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Fiscal and Monetary Policy Interactions in a Developing Economy: A DSGE-Based Evidence from Nigeria

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This study characterizes the nature of fiscal-monetary interaction in Nigeria and gauges its macroeconomic effects by estimating a New Keynesian Dynamic Stochastic General Equilibrium (NK DSGE) model. Two policy simulations were also conducted. The first experiment considers the desirable active-passive policy mix while the second experiment ranks alternative monetary policy rules among the differing objectives of price, output and exchange rate stabilization. The study finds that fiscal and monetary policies interact as complements in an active monetary and passive fiscal policy mix over the sample period. The result from the first policy simulation reveals that the active monetary and passive fiscal stance guaranteed the least volatile macroeconomic outcomes. The result from the second experiment shows that the monetary authority in Nigeria should maintain its focus on conventional mandate of price stabilization to induce improved output and welfare gains. This implies that the existence of an independent central bank that can control inflation without being constrained by fiscal decision is desirable.

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1. Introduction

Fiscal and monetary policies are the two most significant tools available to policymakers in guiding an economy towards attaining desired macroeconomic objectives. Both policies are useful for maintaining macroeconomic stability and achieving medium to long-term economic growth and welfare (World Bank, 2014). However, there has been a lack of consensus on the most appropriate manner that policymakers can use fiscal and monetary policies (Wren-Lewis, 2011). This relates, in specific terms, to whether the instruments of fiscal and monetary policies are independent or intertwined in their impact on the economy (Hallett *et al.*, 2011; Hetzel,

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2013). Policy discourse has, however, evolved in recent times into the proposition that fiscal and monetary policies are interdependent rather than separate (Niemann & Hagen, 2008). This proposition relates to the view that these two policies interact on an ongoing basis. Policymakers belonging to this school of thought argue that fiscal and monetary instrument should be combined to address macroeconomic problems. The central argument, therefore, is to mix fiscal and monetary policies since externalities are assumed to exist between the two, such that a change in one influences the stance of the other and its overall macroeconomic effect (Niemann & Hagen, 2008). In other words, the successful outcome or effectiveness of fiscal (monetary) policy depends on the stance of monetary (fiscal) policy. For instance, rising and uncontrolled budget deficits can constrain the ability of central banks to control inflation.

Furthermore, economic events like the formation of the European Monetary Union (EMU) and the aftermath of the global financial crisis have sparked interest in fiscal and monetary policy interaction. The EMU presents an economic policy game among several national fiscal authorities and a single central bank, the European Central Bank. Both fiscal and monetary policymakers within the union, therefore, are expected to act together. In the same vein, the global financial crisis also underscores the essence of the interrelation between the government and the central bank. In the aftermath of the crisis and the recession following, some advanced economies opted for expansive fiscal policy in the form of bailouts and stimulus packages to complement the efforts of monetary policy to stimulate the economy at the zero lower bound rate (Leeper & Leith, 2015).

In the case of Nigeria, the concern for fiscal and monetary policy interaction stems from the need for policy alignment between the Central Bank of Nigeria (CBN) and the Federal Ministry of Finance (FMF). The CBN and the FMF are two independent bodies in charge of respectively conducting monetary and fiscal policies in Nigeria. However, by the CBN Act of 2007, the CBN is granted operational independence to direct monetary policy using policy instruments. Its primary macroeconomic objective is to maintain price stability. Conversely, the FMF alongside adjunct parastatals such as the Debt Management Office (DMO) oversees fiscal policy using instruments such as taxes and expenditure, usually with the focal objective of long term eco-

nomic growth and fiscal policy sustainability. The absence of coordination between both policy authorities can threaten internal consistency in the macroeconomy, constrain policy effectiveness and become a potential source of instability and lower macroeconomic performance. As a result, there is need to constantly harmonize both policies, necessitating the existence of both institutional and operational frameworks for achieving such policy harmonization.

The core objective of this study is to characterize the nature of fiscal and monetary policy interaction in Nigeria using the New Keynesian Dynamic Stochastic General Equilibrium (NK DSGE) approach. Specifically, the study attempted to provide answers to the following question: What is the nature of fiscal and monetary policy interactions in Nigeria? In line with this, existing empirical studies have examined fiscal-monetary policy interactions in a DSGE modeling setup (Muscatelli *et al.,* 2005; Davig &Leeper, 2009; Gilksberg, 2016). Most of the existing studies have been conducted for developed economies while the empirical literature on fiscal and monetary policy interactions in developing economies, specifically in Nigeria remain sparse (Chuku, 2010; Musa *et al.*, 2013; Goshit & Landi, 2014; Oye *et al*., 2018; Tule *et al*.,2020; Omotosho, 2021).

This study contributes to existing literature as it simulates two policy scenarios. The first experiment is based on the 'best' form of fiscal and monetary policy interactions that is expected to guarantee stable macroeconomic outcomes. The second simulation considered whether central banks in developing economies such as the CBN should focus on the core mandate of price stability or redirect their focus on output stability. This is in the light of recent efforts of the CBN to stimulate growth in the real sector of the Nigerian economy through development financing interventions.

The rest of this paper comprises of Section 2, which presents the review of relevant literature and some stylized facts; Section 3 presents data, and methodology. The results are presented and discussed in Section 4, while the conclusion and policy recommendations are contained in Section 5.

2. Literature Review

2.1 Theoretical Literature

There has been a myriad of both theoretical and empirical contributions to the issue of fiscal and monetary policy interactions. The theoretical literature puts forth the central argument that fiscal and monetary policies should be considered as a coherent entity. In other words, policy authorities can mix fiscal and monetary instruments in the right proportion to simultaneously attain desired policy outcomes (Tinbergen, 1952; Theil, 1957). For instance, fiscal and monetary policies can be appropriately combined to determine the general price level (Sargent & Wallace, 1981; Leeper, 1991; Leeper & Leith, 2015). The main theories underlying fiscal-monetary policy interaction are the Monetarist Arithmetic (Sargent & Wallace, 1981; McCallum, 1984) and the Fiscal Theory of Price Level (Leeper, 1991; Sims 1994, 1999; Woodford,1995, 1996, 2001).

The seminal contribution to the concept of the Monetarist Arithmetic was by Sargent and Wallace (1981). It highlights the idea that central bankers are required to regard the government's fiscal policy, while making monetary policy decisions. This is because government actions can render ineffective the ability of monetary authority to stabilize price level in the economy. Sargent and Wallace (1981) define fiscal-monetary policy interaction as a Stackelberg game between the central bank and the fiscal authority. They demonstrate that in a fiscally dominant regime, the central bank may find it difficult to control inflation since it may be unable to decide the path of money stock given the exogenously determined path of government's budget deficit. In arriving at this conclusion, they draw on a monetarist model embedded in an Over-Lapping Generation framework. In this model, they centrally assume that the path for government deficit is exogenously determined i.e., the government is assumed to set the deficits, while the central bank controls the level of money supply and can raise revenue from money creation. In the model, fiscal and monetary policies are interacting within a consolidated government budget constraint. This constraint is an identity that links both policies. It shows that the government finances its budget deficit by issuing one-period bonds and by money creation. The path of fiscal policy is, therefore, assumed to exogenously evolve under this form of policy game, while

the central bank passively adjusts to the path of fiscal policy. Under this circumstance, for every deficit the government fixes, the central bank is forced to finance it through money creation, if it cannot be financed by the sale of bonds. The central bank is also constrained to finance government deficit if the economy reaches a fiscal limit where the government can no longer issue new bonds since it has accumulated a large amount of debt which it is likely to default on. The creation of money by the central bank either by printing money or buying government securities, injects money into the economy, which leads to a surge in volume of money supplied and by the monetarist quantity theory implies increases in the price level and then inflation.

The proponents of the Fiscal Theory of Price Level (FTPL) argue that fiscal policy is the foremost determinant of price level, unlike the monetarists who propose that government budgets indirectly affect the price level through seignorage- money stock channel. Woodford (1995, 1996, 2001) and others posit that government budget can have a direct impact on price level void of any monetary channel. This indicates that fiscal policy takes on an active role while monetary policy only plays a passive role in controlling the price level. One of the key contributions to the literature on FTPL is Leeper (1991). The study shows the pairing of fiscal and monetary policy paths which uniquely determines equilibrium price level. In a specific manner, the study models the interaction between fiscal and monetary policy as an active and passive game. An active policy is defined as policy that fixes its path independently from variation to the budgetary condition or debt shocks while a passive policy responds to budgetary shocks and is constrained by the actions of the authority with the active policy. A unique determination of the price level, therefore, requires the pairing of an active policy with a passive one. For instance, an active monetary policy with a passive fiscal stance and an active fiscal policy coupled with a passive monetary policy leads to uniquely determined prices. The combination of two passive policies leads to indeterminacy of the price level, while the pairing of two active policies produces an explosive path. The fiscal policy in the proposition of the Fiscalists takes on an active path while monetary policy is passive to uniquely determine the price level.

