

Commodity price shocks and monetary policies in commodity exporting African countries - A DSGE analysis

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The study investigates alternative monetary policy rules in commodity-exporting African countries, by formulating, estimating and simulating a DSGE model for 5 African countries. We apply the Bayesian technique for our estimation and utilize impulse response functions to evaluate alternative monetary policy rules to commodity price shocks. Our results show that commodity price shocks influence business cycle fluctuations in African countries, whereas the results from alternative monetary policy rules are mixed. The findings show that nominal GDP targeting (NGDPT) is the best policy rule to minimize output volatility and price variations against positive commodity price shocks. However, if the objective is to minimize the effects of positive commodity price shocks on the exchange rate, the inflation targeting (IT) is the best policy rule. Further, the findings shows that IT and NGDPT are the best policy rules to stabilize output and prices against negative commodity price shocks while exchange rate targeting (ERT) is the best policy rule to stabilize exchange rate against negative commodity price shocks.

Keywords: African countries, bayesian technique, commodity prices, DSGE and monetary policy.

JEL Classification: C33, F31, F41

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1. Introduction

One of the major challenges facing policymakers in commodity-exporting developing countries is the formulation of appropriate policies that will mitigate the vulnerability of their economies to recurrent swings in commodity prices. Sharp and frequent shocks in commodity prices induce macroeconomic volatility and cause disruptive business cycles in commodity-exporting developing countries. Commodity price shocks threaten fiscal balances and debt sustainability (Medina & Soto, 2016; Richaud *et al.*, 2019), increase exchange rate volatility (Englama *et al.*, 2010; Tule,

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2014; Jimenez-Rodriguez & Morales-Zumaquero, 2020; Kassouri & Altintas, 2020), amplify inflationary trends (Bawa *et al.*, 2020; Yildirim & Arifli, 2021), aggravate macroeconomic volatility (Iwayemi & Fowowe, 2011; Abdulkareem & Abdulha-keem, 2016) and adversely impact long term growth and societal welfare (Cespedes & Velasco, 2014).

To minimize these adverse macroeconomic effects caused by commodity price shocks, various measures have been proposed. Notably, commodity-exporting countries have adopted fiscal measures as the main instruments of reducing the adverse effects of commodity price shocks on their economies. This perhaps is due to the direct link between commodity prices and fiscal balances in commodity-exporting countries. Several commodity-exporting countries have introduced fiscal rules to reduce the vulnerabilities of their economies to commodity price shocks (Baunsgaard 2003; Snudden, 2016; Richaud *et al.*, 2019). Others have established resource funds (Kalyuzhnova 2011). Studies, however, have shown the limited success of these fiscal measures in commodity-exporting countries (Arezki & Ismail, 2013). This minimal success of fiscal measures has generated renewed interest in the application of monetary policy as an alternative instrument to minimize the susceptibility of commodity-exporting countries to commodity price shocks (Medina & Soto, 2005; Allegret & Benkhodja, 2015).

A number of studies have shown the effectiveness of monetary policy in reducing the adverse effects of commodity price shocks. Naraidoo and Paez-Farell (2023) show that monetary policy can reduce the effects of commodity price shocks in small open economies. Further, findings in non-commodity exporting countries have shown that monetary policy can aggravate or lessen the impact of commodity price shocks on the economy (Leduc & Sill, 2004; Kormilitsina, 2011). Despite the relevance and effectiveness of monetary policy in stabilizing the economy, little attention has been paid to its capacity to dampen the effects of commodity price shocks in African countries. Rather, the existing literature has mainly focused on the stabilizing role of fiscal policy. For instance, Baunsgaard (2003) propounded fiscal rule as the optimal policy response to oil price fluctuations in Nigeria.

A notable exception is the study by Allegret & Benkhodja (2015) and Hove *et al.*

(2016) who examined alternative monetary policy rules to commodity price shocks in Algeria and South Africa, respectively. Our study differs from Allegret & Benkhodja (2015) and Hove *et al.* (2016) as we apply a different DSGE model with frictions and rigidities. Further, the above studies did not evaluate the effects of commodity price shocks on the sample economies. Hence, the gap this study seeks to fill is to evaluate the roles of commodity price shocks in African business cycle fluctuations and investigate alternative monetary policy rules for 5 commodity exporting African countries. What could be the appropriate monetary policy instrument the monetary authorities in commodity-exporting countries should deploy in the face of high commodities price shocks?

