JOURNAL of Applied Economic Sciences

JAES

Journal of Applied Economic Sciences

Volume XIII

Issue 6(60) Fall 2018

ISSN-L 1843 - 6110

ISSN 2393 - 5162

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Journal of Applied Economic Sciences

ISSN-L 1843 - 6110

ISSN 2393 – 5162

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Optimal Fiscal and Monetary Policy Rules in Nigeria

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Suggested Citation:

Oye, Q.E., Alege, P., Olomola, P. 2018. Optimal fiscal and monetary policy rules in Nigeria. *Journal of Applied Economic Sciences*, Volume XIII, Fall 6(60): 1615-1622.

Abstract:

Commodity-exporting and developing economies such as Nigeria can adopt fiscal rules that guarantee short-term macroeconomic stability and long-term fiscal sustainability. This study, in this respect, considered the relevance of fiscal rules where the fiscal balance of government reacts to the revenue base and state of the economy. The study also examined the desirability of the Taylor-type rule for the Nigerian economy. The study computed optimal monetary and fiscal rules using a Linear-Quadratic approximation of the equilibrium conditions in a New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model. The parameters of the DSGE model were calibrated to suit the Nigerian economy. The main findings of the study showed that the optimized monetary rule obeys the Taylor principle while the optimized fiscal rule ensures a passive and countercyclical fiscal path. The implication of the finding shows that in the presence of a government that commits to a fiscal balance rule, it is desirable for the central bank to stabilize inflation while the government should avoid the procyclical bias.

Keywords: fiscal; monetary; policy rules; optimal; DSGE; Nigeria

JEL Classification: E61; E63; C69

Introduction

The Nigerian economy slipped into a recession after it contracted by -0.36% and -2.06% in 2016Q1 and 2016Q2. At the same time, inflation rate rose from an average of 12.24% over the period 1996-2016 to 18.10% in October 2016 (National Bureau of Statistics 2016). Policy analysts deduced that these twin problems were aggravated by the conflicting and uncoordinated stances of both fiscal and monetary policy. This paper, in this regard, argues that the design and implementation of optimal fiscal and monetary policy is a channel to guarantee future efficient macroeconomic outcomes in Nigeria. Both policies aid the short-term stabilization of the economy that guarantees medium to long-term outcomes in growth and welfare (World Bank 2014, Ayopo *et al*. 2015). In practice, Taylor (1993, 2000) shows that economic policy decisions can be approximated using simple feedback rules and that these rules produce good macroeconomic outcomes.

This study, therefore, examined the design of optimal policy rules that lead to efficient outcomes in inflation and output in Nigeria within a new Keynesian Dynamic Stochastic General Equilibrium model. Only few authors have contributed to the literature on optimal macroeconomic policy in Nigeria (Olayeni 2015, Udom and Yaaba 2015, Adegboye 2015). Adegboye (2015) is the only exception that considered the joint optimal fiscal and monetary policy but left out peculiar factors such as rent-seeking and fossil oil. In this respect, Baansguard (2003) and Snudden (2016) argue that oil-exporting economies such as Nigeria should consider the relevance of this commodity in explaining fiscal decisions. This study, therefore, differs from Adegboye (2015) by combining an oil revenue-based fiscal rule with a Taylor-type rule in order to obtain the optimal mix of fiscal and monetary policy in Nigeria.

1. Research background

Several studies have examined the joint optimal paths for fiscal and monetary policy. Optimal policies can be described as rules or discretionary. This section however focuses on optimal fiscal and monetary policy rules which can be characterized as Ramsey policies or optimal simple rules. Lucas and Stockey (1983), Chari, Christiano and Kehoe (1991) are some earlier contributions to optimal fiscal and monetary policy. These studies compute joint Ramsey policies within a dynamic general equilibrium framework. Other studies include Schmitt-Grohe and Uribe (2004) who simulated a DSGE model and found that the Ramsey planner desires monetary policy paths in nominal interest rates to be greater than zero and highly volatile over time. The authors characterized the Ramsey fiscal policy to feature stable income tax rates. Bhandari *et al*. (2018) examined the optimal fiscal and monetary paths in a New Keynesian model with heterogenous agents where a Ramsey planner is assumed to be concerned with inflation stability and mitigating against mark-up shocks. The study characterized optimal monetary policy to fall in response to a mark-up shock while the reaction of the optimal tax depends on whether the planner is concerned with price stability or with insuring the household agents against shocks.

