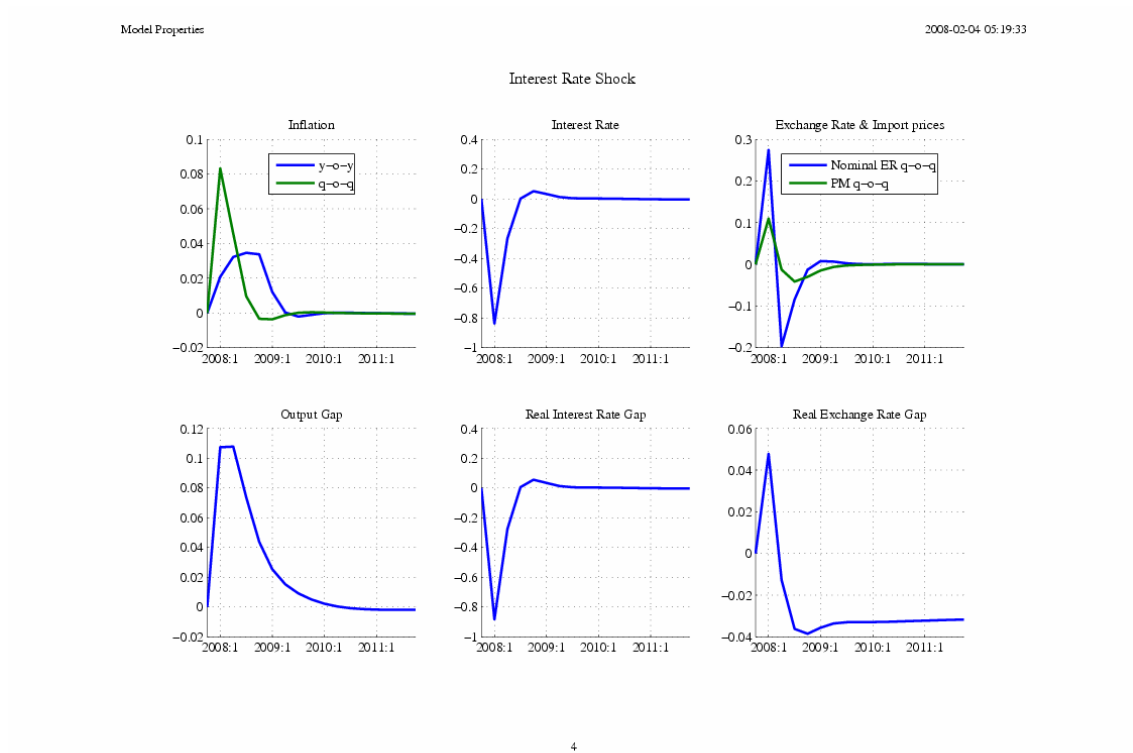
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Exchange Rate Shock



3

## Interest Rate Shock



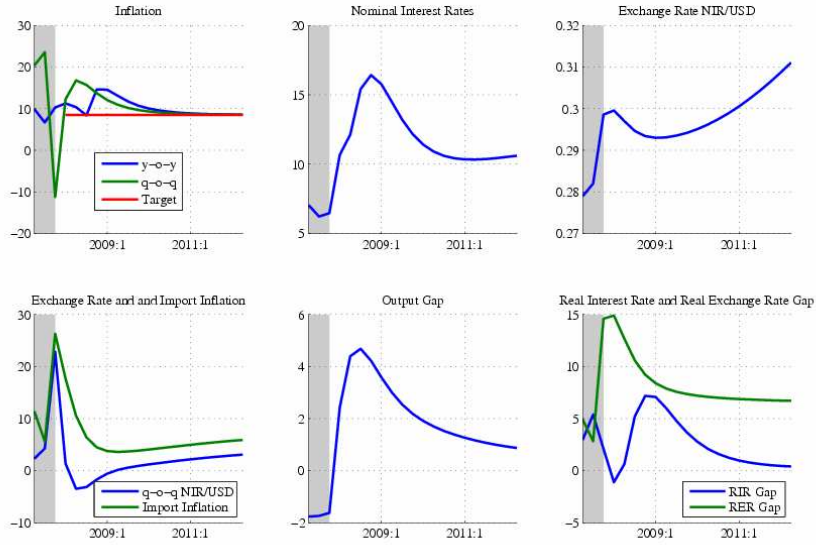
Above are the basic model properties depicting projection of various economic indicators and how they response to shocks in the economy. From the above, the transmission process takes approximately 2 years to pass through the economy in the first instance. Shocks to the various indicators have different effects on each other. However, an interest rate shock to the economy is more pronounced on output, as the output gap is impacted significantly.