2.2 Empirical Literature

Several studies have examined the issue of fiscal and monetary policy interactions

(Muscatelli *et al*.,2005; Davig &Leeper, 2009; Algozhina, 2012; Xie, 2019; Afonso *et al*., 2019; Chen *et al*., 2020). Fiscal and monetary policies can by nature, interact as substitutes or in a complementary manner in their effect on the aggregate economy. Both policies interact as substitutes when an expansionary fiscal (monetary) policy is countered by contracting monetary (fiscal) policy and as complements, when an expansionary fiscal (monetary) policy is accompanied by a corresponding expansionary monetary (fiscal) policy stance, i.e. they offset and support each other in the stabilization of the economy (Chuku, 2010; Jawadi *et al*., 2016; Qayyum & Shahid, 2016). Muscatelli et al., (2003) is one of the earliest papers estimating a NK DSGE model to characterize fiscal and monetary policy interaction. The study concludes that the strategic complementarity or substitution between fiscal and monetary policy depends on the form of shock hitting the economy per time. Muscatelli *et al*., (2005) considers fiscal and monetary policy interactions by examining whether fiscal policy aid or hinders an independent forward-looking central bank. They conclude that in the face of a forward-looking monetary authority, automatic stabilizers are welfare enhancing.

Jawadi *et al*., (2016) for instance characterized the existing nature of fiscal and monetary interrelation in five emerging economies. The study finds a positive correlation between fiscal and monetary policy using the panel vector autoregression (VAR) method. This implies that both fiscal and monetary policy interacts as complements. Differently, Chuku (2010) estimated a Markov switching model for regime shifts in fiscal-monetary policy interactions in Nigeria over the period 1970-2008. The results showed the correlation between fiscal and monetary policy to be negatively weak. This means that both policies act as weak substitutes. Shahid *et al*., (2016) also find evidence for interactions between fiscal and monetary policy after the authors calibrated and estimated a small open economy dynamic stochastic general equilibrium model for Pakistan. However, Cazacu (2015) estimates a structural VAR model for Romania and did not find a distinct pattern of interaction between fiscal and monetary policies over the period 2000Q1 to 2014Q2.

A second characterization of the nature of fiscal and monetary policy interaction borders on Leeper (1991) classification of active and passive regimes. Both policies can

interact either in a passive or active manner. For instance, an active monetary policy authority makes its policy decision without regards to the path of government budget while a passive monetary policy responds to changes in the state of fiscal debt (Leeper, 1991). Gilksberg (2016), using the classification of Leeper (1991), numerically investigated the joint fiscal and monetary policy rules that guarantee a unique solution to a dynamic general equilibrium model. The study found that three forms of fiscal-monetary interactions deliver unique rational expectation equilibrium. These include active fiscal and passive monetary, active monetary and passive fiscal, and a passive fiscal and passive monetary combinations. The passive fiscal-passive monetary regime is a novel finding different from Leeper (1991) conventional prescription of an active and passive combination. In the same vein, Cevik *et al*., (2014) found that the fiscal and monetary policies of six emerging European economies over the quarterly period 1995Q1 to 2010Q4, evolve as a Markov switching process between active and passive regimes. This indicates the existence of divergent forms of interaction between fiscal and monetary policies over a sample period.

Furthermore, some studies are concerned with examining the existence of fiscal or monetary dominance. This closely relates to the active-passive nature of fiscal policy and monetary policy interactions. Ornellas and Portugal (2011), for example, estimated a dynamic stochastic general equilibrium model and find the degree of fiscal dominance to be trivial in Brazil. This implies that the central bank may not have to passively adjust its instruments to suit the fiscal stance of the government. Janku and Kappel (2014) also employed the simple ordinary least square regression on quarterly data for the Czech Republic, Slovakia, Hungary, and Poland. The study found evidence of monetary dominance in all the countries except Hungary. This depicts the existence of an active monetary policy and a passive fiscal policy. Lima, *et al*., (2012) also used a SVAR model to study the interactions between fiscal and monetary policy in Brazil. The study used two different identification schemes but produced inconsistent results in deciding the existence of fiscal dominance in Brazil.

2.3 Stylized Facts

The CBN and the FMF are two independent institutions in Nigeria responsible for conducting monetary and fiscal policies, respectively. By the CBN Act of 2007, the

CBN is granted operational independence to conduct monetary policy using policy instruments such as the policy rates and broad money supply. Its primary macroeconomic objective is to maintain price stability. Conversely, the FMF alongside adjunct parastatals such as the Debt Management Office (DMO) oversees fiscal policy using instruments such as taxes and expenditure, usually with the focal objective of achieving long term economic growth and fiscal policy sustainability. Often times, conflicts and externalities arise when monetary and fiscal policy variables and targets are independently set and implemented, which threatens internal balance in the macroeconomy and leads to suboptimal policy outcomes (Garba, 2004). As a result, there is need to harmonize both policies, necessitating the existence of both institutional and operational frameworks for harmonizing these policies in Nigeria.

The institutional framework for policy coordination in Nigeria creates avenue for joint decision making between the CBN and the FMF through formal committees. These include: The Fiscal Liquidity Assessment Committee (FLAC) of the CBN, Monetary and Fiscal Policy Coordinating Committee (MFPCC) of the DMO, and the Cash Management Committee of the FMF. FLAC comprise of members from FMF, DMO, Office of the Accountant- General of the Federation (OAGF), Budget Office of the Federation (BOF), Nigerian National Petroleum Corporation (NNPC), Nigeria Customs Service (NCS), Federal Inland Revenue Service (FIRS), the Department of Petroleum Resources (DPR) and relevant departments of the Central Bank of Nigeria, who meet weekly to deliberate on how government fiscal operations affect CBN's goal of price stability. FLAC has developed a database on the operations of the relevant MDAs and a template for forecasting the Treasury's operations as input to the Bank's Liquidity Assessment Model (CBN, 2011b).

The MFPCC of the DMO was created in 2003 to handle matters relating to the way monetary activities of the CBN affects budget deficit financing and management of the public debt. This is because monetary policy decisions influence government's capacity to finance budget deficits as it determines the cost of obtaining and servicing its debts. Membership of the MFPCC include delegates from Federal Ministry of Finance, Budget office of the Federation (BOF), Office of the Accountant-General of the Federation (OAGF), National Planning Commission (NPC), Securities and

Exchange Commission (SEC), Nigerian Stock Exchange (NSE), Pension Commission (PENCOM), Federal Inland Revenue Services (FIRS), National Insurance Commission (NAICOM), National Assembly, and the Central Bank of Nigeria (CBN). The Cash Management Committee of the Federal Ministry of Finance monitors and projects revenue and expenditure of Federal Government. The Committee members meet monthly and include representatives of Office of the Accountant-General of the Federation (OAGF), Budget office of the Federation (BOF), Revenue Generating Agencies of the Government, and the CBN.

Business cycle facts that explain the cyclical components of fiscal and monetary policy, are presented next. The business cycle statistics are obtained by applying the HP-filter on logged data on real GDP, government expenditure and interest rate, to derive their corresponding cyclical series. The sample period considered is between 2010Q1 and 2020Q1. The following stylized facts can be deduced from Table 1.

Table 1: Business Cycle Statistics

	Volatility	Relative Volatility	Autocorrelation	Correlation with Output
RGDP	0.058	1	-0.013	1
Government Expenditure	0.044	0.759	0.878	-0.085 (Countercyclical)
Interest Rate	0.100	1.724	0.819	0.005(Acyclical)

The stylized facts from Table 1 show that the cyclical components of fiscal and monetary policy variables are weakly correlated with output. In Table 1, the coefficients of the contemporaneous correlation of fiscal and monetary policy variables are seen to be less than 0.5, implying a weak association between output and the policy variables. The result in Table 2 shows a positive but weak association between government expenditure and interest rate. This means that as interest rate rises (restrictive monetary policy), government spending also rises (expansionary fiscal policy). Therefore, a restrictive monetary policy is accompanied by an expansionary fiscal policy. This can be deduced that fiscal and monetary policy acts as substitutes over the business cycle.

Table 2: Cyclical Correlation between Fiscal and monetary policy

	Interest Rate	Government Expenditure
Government Expenditure	0.112*	1
Interest Rate	1	0.112

3 Data and Methodology

3.1 Data

Quarterly data obtained from the Central Bank of Nigeria's Statistical Database on GDP, domestic inflation, monetary policy rate[3]and government spending[4]over the period 2010Q1- 2020Q1 for the Nigerian economy were used while the GDP for the United States was obtained from Federal Reserve Bank of St. Louis (FRED) database. The dataset was detrended using the one-sided Hodrick-Prescott filter with a lambda value of 1,600. This is required to express the variables in their model consistent forms, i.e., as a percentage deviation from their deterministic steady-state values. The choice of the sample period was influenced by the availability of quarterly data for the Nigerian economy.

3.2 The model

The DSGE model adopted in this study draws from the works of Gali and Monacelli (2005) and Li and Spencer (2014). The model comprises five optimizing agents: infinitely-lived households, firms, the central bank, government and the rest of the world. The infinitely-lived household maximizes lifetime utility subject to its budget constraint. The household sector is assumed to consist of two types of households, Ricardian and non-Ricardian. Unlike the Ricardian, the non-Ricardian agent is liquidity-constrained and lacks access to the financial market. A large amount of non-Ricardian consumers imply that fiscal policy is not passive as proposed in models with Ricardian equivalence since the fiscal authority makes direct transfer payment to low-income households (Algozhina, 2012). The household also form habits in their consumption. This means that utility is time non-separable and de-

[3] *Monetary policy rate was transformed from monthly to quarterly frequency*
[4] *Government spending was transformed from annual to quarterly frequency.*

pends on consumption in the previous period.