The study is important as understanding the appropriate monetary policy response to commodity price shocks will assist the monetary authority to design relevant policies that will minimize macroeconomic fluctuations occasioned by commodity price shocks. What should the monetary authority target in the face of commodity price shocks? Should the monetary authority adopt inflation targeting, nominal GDP targeting, exchange rate targeting or export price index targeting as espoused by Frankel (2003)? Allegret & Benkhodja (2015) find that core inflation targeting is the optimal monetary policy for Algeria in the face of oil price shocks. Gonzalez *et al.* (2015) conclude that a combination of exchange rate intervention, short term interest rate and financial regulation are the optimal monetary policy rules for a commodity exporting country like Columbia.

This paper contributes to the existing literature in three respects. First, we empirically investigate the effects of commodity price shocks on economic fluctuations in African countries. Second, we examine the appropriate monetary policy rule in response to variations in commodity prices in the 5 African countries – Kenya, Malawi, Nigeria, South Africa, and Uganda. The choice of these countries center on the issue of availability of data which is a serious challenge for almost all African countries. (ii) These countries are among those in Africa classified as having the highest levels of commodity price and growth volatilities by the United Nations Conference on Trade and Development report (UNCTAD, 2022). (iii) They are among the top ten leading countries in the export of crude oil & natural gas, minerals, ores & metals and

agricultural commodities (such as tea, coffee, vegetables & oils, fishery and tobacco). According to the UNCTAD statistics (2023), these commodities constitute more than 60% of total merchandise exports in more than two-third of the 54 countries in Africa thus, making the entire African countries highly vulnerable to persistent global commodity price shocks. Third, we formulate and estimate a DSGE model that incorporates features peculiar to African economies as commodity-exporting countries while adopting the Bayesian technique.

The rest of the paper is organized as follows. Section 2 presents the literature review. Section 3 presents the details of the model and discusses the parameters calibration, data and priors. Section 4 presents the estimation results of alternative monetary policy rules while Section 5 concludes the study.

1.2 Stylized Facts

Table 1 presents the correlation results between commodity price shocks and some macroeconomic variables. The results on the correlation between commodity prices and output in the 5 African countries are mixed. Commodity prices have positive correlation with output in Kenya and Nigeria. This implies that a rise in commodity prices, generates windfall income, increases aggregate demand and stimulates domestic output in these two countries. This is similar to the findings by Yamout (2022) and Naraidoo (2023) for commodity exporting countries. In contrast, the correlation is negative in Malawi, South Africa and Uganda. This suggests the effects of Dutch disease syndrome in these economies. This is in line with the findings by Chen and Lee (2023).

Further, the correlation results indicate significant positive relations between commodity prices and inflation in Malawi and Uganda. This implies that a rise in commodity price increases money supply in these 2 countries and hence leads to a rise in general prices. This is in line with the findings by Bawa *et al.* (2020). However, the results are significantly negative for Kenya. This suggests that the effects of an increase in commodity prices is followed by a policy of sterilization and fiscal smoothing which therefore dampen the inflationary effects of positive commodity price shocks. For Nigeria and South Africa, the results are insignificant. This suggests that the effects of rising commodity prices are offset by exchange rate move-

ments (Böwer *et al.* (2007).

Table 1: Correlation between commodity price shocks and macroeconomic aggregates

Countries	$\rho_{cp,y}$	$\rho_{cp,\pi}$	$\rho_{cp,ner}$
Kenya	0.319** (3.042)	-0.351** (3.393)	0.242** (2.257)
Malawi	-0.506** (5.179)	0.263** (2.404)	0.572** (6.159)
Nigeria	0.359** (3.883)	-0.174 (1.786)	0.62** (7.973)
South Africa	-0.811** (14.01)	-0.128 (1.298)	0.667** (9.035)
Uganda	-0.40** (4.352)	0.311** (3.309)	0.345** (3.712)

The estimates for commodity price and exchange rate show a significant positive relation in all the countries. This implies that commodity price shocks induce exchange rate depreciations in these countries. This may be attributed to a rise in general prices that accompanied positive commodity price shocks. This rise in general prices leads to a decline in aggregate demand thereby resulting in exchange rate depreciation. This is similar to the findings by Jiménez-Rodríguez & Moralez-Zumaquero (2020) for commodity-exporting countries.