Studies that compute optimal simple rules include Chadha and Nolan (2007) who showed that the optimized combination of Taylor and fiscal surplus rules obey the assignment consensus. In this case, the optimal monetary policy is concerned with inflation stability while the optimal fiscal policy focuses on smoothing the output gap. Schmitt-Grohe and Uribe (2007) used the second-order approximation of equilibrium conditions within a DSGE model to compute values for optimized feedback policy rules. The mix of the optimal simple fiscal and Taylor-type rules have the features of active-passive monetary and fiscal policies. In the same vein, Gali and Monacelli (2008) used the second-order approximation method to derive the optimal fiscal and monetary rules that maximizes households' welfare in the European Union, within a dynamic general equilibrium framework. The study found that optimal monetary policy be assigned to price level stability. The optimal fiscal policy in individual economies is pro-stabilizing and is void of constraining the monetary stance of the Union's central bank.

Bi and Kumhof (2011) found that in a general equilibrium model with non-Ricardian households and the presence of huge debt and distortionary taxes, the optimized simple fiscal rule in surplus as percent of GDP smooths the income of non-Ricardian household. The optimized nominal interest rate rule is highly persistent and passive in nature according to the classification of Leeper (1991). Phillippopoulos, Varthalitis and Vasillatos (2015) calibrated a New Keynesian DSGE model to data on the Euro area. They used the second-order approximation method to compute the optimized simple rules that guarantees both output and debt stabilization. The study specified more than one fiscal instrument in distortionary taxes and government spending, alongside a Taylor-type monetary rule. The author found that the optimized monetary path followed the Taylor principle, such that it has inflation-stabilizing aim. The optimized fiscal rule, on the other hand, should focus on balancing role of debt consolidation or economic stabilization. This balancing role depends on the distortedness in the nature of the fiscal instrument. In addition, Cantore *et al*. (2017) studied a richer set of optimal fiscal-monetary rules, that is the Ramsey policy, time-consistent policy and optimal simple rules under a normal and abnormal or crisis period. The result from the study revealed that the nature of optimal policy depends on the initial debt level in the economy and whether the government is committed to a set of rules or not.

The aformentioned studies reviewed have been calibrated to suit developed economies such as the United States and Euro area. This study differs from the most of the rest by considering optimal fiscal and monetary policy rules for a developing economy such as Nigeria. In this light, a Taylor rule is combined with a fiscal rule that responds to the peculiarity of Nigeria as an oil-exporter. This study corroborates Snudden (2016) who showed that commodity-exporting economies such as Nigeria should consider the relevance of this commodity in the design of fiscal rules.

2. Methodology

2.1. An open economy New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model

The model is constructed drawing on the works of Gali and Monacelli (2008). It comprises of four optimising agents that include households, firms, the central bank and the government who form model-consistent expectation based on available information. The infinitely lived households decide how much units of goods to consume and labour to supply in order to maximise its lifetime utility subject to budget constraints. The household sector is also assumed to supply labour to firms in a perfectly competitive labour market. The production sector comprises of intermediate-goods producers. The intermediate-goods producers are in monopolistic competition and cannot change prices. Following the Calvo (1983) sticky price setting, a fraction of the intermediate-goods firms is allowed to re-set their price. The third agent is a monetary authority, the Central Bank of Nigeria that implements monetary policy by following a Taylor-rule to set its policy rate. The fiscal authority is also assumed to implement policies by committing to fiscal rules in government spending and budget surplus. Finally, the model is perturbed by some exogenous shock processes.