The model economy also consists of several intermediate-goods, monopolistic competitive firms, who make price-setting decisions. The third agent is a monetary authority that implements Taylor-type rule when setting the nominal interest rate while government makes fiscal policy decision and satisfies its budget constraint. It is also posited that Nigeria is a small open economy that is linked to the rest of the World. Finally, it is assumed that the economy is hit by some exogenous shocks.

(i) **Households**

There is a continuum of infinitely lived households $j \in [0,1]$ who makes consumption and labour supply decisions to maximize its utility function subject to inter-temporal budget constraints. Households comprise of two types, where the fraction μ are Ricardian households and the other fraction $(1-\mu)$ arenon-Ricardian households.

Ricardian Households

These are optimizing households who can access funding from the financial market. They own firms in the economy and can earn profits in form of dividends from their investments. The Ricardian consumer derives utility at time t from consuming a composite good,C_t, government-produced goods, G_t, and disutility from labor, N_t.

$$E_t \sum_{t=0}^{\infty} \beta^t U\left[\left(C_{R,t} - hC_{R,t-1}\right), G_t,\ N_t\right] \tag{1}$$

The objective of the Ricardian household is to maximize the sum of discounted expected utility in (2) subject to the nominal budget constraint in Equation (4):

$$U(C_{R,t}, G_t,\ N_t) = E_t \sum_{t=0}^{\infty} \beta^t \left[\left(\frac{\left(C_{R,t} - hC_{R,t-1}\right)^{1-\sigma}}{1-\sigma} + \chi \frac{{G_t}^{1-\rho}}{1-\rho} - -\frac{{N_t}^{1+\varphi}}{1+\varphi}\right)\right] \tag{2}$$

Where E_t is the rational expectation operator; β^tdenotes the inter-temporal discount factor; $C_{R,t}$ is composite goods consumedby Ricardian households; $G_t$is public goods consumed; and N_t represents labor supplied. It is assumed that households form

habits on their consumption where h denotes the coefficient of habit formation; σ is the inverse of the intertemporal elasticity of substitution; χ denotes the weight placed on the consumption of public goods; φ is the parameter on inverse Frisch elasticity of labor supply.

$$h, \sigma,\ \chi,\ \varphi > 0; \qquad 0 < \beta^t < 1$$

$C_{R,t}$, is a composite good that consists of domestic goods $C_{D,t}$ and foreign goods $C_{F,t}$. This implies that the household allocates its resources in consuming both domestically produced goods and imported goods.

$$C_{R,t} \equiv \left[(1-\alpha)^{\frac{1}{\eta}} {C_{D,t}}^{\frac{\eta-1}{\eta}} + (\alpha)^{\frac{1}{\eta}} {C_{F,t}}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \tag{3}$$

Where $C_{D,t}$ represents the consumption index of domestic goods; $C_{F,t}$ is the index of consumption of foreign goods; α denotes the degree of openness; η is the elasticity of substitution between domestic and foreign goods.

The household maximizes its utility function subject to a nominal budget constraint. The budget constraint in Equation (4) depicts that on the revenue side, the household receives wages on stock of labor supplied,$W_t N_t$, they own businesses and receive profit from these ventures in form of dividend, DV_t, they possess risk-free financial instruments, D_t, and receive government transfer payment, TP_t. It is also assumed that the individual household uses its total revenue to buy consumption goods $P_t C_{R,\,t}$ and obtain financial assets, D_{t+1}. The budget constraint is written as The model adopted in this study is a canonical DSGE model which omits capital and has an advantage of being tractable. Future studies may adopt this feature:

$$P_t C_{R,\,t} + E_t(Q_{t\,,\,t+1} D_{t+1}) \leq W_t N_t + D_t + TP_t + DV_t \tag{4}$$

Where $P_t C_{R,\,t} = P_{D,t} C_{D,\,t} + P_{F,\ t} C_{F,\,t}$; $E_t(Q_{t\,,\,t+1}) \equiv Q_t = \left(\frac{1}{1+i_t}\right)$ is the stochastic discount factor and i_t denotes the nominal interest rate; D_{t+1} denotes the payment at period $t+1$ of asset portfolio held at the end of period t.

From the optimization problem, there are two major optimality conditions for the household sector: The consumption Euler equation (Equation 5) and the intra-temporal consumption equation (Equation 6). The consumption Euler equation describes the optimal consumption of the household between the current and future period. The intra-temporal consumption equation shows the marginal rate of substitution between consumption and labor supply. These are specified respectively as:

$$1 = \beta R_t E_t \left(\frac{C_{R,t+1} - hC_{R,t}}{C_{R,t} - hC_{R,t-1}} \right)^{-\sigma} \frac{P_{D,t}}{P_{D,\,t+1}} \tag{5}$$

$$\frac{W_t}{P_t} = (C_{R,t} - hC_{R,t-1})^{\sigma} N_t{}^{\varphi} (1+\tau) \tag{6}$$

Equations (5) and (6) are log-linearized to obtain:

$$hc_{R,t} - hc_{R,t-1} = E_t(c_{R,t+1} - hc_{R,t}) - \frac{1-h}{\sigma}(r_t - E_t D_{,\,t+1}) \tag{7}$$

Where $_{D,\,t+1} = p_{D,\,t+1} - p_{D,t}$

$$w_t - p_t = \frac{\sigma}{1-h}(c_{R,t} - hc_{R,t-1}) + \varphi n_t \tag{8}$$

Non-Ricardian Household

These are liquidity constrained consumers who can neither borrow nor own firms. The non-Ricardian household maximizes its utility function subject to its budget constraint stated as:

$$P_t C_{NR,\,t} \leq W_t N_{NR,\,t} + TP_t \tag{9}$$

The budget constraint postulates that the household receives only wages $W_t N_t$ and lump-sum transfer from the government TP_t and uses its income to buy consumption goods. The budget constraint takes this form since it is assumed that the non-Ricardian household cannot accumulate bonds from the financial market and cannot earn a profit.

The consumption equation for the non-Ricardian household is obtained by log-linearizing the budget constraint in equation (9) to obtain:

$$c_{NR,t} = \frac{\overline{WN}}{P}(w_t - p_{,t} + n_{NR,t}) + \frac{\overline{TP}}{P}(tp_t) \tag{10}$$

Equation (10) shows that the non-Ricardian household does not optimize but simply equate their consumption expenditure to wage income plus transfer payment from the government. Furthermore, the labour supply schedule in log-linearized is given as:

$$w_t - p_{D,t} = \frac{\sigma}{1-h}(c_{NR,t} - hc_{NR,t-1}) + \varphi n_{NR,t} \tag{11}$$

(ii) The firms

Following Gali and Monacelli (2005), it is assumed that there is a continuum of identical monopolistic competitive firms $j \in [0,1]$that produce differentiated goods ($Y_{t(j)}$) using a linear production technology with labor as the only input:

$$Y_{t(j)} = A_t N_{t(j)} \tag{12}$$

Where A_t is the Total Factor Productivity; $N_{t(j)}$ denotes the labor input for each firm j; Log $A_t \equiv a_t$ evolves as a random-walk process such that:$a_t = \rho_a a_{t-1} + \varepsilon_t^a$
ε_t^a shows the shock to Total Factor Productivity, that is, technology shock. It is assumed to be normally distributed with mean of zero and the standard deviation is σ_{ε^a}, i.e.,$\varepsilon_t^a \sim N\left(0, \sigma^2{}_{\varepsilon^a}\right)$ Let the aggregate output produced across the firms be defined as:

$$Y_t = \left[\int_0^1 Y_{t(j)}{}^{1-\frac{1}{\varepsilon}} dj\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{13}$$

Y_t is an index for aggregate domestic output.
The intermediate firms optimize by minimizing their total cost subject to the linear production technology to derive the nominal marginal cost stated as:

$$MC_t = \frac{W_t}{A_t} \tag{14}$$

The real marginal cost is then defined as:

$$mc_t = \frac{W_t}{A_t P_{D,t}} \tag{15}$$

Log-linearizing equation (15) yields:

$$mc_t = w_t - p_{D,t} - a_t \tag{16}$$

From the linear production function, we derive the amount of labor demanded by each firm (j) as:

$$N_{j,t} = \frac{Y_{j,t}}{A_t} \tag{17}$$

The aggregate amount of labor to be demanded across the firms is obtained as:

$$N_{j,t} = \frac{Y_{j,t}}{A_t} \rightarrow N_t \equiv \int N_{j,t}\, dj = \frac{\int Y_{j,t}}{A_t}\, dj$$