2. Literature Review

2.1 Theoretical Literature

Overtime, many commodity exporting countries have experienced poor performances in their macroeconomic environment and output growth. Two main strands of studies have provided possible explanations for the poor performances of these two indices as it relates to resource-rich commodity exporting economies. First, is the resource curse hypothesis (RCH) which explains that countries with abundance of natural resources are prone to suffer from what is generally regarded as the “Dutch Disease Syndrome”—a condition which commodity price booms induce real exchange rate appreciation, making other tradable sectors uncompetitive (Sachs & Warner, 2001; Benkhodja, 2014; Chukwu & Malikane, 2017) and second, the portfolio balance theory by Chen & Rogoff (2003). These two theories have overtime, been used to discuss the effects of macroeconomic policies on commodities price shocks on resource-rich commodities exporting countries.

According to received studies, the RCH model produces two-type effect on resource-rich commodities exporting economies —the “spending effect” (SE) and “resource movement effect” (RME) though, depending on the nature of the commodities and

the macroeconomic environments (Diao *et al.*, 2013; Benkhodja, 2014; Keho, 2017; Shao *et al.*, 2020). Resource curse studies demonstrate that, the SE occurs mainly as higher incomes resulting from increase in prices of primary commodities (especially) continually lead to increase in expenditures in the non-tradable sectors. On the other hand, the RME occurs as a result of the movement of labour from the non-boom to the boom sector due to high wage income in the boom sector. Therefore, when this happens, the booming sector competes sternly with other non-booming sectors for the available factors of production thus, leading to overall increase in prices of goods and level of incomes.

However, since the price of tradable goods is determined in international markets, the increase in incomes arising from gains of high prices has no effect on the tradable goods price. However, this conclusion is not entirely the case with the non-tradable goods as relative prices are significantly affected due to the fact that prices are determined in the domestic rather than the international markets. The increase in demand in the domestic economy arising from an increase in income and expenditures causes the prices of commodities to rise to a higher level, according to the magnitude of increase. As the relative prices of non-tradable goods increases, it leads to a comparative rise in the level of profitability in that sector which in turn, crowds out resources (labour and capital investments) from the tradable goods sector (Neary & Van Wijnbergen, 1986).

As the price of the factors of production rises in the boom sector, initial cost of marginal product of factors hired on the factors of production increases thus, leading to a contraction in the profitability margin and a decline in the boom tradable goods sector. The effect of lower profitability and decline in the tradable goods is such that it limits the capacity of the producers in the manufacturing sector to compete for higher prices of factor inputs in the production value chain. The overall direct effect to the economy therefore, is the decrease in the output level of the producers and the overall contraction of the traded goods sector.

The second strands of literature of portfolio balance theory by Chen & Rogoff (2003) discusses the appropriateness of macroeconomic stabilization policy in returning the economy to steady-state equilibrium after each round of price shocks. Specif-

ically, the theory showed how real exchange rate (RER) movements are influenced by changes in the demand and supply of domestic and foreign currency as a result of upward trajectory of commodity prices.

2.2 Empirical Literature

A plethora of studies have adopted these two theories in determining the effects of monetary policy instruments on commodities price shocks. According to the studies by Edwards & Yeyati (2005), Chia & Alba (2006) and Sangare (2016), flexible exchange rate regime is the best policy response to return the economy to steady-state equilibrium after external price shocks. Benkhodja (2014) investigated the relationship between monetary policy and the Dutch disease effect in an oil exporting economy using the multi-sector DSGE model. The study found that exchange rate targeting is more potent in tackling the twin challenges of spending and resource movement effects which occurred during the period of flexible prices and wages; and flexible wages and sticky prices regimes.