# Baseline Results

Nigeria - Forecast

2008-02-04 05:29:55

Nigeria: Forecast - Main Indicators



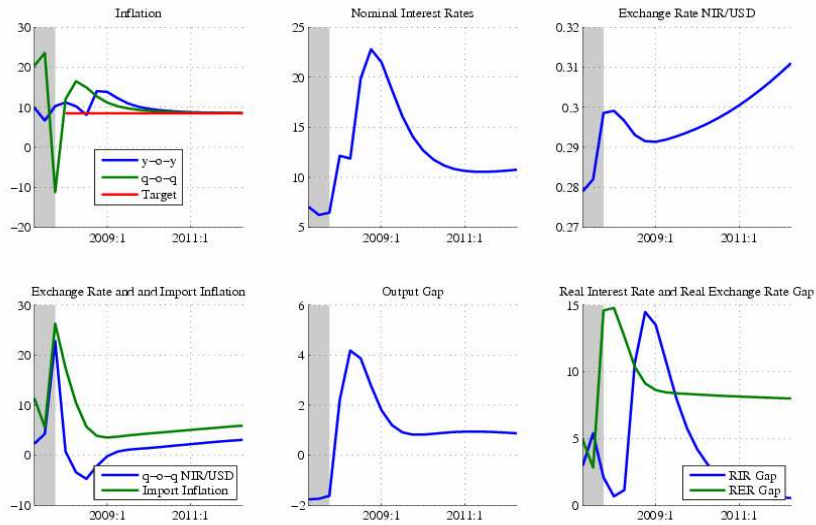
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# Shock Scenario – 200 basis points

Nigeria - Forecast

2008-02-04 05:31:59

Nigeria: Forecast - Main Indicators



1

A shock of 200 basis points to the policy interest rate has significant impact on the forecast for 2008 – 2009.

## **5 Conclusions and Recommendation**

### **5.1 Conclusions**

The paper estimated a monetary policy reaction function for the CBN. Theoretically, similar approaches are applied by several inflation targeting central banks around the world. Such a framework is useful in determining the path of monetary policy decision making by central banks. A major policy inference from the result in this study is that the Nigerian monetary authorities could apply such an approach in the conduct of monetary policy.

This paper described an approach to forecasting and monetary policy analysis based on the use of a small open economy macroeconomic structural model. Little emphasis was placed on the use of monetary aggregates as a determining factor, which is in contrast to that found in a financial programming framework. It was argued that such a modelling framework could also help in the day-to-day work and conduct of monetary policy in the central bank. The model is centred on the nominal interest rate as the policy instrument with the key principle that the role of monetary policy is to anchor inflationary expectations. Most channels through which monetary policy acts in a small open economy with a managed floating exchange rate are captured by the model. The most important use of the model is to help structure the discussion about monetary policy and provide a veritable approach for assessing risks and alternative scenarios. It should be noted that the specification and parameterization of the model was not data-driven, however, it provides a framework within which all available information, that is, both judgmental and econometric, can be used to evaluate economic behaviour. The resulting model is merely an abstraction of the economy and but captures the key features that matter for monetary policy.

The model has numerous limitations. For one, emphasis is placed on its simplicity as its supply side does not contain stock-and-flow relationships, so for example, there is no treatment of the current account or debt profile of the economy. The cost of simplicity also presents an issue of the model been susceptible to the “Lucas Critique”, since there was little microeconomic foundation; therefore, policy regime changes would change parameters of the model. Other limitations exist based on the fact that certain economic features are not explicitly modelled, including credibility and optimality of policy.

It should be noted however that some limitations of the models can be addressed with minor modifications. Simple extensions could integrate more complicated expectation dynamics, modules for monetary aggregates, administered price increases, as well as fiscal operations of Government.

## **5.2 Recommendations**

Due to time constraints the study would not be extended to cover other variables the CBN used in taking decisions on its key policy rate in the considered period. However, the lapse provides opportunity for further research. As model-building projects could help in developing of institutional knowledge, the process should evolve over time. Models that embody the basic economic principles run the risk of being inconsistent across time in ways that sometimes defy logic and reason. The model does not have to be perfect to be useful. A very useful strategy is to start simple initially and then to extend the model as suggested by experience.

It is encouraging to note that the recently amended CBN Act, 2007 makes adequate provision in terms of mandate as well as conduct of monetary policy in Nigeria. In sum, a small open economy model has the obvious advantage of providing a simple and clear structure for thinking about

monetary policy. This is important not only for the internal discussions of the central bank, but also for its communications with the public. For policy makers facing real-time policy decisions, the usefulness of the model is more pronounced.

The CBN is currently transiting to inflation targeting framework for conduct of monetary policy and market based instruments in the implementation of monetary policy. With the recent introduction of the Monetary Policy Rate (MPR) by the CBN as the major tool for signalling its monetary stance, the need for a monetary policy reaction function which clearly depicts the decision making intention of the Bank would assist economist and financial markets in predicting the future path of monetary policy. Knowledge on how monetary authorities view economic developments to take decisions on the policy interest rate is very important in this light.

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