This implies that:

$$N_t = \frac{Y_t}{A_t} \tag{18}$$

Log-linearize equation (18) to get the production relation as:

$$n_t = y_t - a_t \tag{19}$$

Price-setting decision

The intermediate firms face the optimal price-setting problem such that firms fix prices based on the Calvo (1983) price-setting mechanism. In this regard, at each period, $1-\theta$ fraction of randomly selected domestic firms set prices optimally, while the other θ fraction keeps their prices unchanged. Let $p^*_{t(j)}$ represent the price chosen by firm (j) resetting its price in period t. $p^*_{t(j)}$ is canonically assumed to be identical

across all firms since they will choose the same price in any given period such that $p^*_{t(j)} = p^*_t$. This assumption makes the model tractable.The optimal price, P^*_t, is fixed by maximizing the nominal discounted profits of the representative firm subject to demand constraints such that:

$$MaxE_t \sum_{k=0} (\theta)^k E_t \left(Q_{t,t+k} \left[Y_{t+k} (P^*_{D,t} / P_{D,t+k} - MC_{t+k}) \right] \right) \tag{20}$$

Subject to the firm's demand function for good (j):

$$Y_{t+k} = \left(\frac{P^*_{D,t}}{P_{D,t+k}} \right)^{-\varepsilon} Y_{t+k} \tag{21}$$

Where MC_{t+k} is the nominal marginal cost of the firm (j) in period t+k and $Q_{t,t+k}$ is the stochastic discount factor for k-period-ahead payoffs. $Q_{t,t+k} = \beta^k \left(\frac{C_{t+k}}{C_t} \right)^{-\sigma} \frac{P_{D,t}}{P_{D,t+k}}$
The first-order condition of the maximization problem is such that:

$$\sum_{k=0} (\theta)^k E_t \left[Q_{t,t+k} Y_{t+k} (P^*_{D,t} / P_{D,t+k} - \frac{\varepsilon}{\varepsilon - 1} MC_{t+k} \right] = 0 \tag{22}$$

This gives the firm's optimal price setting rule as:

$$P^*_{D,t} - P_{D,t-1} = \beta \theta E_t \left[P^*_{D,t+1} - P_{D,t} \right] + \pi_{D,t} + (1 - \beta\theta) \widehat{mc}_t$$

For the θ fraction of firms that keep their prices unchanged, the aggregate price evolves according to:

$$P_{D,t} = \left[\theta P^{1-\varepsilon}_{D,t-1} + (1-\theta) \left(P^*_{D,t} \right)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \tag{23}$$

The optimal price-setting condition is combined with the aggregate price level dynamics to obtain the New Keynesian Philips curve as:

$$\pi_{D,t} = \hat{a} \mathrm{E_t} \ [\pi_{D,\, t+1}] + \ddot{e} \widehat{\mathrm{mc_t}} \tag{24}$$

Where $\ddot{e} = \frac{(1-\grave{e})(1-\hat{a}\grave{e})}{\grave{e}}$
Equation (24) shows that domestic inflation depends on the expected inflation and the deviation of the real marginal cost from its steady state.

(iii) Open Economy Features

It is assumed that the world economy consists of a continuum of countries. Each economy is small and open, with its decisions having no significant international impact. Domestic goods represent a negligible fraction of the rest of the world's consumption. It is also assumed that there are identical preferences across the households in both the domestic and foreign economies. This assumption makes the model tractable.

International Risk Sharing

There is equal risk-sharing between domestic and foreign households since domestic (P_t) and foreign (P_t^*) bond prices are assumed to be the same. Since domestic ($C_{R,t}$) and foreign households (C_t^*) share similar preferences, the first-order condition for domestic Euler consumption equation is given as:

$$Q_{t\ ,\ t+1} = \beta \left(\frac{C_{R,t+1} - hC_{R,t}}{C_{R,t} - hC_{R,t-1}} \right)^{-\sigma} \frac{P_t}{P_{t+1}} \tag{25}$$

This also holds for consumers in foreign economies such that:

$$Q_{t\ ,\ t+1} = \beta \left(\left(\frac{C^*_{t+1} - hC^*_{t+1}}{C^*_t - hC^*_{t-1}} \right)^{-\sigma} \right)^{-\sigma} \frac{P^*_t}{P^*_{t+1}} \frac{\varepsilon_t}{\varepsilon_{t+1}} \tag{26}$$

Combine equations (25) and (26) with the definition of the real exchange rate as $\rho_t = \frac{\varepsilon_t P^*_t}{P_t}$, this yields (27), as found in Gali and Monacelli (2005):

$$C_{R,t} = KC^*_t \rho_t{}^{\frac{1}{\sigma}} \tag{27}$$

Log-linearized version of equation (27) produces:

$$c_{R,t} = c^*_t + \frac{1}{\sigma} q_t \tag{28}$$

Since Gali and Monacelli (2005) shows that the relation between the real exchange rate (q_t) and terms of trade(s_t) is $q_t = (1-\alpha)\, s_t$, then equation (28) becomes:

$$c_{R,t} = c^*_t + \frac{1-\alpha}{\sigma} s_t \tag{29}$$

Since consumers are assumed to form habits (h) on their consumption and with world market-clearing condition$y_t^* = c_t^*$, this becomes:

$$c_{R,t} - hc_{R,t-1} = y_t^* - hy_{t-1}^* + \frac{(1-h)(1-\alpha)}{\sigma} s_t \tag{30}$$

Uncovered Interest Parity

There is an incomplete international financial market that accommodates risk premium between investors buying domestic or foreign bonds. This is derived as:

$$r_t = r_t^* + E_t(e_t - e_{t+1}) \tag{31}$$

Re-arranging, it becomes:

$$r_t - r_t^* = E_t \Delta e_{t+1} \tag{32}$$

The expression shows that changes in the nominal exchange rate depend on the wedge between domestic and foreign interest rates.

(iv) The Monetary Authority

The Central Bank implements monetary policy using an interest rate rule. The nominal interest rate (R_t)is set based on lagged interest rate (R_{t-1}) and the inflation deviation, output gap and exchange rate (e_t) movement.

$$\frac{R_t}{R}\{= \left[\frac{R_{t-1}}{R}\right]^{\rho_R} \left[\left(\frac{\pi_t}{\pi}\right)^{\upsilon_\pi} \left(\frac{Y_t}{Y}\right)^{\upsilon_Y} \left(\frac{e_t}{e}\right)^{\upsilon_e}\right]^{1-\rho_R} exp(\varepsilon_{r,t}) \tag{33}$$

Where,$_t$ is the inflation rate; Y_t is the output $_{r,t}$ denotes monetary policy shock; $_R$ is the degree of interest rate smoothing. $,_Y,_e$showthe responsiveness ofnominal interest rate to changes in inflation, output and exchange rate;R, , Y, and $e$denote the steady state values.

The log-linearization of equation (33) yields:

$$\tilde{r}_t = \rho_r \tilde{r}_{t-1} + (1-\rho_r)[\upsilon_\pi \tilde{\pi}_t + \upsilon_y \tilde{y}_t + \upsilon_e \tilde{e}_t] + \varepsilon_{r,t} \tag{34}$$

(v) The Fiscal Authority

The fiscal authority is bound by a balanced budget constraint where it earns revenue from bonds(D_t)and collecting lump-sum taxes (TP_t). The revenue is used to fund government expenditure on public goods(G_t)and interest payable on government debt ($R_{t-1}D_{t-1}$). The government budget constraint is given as:

$$TP_t + D_t = G_t + R_{t-1}D_{t-1} \tag{35}$$

The government also implements fiscal rule in government spending and lump sum taxes as seen in equation (35) which shows that government spending reacts to debt, output and an exogenous component. In equations (36) and (37) , the fiscal rules in debt and lump sum taxes are explicitly defined in the log-linearized form as:

$$\tilde{g}_t = \rho_g \tilde{g}_{t-1} + (1-\rho_g)\left(\upsilon_d \tilde{d}_t - \rho_y \tilde{y}_t\right) + \varepsilon_t^g \tag{36}$$

$$\widetilde{tp}_t = \rho_{tp} tp_{t-1} + (1-\rho_{tp})\left(\rho_d \tilde{d}_t - \rho_y \tilde{y}_t\right) + \varepsilon_t^{tp} \tag{37}$$

$$d_t = \rho_d d_{t-1} + \varepsilon_t^d \tag{38}$$

Where ρ_g, $and \rho_d$ are AR(1) parameters measuring persistence in government spending and debt while ρ_y *and* ρ_y measures the fiscal cyclicality that is, the response of government expenditure and taxes to output.

Exogenous Processes in the Rest of the World

Nigeria is assumed to be a small open economy relative to the large global economy and can barely affect foreign economies concerning their interest rate, inflation and output. The foreign variables are modeled as exogenous and follow AR(1) processes such that:

$$Foreign\ \ Output:\ y_t^* = \rho_{y_t^*} y_{t-1}^* + \varepsilon_t^{y_t^*} \tag{39}$$

$$Foreign\ \ Inflation:\ \pi_t^* = \rho_{\pi_t^*} \pi_{t-1}^* + \varepsilon_t^{\pi_t^*} \tag{40}$$

$$Foreign\ \ Interest\ \ rate:\ r_t^* = \rho_{\ r_t^*}\ r_{t-1}^* + \text{"}_{\text{t}}{}^{\ r_t^*} \tag{41}$$

The stochastic processes $\varepsilon_t^i \sim iiN\left(0,\ \sigma_i^2\right)$

$$for\ i = y_t^*, \pi_t^*,\ r_t^*.$$

This means that the stochastic processes of foreign output, inflation and interest rate are identically, independently and normally distributed of zero mean and variance of σ_i^2.