2.1.1. The households

There is a continuum of infinitely lived households $j \in [0,1]$ who decides how much units of goods to consume and labour to supply in order to maximize its lifetime utility subject to its inter-temporal budget constraints. The household sector consists of forward-looking optimisers who have access to the financial markets and can own firms in the economy. The household derives utility at time t from consuming a composite good, C_t, public good G_t and leisure $1 - N_t$. Furthermore, there is neither saving nor investment. The households' objective is therefore to maximize the sum of discounted expected future utility in equation (1):

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

where: E_t is the rational expectation operator; β^t is the inter-temporal discount factor; C_t comprises of private consumption of composite goods; G_t is the consumption of public goods; N_t is the amount of labour supplied; σ is the parameter for inverse of elasticity of substitution; χ is the weight on public goods consumption and φ is the inverse on frisch elasticity of labour supply.

The household maximizes utility function in equation (1) subject to a standard budget constraint in nominal terms (2). The budget constraint postulates that the household receive wages for their labour supply $W_t N_t$, they own the firm and receive profit in form of dividend DV_t, they own stock of risk-free financial assets, D_t and receive lump sum transfer from government TP_t. The household uses their resources to pay lump sum tax $P_t C_t$ and to purchase portfolio of financial assets, D_{t+1}. This relation can be written as:

$$P_t C_t + E_t(Q_{t,t+1} D_{t+1}) + \leq W_t N_t + D_t + TP_t + DV_t \tag{2}$$

where: $E_t(Q_{t,t+1}) \equiv Q_t = \left(\frac{1}{1+i_t}\right)$ is the one period ahead stochastic discount factor; i_t is the nominal interest rate. The equilibrium conditions in the household sector include the consumption Euler equation (3) and the labour supply schedule (4):

$$c_t = E_t(c_{t+1}) - \frac{1}{\sigma}(i - E_t \Pi_{t+1} - \rho) \tag{3}$$

where: $\Pi_{t+1} = P_{t+1} - P_t$; $\rho \equiv -log\, \beta$ and $i \equiv -\log Q_t$

$$w_t - p_t = \sigma c_t + \varphi n_t \tag{4}$$

2.1.2. The firms

The monopolistic competitive firms in the production sector produce differentiated goods using a linear production technology:

$$Y_t = A_t N_t \tag{5}$$

where: A_t denotes the Total Factor Productivity; N_t is the labour input, Log $A_t \equiv a_t$ is assumed to evolve with an AR(1) process such that: $a_t = \rho_a\, a_{t-1} + \varepsilon_t^a$, $\varepsilon_t^a$is the technology shock to production in the economy. It is normally distributed with mean of zero and the standard deviation is σ_{ε^a}, *i.e.*,$\varepsilon_t^a \sim N(0, \sigma^2{}_{\varepsilon^a})$.

Log-linearize equation (5) to get the production relation:

$$y_t = a_t + n_t \tag{6}$$

Price setting

The intermediate firms are concerned with the optimal pricing of their goods. The firms in this regard, choose the price that maximizes the discounted real profits. It is also assumed that the firms follow the Calvo (1983) price-setting mechanism such that while a fraction θ cannot reset their prices, the other fraction $1 - \theta$ can. The firms fix prices, P_t^*, by maximizing their real discounted profits subject to demand such that:

$$\text{Max } E_t \sum_{k=0}^{\infty} (\beta\theta)^k E_{t,t+k} Y_{t+k|t} \left[P_t^* - mc_{t+k|t}\right] \quad (7)$$

Subject to:

$$Y_{t+k|t} = \left[\frac{P_t^*}{P_{t+k}}\right]^{-\varepsilon} Y_{t+k} \quad (8)$$