Goods market-clearing condition and Aggregation

The goods market is cleared when the aggregate domestic output (y_t) equals the sum of domestic demand (c_t), foreign demands (s_t) and government spending (g_t) such that:

$$y_t = c_t + \frac{\alpha\omega}{\sigma} s_t + g_t \tag{42}$$

Where $\omega$is defined after algebraic manipulation (See Gali and Monacelli, 2005) as:

$$\omega = \sigma\gamma + (1-\alpha)(\sigma\eta - 1)$$

Aggregation

Aggregate consumption for both Ricardian and non-Ricardian agents is given by:

$$c_t = \mu\ c_{R,\,t} + (1-\mu\ ) c_{NR,\,t} \tag{43}$$

Aggregate labour supply for both Ricardian and non-Ricardian agents is given by:

$$n_t = \mu\ n_{R,\,t} + (1-\mu\ ) n_{NR,\,t} \tag{44}$$

Total inflation is also given by the sum of domestic inflation and foreign inflation, such that:

$$\pi_t = \pi_{D,\,t} + \pi_{F,t} \tag{45}$$

The economy is also assumed to be perturbed by shocks relating to foreign output, foreign interest rate, foreign inflation, technology, government spending, interest

rate, debt, taxes and domestic output supply.

4 Results and Discussion

4.1 Priors

Some of the parameters were fixed while the remaining was estimated. For instance, the discount factor (β) was fixed in line with Tule *et al.* (2017) while the persistence parameters were inferred from Traum and Yang (2011) to depict high persistence of the shock processes. The steady state values on non-Ricardian consumption were inferred from Oye (2018). The priors were chosen based on existing long trend data, values reported in existing studies, and the researchers' subjective belief as informed by the literature. The prior mean of structural parameters such as habit formation(h), was set to 0.70 as obtained from Tule *et al.* (2017). The inverse elasticity of substitution(σ) was set to 3.00 based on Cebi (2011). Calvo price setting (θ) was fixed at 0.50 in line with Adegboye (2015). The prior mean of the inverse elasticity of labour supply (φ) is 4.38 based on Cebi (2011). The share of non-Ricardian household (ψ) is set at 0.70 as inferred from Iwata (2009). The degree of trade openness was chosen as 0.40 to match Nigeria's data on average value of trade openness between 1960 and 2015.

The priors for the monetary policy parameters were obtained from Adebiyi and Mordi (2016) and Oladunni (2020). The Taylor rule feedback coefficient on inflation (υ_π) and output (υ_y) were 1.5 and 0.5, respectively, while the feedback on exchange rate (υ_e) was set as 0.80 in line with Adegboye (2015). Interest rate smoothening (ρ_r)was set at 0.70. The fiscal policy parameters were informed by Omotosho (2021) and Cebi (2011). Based on Omotosho (2021), the response of government spending (υ_d) and taxes (g_d) to debt were set at -0.30 and 0.40, respectively, while the response of government spending (υ_y) and taxes (g_y)to output were assumed to be 0.00. This will aid the measurement of fiscal cyclicality. The persistence parameters in taxes (ρ_{tp}), government spending (ρ_g), debt (ρ_d) and foreign output (ρ_{y^*}) were set at 0.70. The values were inferred from Traum and Yang (2011) to depict high persistence of shock processes. The AR(1) parameter on technology (ρ_A)was obtained from Tule *et al.*, (2018) at 0.85.

Table 3: Calibrated Parameters

Symbol	Parameters	Value
β	Discount factor	0.95
$\rho_{\pi_t^*}$	persistence parameter on foreign inflation	0.7
$\rho_{r_t^*}$	persistence parameter on foreign interest rate	0.7
ρ_{tp}	persistence parameter on taxes	0.7
$\frac{\overline{WN}}{P}$	Steady state value of wage income share in Non-ricardian consumption	3.2
$\frac{\overline{TP}}{P}$	Steady state value of transfer payment share in Non-ricardian consumption	1.35
γ	Terms of trade coefficient in the IS curve	0.75

4.2 Posteriors

The estimated model is a small-scale New Keynesian DSGE model with a system of 21 equations and 21 endogenous variables. The posterior moments of this model were computed by using the Metropolis-Hastings algorithm.

A. Structural Parameters

The results displayed in Table 4 show the posterior means of estimated parameters of the DSGE model. The estimated value of habit formation is 0.88 and is larger compared to its prior mean. The result means that a greater proportion of Nigerian households tends to base their current preferences on past consumption patterns. The inverse elasticity of inter-temporal substitution(σ) is estimated to be 5.14.The estimated value of the share of non-Ricardian households,(ψ) ,is 0.69, which is higher than the reported estimate of 0.37 in Muscatelli *et al*. (2005). The difference in the estimate of the parameter lies in the distinct economic structure between the advanced economy of the United States and the developing one of Nigeria.

The posterior mean of Calvo price stickiness, (θ),is estimated to be 0.51. This differs from the finding of Rasaki (2017), which estimated 0.71. The estimated value of Calvo price stickiness at 0.51 revealed that about 51 percent of firms do not re-optimize their prices in a given quarter. It also implies that price contracts remain fixed for about two quarters. The posterior estimate of the inverse elasticity of labour, φ, shows the responsiveness of labour supply to changes in the wage rate. The elasticity of labour is low at 0.23 (this is calculated as 1/4.38), implying that the

amount of labor supplied by Nigerian workers is relatively insensitive to changes in the wage rate.

Table 4: Posterior Estimates

Symbol	Parameters	Prior Distribution			Posterior Distribution		
		Density	Mean	Std Dev	Mean	HPD	Interval
Structural Parameters							
H	Habit formation	Beta	0.70	0.10	0.88	0.8107	0.9515
(σ)	Inverse elasticity of substitution	Normal	3.00	1.00	5.14	3.7172	6.4627
(ψ)	Share of non-Ricardian household	Beta	0.70	0.10	0.695	0.5356	0.8568
(φ)	Inverse elasticity of labour	Normal	4.38	2.00	4.376	1.0833	7.6539
(θ)	Calvo Price Stickiness	Beta	0.50	.10	0.51	0.3424	0.6688
Monetary Policy							
(υ_π)	Taylor feedback on Inflation	Gamma	1.50	0.20	1.67	1.4103	1.9342
(υ_y)	Taylor feedback on Output	Gamma	0.50	0.10	0.55	0.3630	0.7250
(υ_{exr})	Taylor feedback on the exchange rate	Gamma	0.80	0.10	0.72	0.5854	0.8663
(ρ_r)	Interest rate smoothening	Beta	0.70	0.10	0.49	0.4901	0.3698
Fiscal Policy							
(υ_d)	Coefficient of debt in government spending rule	Normal	-0.30	0.10	-0.02	-0.0601	0.0231
(g_d)	Coefficient of debt in tax rule	Normal	0.40	0.10	0.396	0.2321	0.5623
(ρ_y)	Response of output to changes in government spending	Normal	0.00	0.10	0.29	0.1604	0.4215
(g_y)	Response of output to changes in tax	Normal	0.00	0.10	-0.002	-0.1654	0.1681
(ρ_g)	AR(1) parameter on government spending	Beta	0.70	0.10	0.88	0.8075	0.9564
(ρ_d)	AR(1) parameter on debt	Beta	0.70	0.10	0.68	0.5083	0.8553

B. Policy Parameters

The policy parameters are those specified in the monetary and fiscal rules. The posterior of the inflation coefficient in the Taylor-type monetary policy rule, (υ_π), is 1.67, while the estimated value of the coefficients of output (υ_y) and exchange rate (υ_{exr}) are 0.55 and 0.72, respectively. The implication of the estimated value of the monetary policy parameters is that the CBN places a higher weight on price stability than on economic growth and exchange rate stability. This conforms to Adebiyi and Mordi (2016) who found that the CBN has placed its greatest focus on price stability. The posterior means show that the CBN has focused on its core mandate to stabilize prices, thereafter, exchange rate management and economic growth. This outcome conforms to reality though there exists evidence of recent interest of the CBN in development financing to boost economic growth.

Another implication of the coefficient of Taylor rule reaction to inflation is interpreted in the sense of Leeper (1991). Monetary policy is active (passive) when the estimated value of the monetary authority's reaction to inflation, is greater (less) than one. The result shows that monetary policy took an active stance over the sample period. Furthermore, the posterior value of the degree of interest rate smoothing (ρ_r) of 0.49 shows that the monetary authority adjusts the interest rate in a fairly slow manner.

The posterior estimates of the fiscal smoothening parameters (ρ_g) and (ρ_d) were 0.88 and 0.68 which provides evidence for substantial fiscal smoothening. Following the classification of Leeper (1991) on active and passive policies, the posterior estimates of the response of government spending (υ_d) and taxes (g_d) to changes in debt are -0.02 and 0.40, respectively. The debt coefficient in the government spending rule is negative but positive in the tax rule in line with the results of Cebi (2012). This implies that taxes have been raised and government spending reduced in response to increased debt stock in Nigeria, over the sample period. This result coincides with a passive fiscal regime in the sense of Leeper (1991). Therefore, based on the policy parameter estimates, an active monetary and passive fiscal policy mix existed over the sample period.

The reaction of government spending and taxes to changes in output was estimated

at 0.29 and -0.002. On one hand, the positive coefficient of output in the government spending rule indicates the existence of a pro-cyclical fiscal spending. It corroborates the findings of Vegh and Vuletin (2012); Herrera *et al.* (2019) who observe that developing economies such as Nigeria usually implement pro-cyclical fiscal stance. On the other hand, the negative coefficient of output in the tax rule suggests a countercyclical stance, although in an insignificant manner.

C. Persistent Parameters

The results on the estimates of the persistent parameters as reported in Table 4 shows that the AR(1) parameter on technology, debt, government spending are persistent, implying that these shocks do not die off quickly.

Impulse Responses

The impulse responses presented in this section are in line with the estimated characterization of monetary and fiscal policy mix in Nigeria.

4.2.1 Monetary Policy Shock

A monetary policy shock happens when the central bank introduces unexpected changes to the interest rate in response deviations of the relevant variables from their steady state levels. The positive monetary policy shock, that is contractionary monetary policy, in Figure 1, causes the nominal interest rate (r) to rise. The monetary shock impacts negatively on domestic inflation (pii_D) for a duration of one period, before it quickly returned to steady state. This finding is in line with the monetarist intuition which expects domestic inflation (pii_D) to fall in the face of contractionary monetary policy. It should be observed that government spending (g) falls in response to the monetary shock. This implies that increased interest rate (r), a restrictive monetary policy causes government spending to fall. From an economic standpoint, a restrictive monetary policy is expected to lower government expenditure since an independent central bank that can effectively control inflation cannot be coerced by the fiscal authority to finance its deficit. Therefore, a restrictive monetary policy combined with a restrictive fiscal policy raises the possibility of a complementary interaction between fiscal and monetary policy in Nigeria over the study period. This is especially when the fiscal authority responds to an active monetary authority.

It is also observed that raised interest rate, that is, a restrictive monetary policy regime induced higher output (y). This negates economic reasoning that when the central bank tightens its policy, borrowing cost rises which will induce reduced investment spending and a decline in economic activity. However, Tule *et al.*(2020) showed that such outcome stems from the peculiarity of the Nigerian economy. From a historical perspective, the period of economic boom seems to coincide with the period of high interest rate.

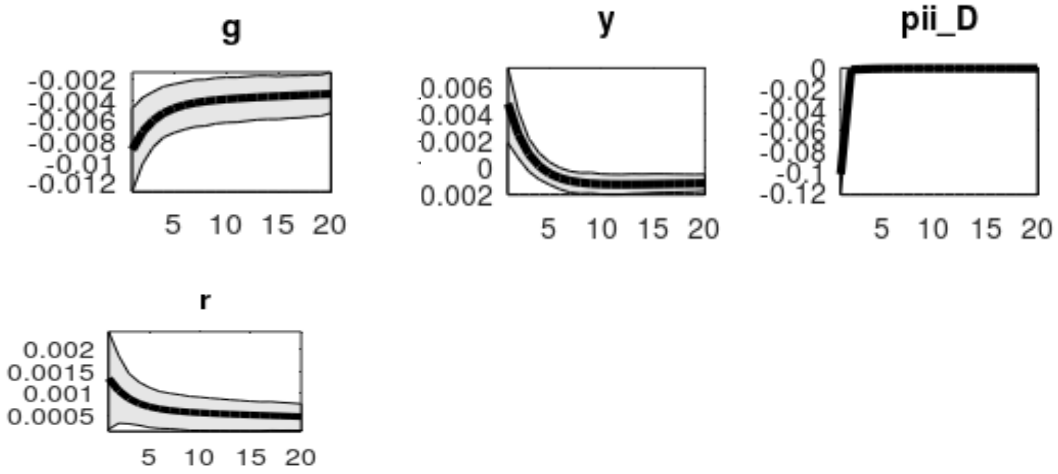

Figure 1: Impulse Responses to Positive Monetary Policy Shock
Note: y=output; pii_D=inflation; r=nominal interest rate and g=government

4.2.2 Fiscal Policy Shock

Figure 2 show that fiscal shock had a short-term negative impact on domestic output[5]. This supports the finding of Tule *et al.* (2020) that higher fiscal operations crowd out private investments and causes a decline in output. At the same time, there was increased inflation following the positive government spending shock. This implies that increased government spending induced upward inflationary trend, as proposed

[5]From Tule, Onipede and Ebuh (2020), it stems from the fact that the main component of government spending goes into recurrent expenditure. There can be a negative impact of fiscal spending on output when government expenditure exceeds tax revenue and government accumulates debt. In the instance that the government finance this debt in the bond market, this may crowd out private sector investment that inhibit economic growth.

by the Monetarist arithmetic hypothesis and proponents of the Fiscal theory of price level. In tackling increased domestic inflation, the central bank responded by increasing the nominal interest rate. The interest rate rose in response to government spending shock implying a conflicting stance. We conclude that there fiscal and monetary policy interacts as substitutes in the case that the monetary authority responds to an active fiscal authority.

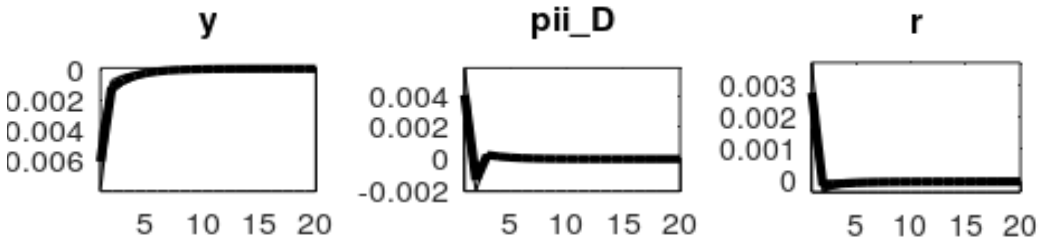

Figure 2: Impulse Responses to Positive Fiscal Policy Shock
Note: y=output, pii_D=inflation and r=nominal interest rate

4.3 Policy Experiments

In this section, two policy experiments were conducted. Bayesian estimates obtained in section 4.1were used to parameterize the DSGE model. The parameterized DSGE model was thereafter solved to conduct the policy simulation.

Experiment 1: Desirable active-passive policy mix

The first experiment examined the macroeconomic effect of different configurations of the active and passive nature of fiscal and monetary policy. This experiment is useful to compare the active monetary-passive fiscal policy stance obtained in this study with the passive monetary and active fiscal policy mix. The result of the experiment is presented in Table 5 and it revealed that the active monetary and passive fiscal (AMPF) policy stance that is conventionally considered as a benchmark outperformed the active fiscal and passive monetary (AFPM) combination. The AMPF induced lesser volatility in the macroeconomic variables compared with the AFPM. This finding consolidates the desirability of the active monetary-passive fiscal policy combination.

Table 5: Volatility Outcomes comparing active-passive policy mix

	AFPM	**AMPF**
	υ_π=0.9	υ_π=1.67
	υ_d= 0.02	υ_d= -0.02
Output	0.2591	0.2067
Inflation	0.7429	0.1450
Consumption	4.8705	3.3357
Ricardian consumption	2.1371	1.4608
Non-Ricardian consumption	11.0993	7.6083

Note: AFPM- active fiscal-passive monetary, AMPF- active monetary-passive fiscal. The calibrated parameter values used in the policy experiments 1 and 2 are posterior values obtained from the Bayesian estimation except υ_π=0.9 that is arbitrarily fixed to mimic a passive monetary regime.

Experiment 2: Desirability of price stability versus output and exchange rate stability

The second experiment considers the desirability of the 'best' configuration of monetary policy that yields the least fluctuations in macroeconomic variables. Ideally, the core mandate of the CBN is to ensure price stability. However, the CBN has, in recent times, proposed and implemented measures to stimulate the real sector of the Nigerian economy in a bid to address the supply side drivers of inflation. This includes spurring growth in the manufacturing and agricultural sectors, financing small-scale businesses, entrepreneurship and skill training amongst other measures. Experiment 2 compares the macroeconomic effect of a first scenario where the CBN focuses primarily on price stability versus the second scenario where the CBN focuses primarily on either output or exchange rate stabilization. The results of the simulation exercise, which are presented in Table 6 showed that the scenario in which the CBN focuses more on price stability produced the least volatility in the macroeconomic variables. However, the scenario on output stability produced the highest fluctuations. This finding implies that central banks in a typical developing economy like Nigeria should maintain their mandate on price stabilization. The result in Table 6 also corroborates the results presented in Table 4 about the desirability of an independent central bank that is able to actively control inflation without being constrained by fiscal decisions.