This yields the optimal pricing equation of the resetting firm such that:

$$P_t^* = \mu + 1 - \beta\theta \sum_{k=0}^{\infty} (\beta\theta)^k E_t \left[\widehat{mc_{t+k|t}} + P_{t+k}\right] \quad (9)$$

where: $\widehat{mc_{t+k|t}} = mc_{t+k|t} - mc$

2.1.3. International risk sharing

In a complete and integrated international financial market, it is assumed that there is perfect risk sharing between households in the domestic and foreign countries i.e. it is assumed that the prices of domestic and foreign bonds are the same. It is also believed that the household in the domestic and foreign economies shares similar preferences. The first order condition on consumption for the domestic economy (10) is combined with a similar one for the foreign economy (11).

$$\beta \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \frac{P_t}{P_{t+1}} = Q_{t,t+1} \quad (10)$$

$$\beta \left(\frac{{C_{t+1}}^f}{{C_t}^f}\right)^{-\sigma} \frac{{P_t}^f}{P_{t+1}} = Q_{t,t+1} \quad (11)$$

This gives:

$$c_t = c_t^f + \frac{1-\alpha}{\sigma} s_t \quad (12)$$

This relation links the domestic consumption (c_t), world consumption (c_t^f) and the terms of trade (s_t)

2.1.4. The monetary authority

The central bank is assumed to follow a simple Taylor-type rule. Under this rule, the monetary authority sets the nominal interest rate by considering past value of interest rate, the deviation of inflation, output growth and exchange rate from target

$$r_t = \rho_R r_{t-1} + (1 - \rho_R)\left[\varphi_\pi \hat{\pi}_t + \varphi_y \hat{y}_t + \varphi_e \Delta e_t\right] + \varepsilon_t^R \quad (13)$$

where: r^t denotes the nominal interest rate; r_{t-1} is the lagged interest rate; π_t is the inflation rate; y_t is the output growth; e_t is the exchange rate; ε_t^R is the Innovation to monetary policy; ρ_R is the degree of interest rate smoothing while $\varphi_\pi, \varphi_Y, \varphi_e$ are the parameters that measure the response of central bank to inflation, output and exchange rate.

2.1.5. The fiscal authority

The fiscal authority is assumed to be benevolent. The fiscal authority faces a budget constraint where the revenue it earns from issuing bonds ($r_{t-1}d_{t-1}$) is expended on government provision of goods and services (g_t). The fiscal policy maker, therefore, has a nominal budget constraint that is defined as:

$$r_{t-1}d_{t-1} = g_t \quad (14)$$

The government implements a generalized fiscal-balance rule as specified in Snudden (2016). This rule assumes that the fiscal-balance reacts to the structural fiscal balance, the deviation of oil and non-oil revenues and government liability from steady state and the level of real GDP. It is specified such that:

$$d_t = d_t^{ss} + \rho_{nor}(NOR_t - NOR_t^{ss}) + \rho_{or}(OR_t - OR_t^{ss}) + \rho_b(B_t - B_t^{ss}) + \rho_{gdp}GDP_t + \varepsilon_t^d \quad (15)$$

2.1.6. Exogenous shock processes

The model is assumed to be perturbed by exogenous shocks in technology, monetary policy and fiscal policy. These are expressed as:

Technology: $a_t = \rho_a a_{t-1} + \varepsilon_t^a$ (16)

Monetary Policy: $r_t = \rho_r r_{t-1} + \varepsilon_t^r$ (17)

Fiscal policy: $\mu_t = \rho_\mu \mu_{t-1} + \varepsilon_t^\mu$ (18)

2.1.7. Market clearing conditions

Goods market clearing condition for the domestic economy requires that aggregate output equals aggregate domestic and foreign demand for locally produced goods with government demand such that:

$$y_t = c_t + g_t + \alpha s_t \quad (19)$$

2.1.8. Equilibrium dynamics

Dynamic Investment-Saving (IS) Curve:
Equation (19) of the goods market clearing condition can be combined with the consumption Euler equation (3) to obtain the dynamic IS curve such that:

$$\tilde{y}_t = E_t\tilde{y}_{t+1} - \left(i - E_t\Pi_{D,t+1} - {r_t}^n\right) - E_t(\Delta\tilde{g}_{t+1}) \quad (20)$$

New Keynesian Philips Curve:
The optimal price setting condition in equation (9) is combined with the dynamics of the aggregate price level in equation (21) to obtain the NK Philips curve in equation (22):

$$\pi_t = (1-\theta)(P_t^* - P_{t-1}) \quad (21)$$

$$\pi_{D,t} = \beta E_t\left[\pi_{D,t+1}\right] + \lambda\widehat{mc}_t \quad (22)$$

where: $\lambda = \frac{(1-\theta)(1-\beta\theta)}{\theta}$

Equation (22) shows that domestic inflation is proportion to the deviation of the marginal cost from its steady state. The real marginal cost is such that:

$$\widehat{mc} = (1+\varphi)\tilde{y}_t - \widetilde{g_t} \quad (23)$$

2.2. Optimal simple policy rules

The optimal fiscal and monetary policy is defined as the path of budget surplus and nominal interest rate rules that optimize the objective function of the policymaker. The optimal simple rules are computed in this section using the Linear Quadratic approximation on Dynare 4.5.1 software. The policymaker, therefore, seeks to minimize the deviation of the actual values of output, inflation and budget surplus from their target values such that:
Minimize

$$\sum_{t=0}^{\infty} \pi^2 + 0.5y^2 + 0.5d^2 \quad (24)$$

Subject to the structural constraints that include the Dynamic IS curve, New Keynesian Philips curve, the monetary and fiscal policy rules.

2.3. Calibration of parameters

Some of the parameters of the model used in this study are borrowed from existing studies on Nigeria such as Adegboye (2015). The discount factor, calvo price stickiness and Inverse of Frisch elasticity () are fixed at 0.99, 0.5 and 4.38 in line with Adegboye (2015).

The persistent parameters on oil and non-oil revenues, government spending, and debt are fixed at 0.7 while the degree of interest rate smoothening is fixed at 0.8. The Taylor reaction to inflation and output are calibrated to take the value of 1.5 and 0.5. The parameters of the response of oil revenue, non-oil revenue, debt and real GDP to the fiscal-balance are fixed at 0.145, -1.089, 0.158 and -0.198. These values were obtained by running a regression on the generalized fiscal rule using Nigerian data for the period 1970 to 2013. The target values for the fiscal balance to GDP, non-oil revenue to GDP and debt to GDP are selected based on projections in the Medium Term Expenditure Framework (2018-2020) of the Budget Office of the Federation (2017). These values are fixed at 1.63, 15 and 18% respectively. The target value for the oil revenue as a ratio of GDP is selected using its average over the period 1970-2013.

Table 1 presents the optimized fiscal and monetary policy rules under four fiscal regimes. In fiscal regime one, the government is assumed to implement a generalized budget balanced rule such that the fiscal balance reacts to both oil and non-oil revenue and to macroeconomic indicators in debt and Real GDP. This rule has the potential to guarantee long-term fiscal sustainability while at the same time stabilizing the economy against cyclical volatility.

The fiscal regime two is a balanced-budget rule that requires that government revenue offset its liabilities such that the budget is balanced in each period. In the third fiscal regime, a structural surplus rule is designed. This rule ensures that government spending matches the long-term sustainable path of revenue. The fourth fiscal regime is a countercyclical rule. The fiscal parameters in the balanced budget, structural surplus and countercyclical are calibrated in line with Snudden (2016).

Table 1. Optimized parameters

	φ_π	φ_y	ρ_{or}	ρ_{nor}	ρ_b	ρ_{gdp}
1. Generalized budget balanced rule	2.204 (1.5)	0.737 (0.5)	0.151 (-1.089)	-0.514 (0.145)	-0.439 (0.158)	-0.183 -(0.198)
2. Budget balanced rule	227.892 (1.5)	76.602 (0.5)	-0.0000131 (0)	-0.0000131 (0)	-0.000024 (0)	-0.000011 (0)
3.Structural surplus rule	2.041 (1.5)	0.682 (0.5)	0.644 (1)	0.644 (1)	0.711 (0)	-0.000000492 (0)
4.Countercyclical rule	3.25 (1.5)	1.094 (0.5)	-0.149 (1.1)	-0.149 (1.1)	-	-0.315 (-0.5)