Table 6: Volatility Measures of Macroeconomic Variables under different Monetary policy regimes

	Price stability υ_π=1.67 υ_y= 0.55 υ_{exr}= 0.72	**Output stability** υ_π= 0.55 υ_y= 1.67 υ_{exr}= 0.72	**Exchange rate stability** υ_π=0.57 υ_y=0.72 υ_{exr}=1.67
Output	0.2067	0.3737	0.3679
Inflation	0.3808	2.2587	1.4168
Consumption	3.3357	17.2938	12.7657
Ricardian consumption	1.4608	7.5963	5.5933
Non-Ricardian consumption	7.6083	39.3915	29.1095

4.4.1 Model Diagnostics

Identification

In this section, the statistical validity of the estimated model was examined to build confidence in the results of the estimated model. Firstly, the estimated parameters of the model are expected to be identified by the observed data. This means that the observed data provide sufficient information about the parameters. The criterion used to gauge parameter identification is the distinctness between the prior and posterior distribution. The plots presented in Figure 3 (see appendix), reveals that the prior distribution (grey line) is distinct from the posterior distribution (black line) for most of the parameters. Furthermore, the plots of the posterior distribution (black curve) possess a near-normal shape while, at the same time, the mode computed from the numerical optimization of the posterior kernel (green vertical line) is seen to be close to the mode of the posterior distribution (black curve). These two additional features justify further confidence in the output of the estimated model.

4.4.2 Mode Check

The accuracy of the Monte-Carlo based optimization routine used in computing the posterior mode is also considered. The accuracy is inspected using the mode check plots. The criteria are that the computed mode (green line) should ideally be located at the maximum of the posterior likelihood (blue line) for each parameter. The mode plots presented in Figure 4(see appendix) show that the estimated mode (green line) is close to the maximum of the posterior likelihood (blue line). The implication is that the optimizer was able to compute a robust maximum for the posterior mode.

4.4.3 MCMC Univariate Diagnostics

The univariate convergence statistics is also examined to determine the validity of the estimated parameter. Specifically, the Brooks and Gelman (1998) test is used to monitor the convergence of the MH simulations. It requires that the iterations between and within the five distinct parallel chains are close and similar for the moments of individual parameters. The existence of convergence of the MH simulations can be assessed by observing the graphical output produced by Dynare. In each graph, the red line (within chain) and the blue line (between chain) should be close and stabilize horizontally for the moments of each estimated parameter. Figure 5 presents the result of the Monte Carlo Markov Chains (MCMC) univariate diagnostics and shows convergence, that is, the red and blue lines converge and are relatively stable, for most of the parameters. According to Grifolli (2013), the convergence and stability property of the MH iterations is the primary avenue to build confidence about the authenticity of the estimation results.

4.4.4 MCMC Multivariate Convergence Diagnostic

Finally, the multivariate convergence diagnostic, a statistic that measures the overall convergence of the aggregate parameters in the model is considered. Just as in the case of the univariate statistics, it is also expected that the simulations within the chains should be similar and that those between the chains should be close, for convergence to be reached. Figure 6 (in appendix) shows that the multivariate convergence for this model exists such that the red line (within chain) and the blue line (between chains) are close and flat.

5. Conclusion and Policy Recommendations

This study examined the nature of fiscal and monetary policy interactions in Nigeria within the new Keynesian dynamic general equilibrium framework. The Bayesian method was employed to estimate the model. We found that the parameter value for the reaction of interest rate to changes in inflation υ_π is greater than one. This indicates the existence of an active monetary policy such that the central bank does not adjust its policy decisions to suit fiscal behavior. At the same time, the reaction of the Taylor rule to inflation υ_π shows that the CBN has primarily been concerned with price stability. The study also found the existence of a passive fiscal policy implying

an active monetary and passive fiscal policy mix.

Furthermore, two policy experiments were conducted. The first experiment demonstrated that the active monetary and passive fiscal stance guaranteed the least volatile macroeconomic outcomes compared to the second experiment of an active fiscal-passive monetary policy. The existence of an independent central bank that can control inflation without being constrained by fiscal decision is therefore desirable. The result of the second experiment showed that there are macroeconomic stability gains should the CBN continue to maintain its focus on its conventional mandate of price stabilization.

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Appendix 1: Log-linearised System of Equations

1. Ricardian Consumption: $c_{R,\,t} - hc_{R,\,t-1} = E_t(c_{R,\,t+1} - hc_{R,\,t}) - \frac{1-h}{\sigma}(r - E_t\Pi_{t+1})$

Where $\Pi_{t+1} = P_{t+1} - P_t$

2. Non- Ricardian Consumption: $c_{NR,t} = \frac{WN}{PC}(w_t + n_{NR,t}) + \frac{TP}{PC}(tp_t)$

3. Labour Supply schedule for Non- Ricardian Household:

$w_t - p_t = \frac{\sigma}{1-h}(c_{NR,t} - hc_{NR,\,t-1}) + \varphi n_t$

4. Transfer to non-Ricardian household: $TP_t = \rho_{TP} TP_{t-1} + \varepsilon_t^{TP}$

5. Marginal cost: $mc_t = w_t - p_t - a_t$

6. Aggregate Consumption: $c_t = \psi c_{R,t} + (1-\psi)c_{NR,t}$ 7. Domestic Market clearing condition: $y_t = c_t + \frac{\alpha\omega}{\sigma} s_t + g_t + e_{y,t}$

Where $\omega = \sigma\gamma + (1-\alpha)(\sigma\eta - 1?)$

8. International Risk Sharing: $c_t - hc_{t-1} = y_t^* - hy_{t-1}^* + \frac{(1-h)1-\alpha)}{\sigma} s_t$

9. Domestic inflation: $\pi_{D,t} = \beta E_t\,[\pi_{D,\,t+1}] + k_\alpha \widetilde{y_t} + s_{\pi D}$

Where $k_\alpha = \lambda(\sigma_\alpha + \varphi) = \frac{(1-\theta)(1-\beta\theta)}{\theta}(\sigma_\alpha + \varphi)$

10. Total Inflation: $\pi_t = \pi_{D,t} + \pi_{F,t}$

11. Terms of trade: $s_t = s_{t-1} + \Pi_{D,t} - \Pi^*{}_{F,t} + \varepsilon_{tot,\,t}$

12. Uncovered Interest Parity: $r - r_t^* = E_t \Delta e_{t+1}$

13. Law of one price gap: $e_t - \mathrm{e}_{t-1} = \Pi^*{}_t - \Pi_{F,t}$

14. Monetary Policy Rule: $r_t = \rho_R r_{t-1} + (1-\rho_R)[\upsilon_\pi \pi_t + \upsilon_y y_t + \upsilon_e \Delta e_t] + \varepsilon_{r,t}$

15. Fiscal Policy Rule: $g_t = \rho_g g_{t-1} + \lambda_g d_t + \rho_y y_{t+} \varepsilon_{g,t}$

16. Debt: $d_t = \rho_d d_{t-1} + \varepsilon_{d,t}$

Exogenous and Shock Processes:

17. Foreign Output: $y_t^* = \rho_{y_t^*} y_{t-1}^* + \varepsilon_{\mathrm{t}}{}^{y_t^*}$

18. Foreign Inflation: $\pi_t^* = \rho_{\pi_t^*} \pi_{t-1}^* + \varepsilon_{\mathrm{t}}{}^{\pi_t^*}$

19.Foreign Interest rate: $r_t^* = \rho_{\,r_t^*}\, r_{t-1}^* + \varepsilon_{\mathrm{t}}{}^{r_t^*}$