Source: Authors' computation using Dynare
Note: *Values in the brackets are the calibrated parameters

3.1. Optimized fiscal rule

The optimized parameter values of the fiscal balance reaction to debt (ρ_b) shows that the fiscal policy in regimes 1,2 and 4 take a passive fiscal path, in line with the classification of Leeper (1991). This implies that government adjusts the budget balance instrument to stabilize debt. It shows that elements of fiscal dominance that stifles central bank independence and induces fiscal inflation are reduced under these regimes.

This result corroborates Oye, Alege and Olomola (2018) who find that passive fiscal rules have the higher welfare benefits than active fiscal rules. The optimized coefficients of fiscal balance reaction to real output (ρ_{gdp}) shows that the fiscal regimes have the potential to guarantee the adoption of countercyclical fiscal policies. This becomes necessary to address the fiscal- procyclical bias in several developing economies. In addition, the autocorrelation coefficient shows the low inertial of the fiscal balance instrument. This implies that the economy quickly responds to adjustments in this instrument.

3.2. Optimized monetary rule

The central bank implements a Taylor rule such that the nominal interest rate reacts to inflation and output. The optimal coefficient values of the Taylor response to inflation (φ_π) are greater than unity in the four regimes. This means that the Taylor principle is satisfied and the central bank ought to adopt an active monetary stance in line with Leeper (1991).

The autocorrelation coefficient also depict that the optimal monetary stance has low persistence such that variations in the monetary instrument is short-lived and transmits quickly onto the economy. The fiscal instrument, however, is less persistent than the monetary instrument.

3.3. Welfare and volatility

The welfare losses of the policymaker obtained from minimizing the variances in output, inflation and fiscal balance are presented in Table 2. In addition, the volatility in output, inflation and debt stock are reported. The result in Table 2 reveals that the welfare loss of the policymaker is best minimized under the countercyclical fiscal regime. It has the least loss value compared to the other regimes.

The loss function, on the other hand, is least minimized under the generalized budget balanced rule. It can then be concluded based on the results in Table 2 that fiscal rules that guarantee short-term macroeconomic stability, are more appealing to the policymaker, since it minimizes their loss function than rules tailored to long-term fiscal sustainability. The volatility values reported in Table 2 shows that output and inflation are best stabilized under the budget-balanced rule while debt is equally stabilized under the four regimes.

Table 2. Welfare and Volatility

	Welfare loss	SD(y)	SD(π)	SD (b)
Generalized budget balanced rule	0.00521	0.065	0.168	0.221
Budget balanced rule	0.00518	0.041	0.015	0.221
Structural surplus rule	0.00293	0.068	0.179	0.221
Countercyclical rule	0.00118	0.557	0.123	0.221

Source: Authors' computation using Dynare

Conclusion

Chile is one example of a country that has adopted a fiscal rule that ensures long-term fiscal sustainability and reduces macroeconomic volatility. Commodity-exporting and developing economies such as Nigeria can also adopt such fiscal rule (Baansguard 2003, Snudden 2016).

The study, therefore, examined a generalized budget rule where the fiscal balance of government reacts to the revenue base and state of the economy. The study compared the outcome of this rule with three similar variants. The main findings of the study showed that the optimized monetary rule obeys the Taylor principle while the optimized fiscal rule ensures a passive and countercyclical fiscal path. The implication of the finding shows that in the presence of a government which commits to a fiscal balance rule, it is desirable for the central bank to stabilize inflation while the government should avoid the procyclical bias.

Acknowledgement

The authors will like to thank Covenant University Centre for Research, Innovation and Discovery (CUCRID) for her financial support.

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JOURNAL of Applied Economic Sciences

ISSN 2393 – 5162 ISSN - L 1843-6110