20. Technology: $a_t = \rho_a a_{t-1} + \varepsilon_t^a$

Appendix 2: Model Diagnostics

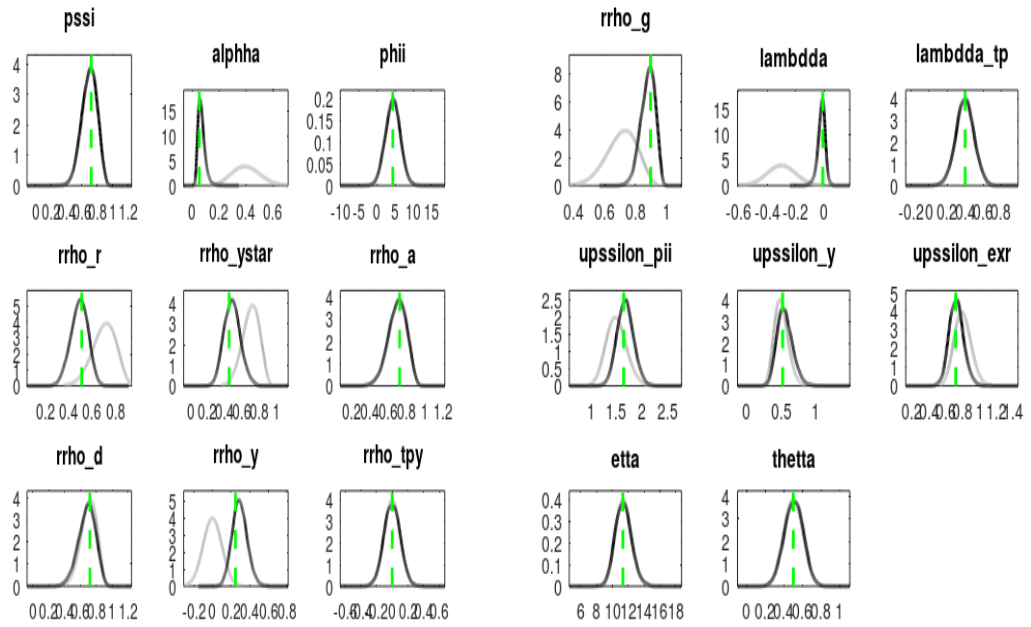
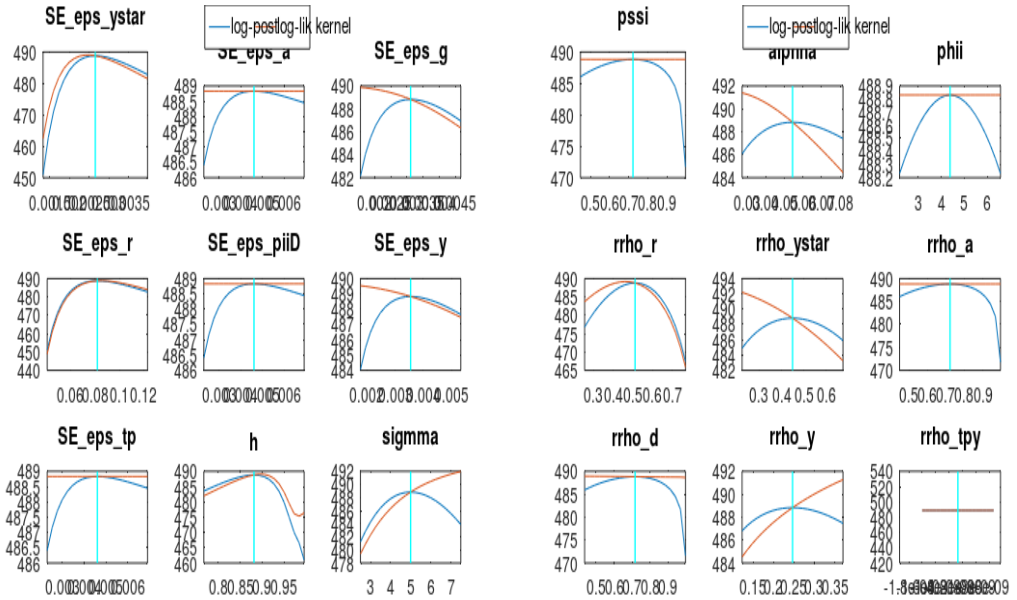


Figure 3: Prior-Posterior Plots



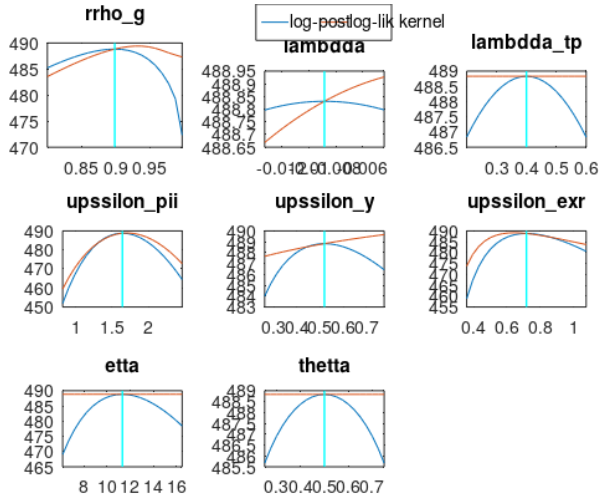
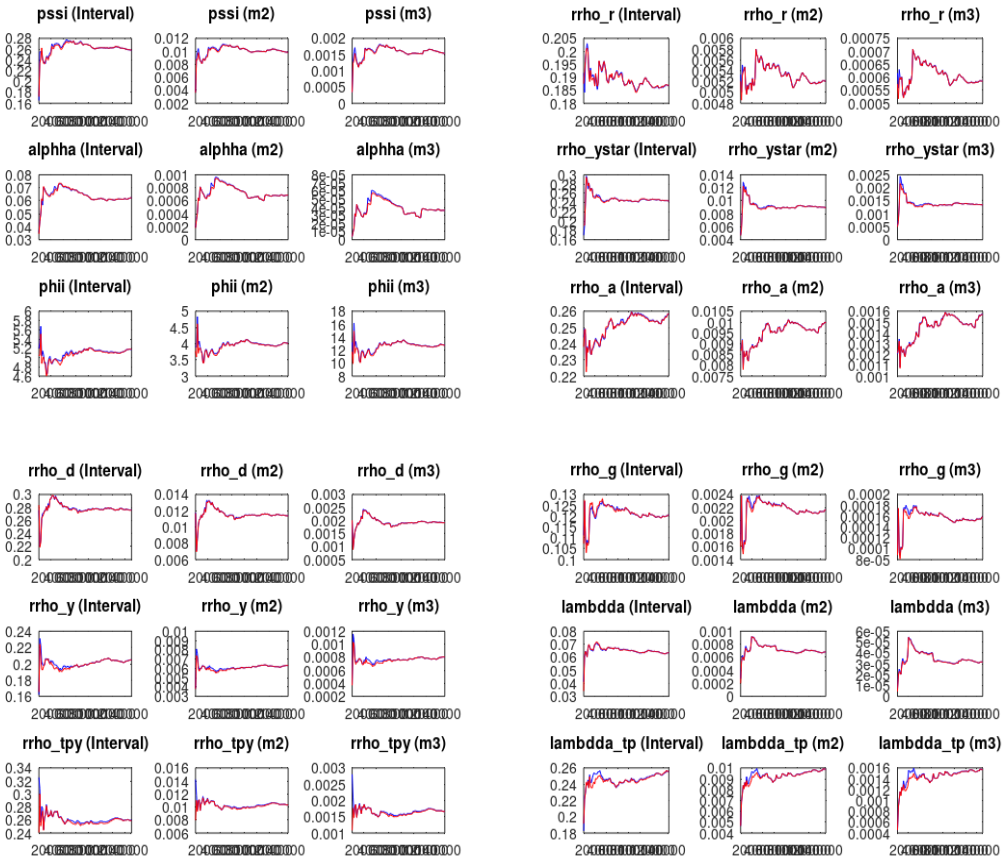


Figure 4: Mode Check Plot



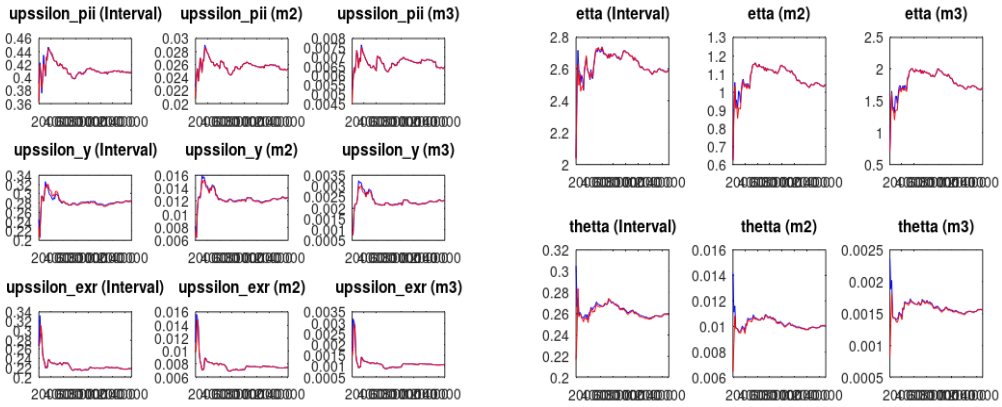


Figure 5: MCMC Univariate Diagnostics for selected parameters

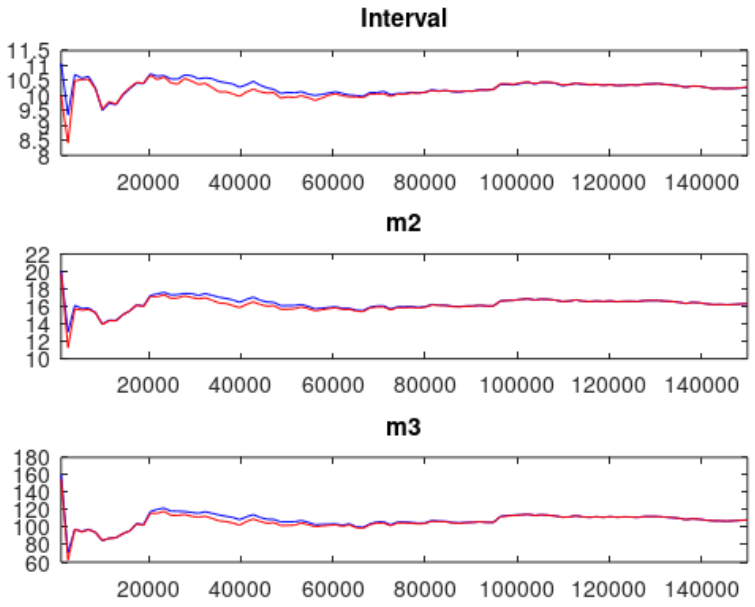


Figure 6: Multivariate Convergence Diagnostic