Similarly, Shao *et al.*, (2020) employed the spatial Durbin model and investigated the existence of the RME and the SE in the boom sector of western China provinces and found that in all the provinces, SE and RME are responsible for the appearance of the “Dutch disease effects” in the resource boom sector. Ball (2000) concluded that the nature of shocks to the exchange rate determines the choice of policy rules the monetary policy authority should adopt in keeping inflation rate more stable overtime. Related studies have investigated the effects of commodity price shocks on the exchange rate of commodity exporting countries. For example, Kassouri and Altıntaş (2020) examined the relation between commodity terms of trade shocks and real exchange rate (RER) in African commodity exporting countries. They concluded that commodity terms of trade shocks have significant asymmetric effects on RER in those countries.

Jiménez-Rodríguez & Moralez-Zumaquero (2020) evaluated the impacts of commodity price on exchange rates in 68 commodity exporting countries. The findings indicate that movements in commodity prices significantly influence exchange rates. Several studies have examined policy responses to external shocks. Edwards & Yeyati (2005) and Chia & Alba (2006) concluded that flexible exchange rate regime is

the best policy response to external shocks. Devereux (2004), however, showed that flexible exchange rate without activist monetary policy may not achieve the desired outcomes. Studies such as Svensson (2000) and Cuche-Curti *et al.* (2008) have shown that alternative monetary policy regimes such as inflation targeting can play a role in dampening cyclical macroeconomic fluctuations and improve welfare in small open economies.

Xu & Xu (2022) investigated the effect of monetary policy rules on external shocks in a small open economy using different DSGE models. The study found that interest rate targeting is key in providing lower welfare loss for five small open economies (SOEs). However, the result showed that the lower welfare loss effect varied across economies as result of differences in domestic economic variables.

The effects of commodity price shocks on macroeconomic performance have also been examined. Valejo (2017) assessed the effects of commodity price shocks on macroeconomic performance and fiscal outcomes in 8 Latin American (LA) countries. The results suggest that commodity price shocks cause economic fluctuations and influence fiscal variables in those countries.

Tule *et al.* (2017) also examined the macroeconomic consequences of commodity price shocks in ECOWAS countries. The results suggest that commodity prices have significant positive impacts on per capita income in ECOWAS region. These findings was similar to Chuku *et al.* (2018) that evaluated the macroeconomic effects of commodity price shocks in African economies. The findings show that commodity price shocks have significant effects on African economies. Roch (2019) investigated the macroeconomic effects of commodity price shocks in 22 commodity exporting countries. The findings indicate that commodity price shocks are an important driver of business cycle fluctuations. Mohtadi & Castells-Quintana (2021) assessed the effects of commodity price shocks on income inequality in a panel of 80 commodity-exporting countries. The results indicate that commodity price shocks have an impact on income inequality.

Few empirical studies have also investigated the alternative monetary rules to reduce the vulnerabilities of commodity-exporting countries to commodity price shocks.

Hove *et al.* (2015) evaluated alternative monetary policy rule to commodity term of trade shocks in South Africa. The findings suggest that CPI inflation targeting is the best response to commodity price shocks in South Africa. Ferero & Seneca (2018) examined alternative monetary policy rules to commodity price shocks in a small open economy. The findings indicate that flexible domestic inflation targeting is the best monetary policy rule. Filardo *et al.* (2020) examine monetary policy response to commodity price shocks in commodity exporting countries. The results show that core inflation targeting is the best monetary response to commodity price.

From the foregoing, it is obvious that commodity price shocks impact macroeconomic variables, such as output, inflation and exchange rates in commodity exporting countries. Hence, different policies have been recommended to mitigate the adverse effects of commodity price shocks in commodity exporting countries. Notable among the policies are fiscal and monetary policy rules. However, studies examining alternative monetary policy rules to have only focused on the adoption of inflation targeting and exchange rate targeting rules. None of these studies has incorporated nominal GDP targeting rule in their alternative monetary policy rules. Hence, this study fills the gap by including nominal GDP targeting rule among the alternative monetary policy rules for commodity exporting countries. Consequently, this study considers 3 alternative monetary policy rules- inflation targeting rule, exchange rate targeting rule and nominal GDP targeting rule- to reduce the vulnerabilities of commodity exporting countries to commodity price shocks.

3. Data and Methodology

3.1 Model

The model features a small open commodity-exporting economy which has consumers, firms and monetary authorities as the domestic actors. The model incorporates some frictions and nominal rigidities such as external habit formation in consumption, partial indexation of prices and staggered price setting. The model includes both internal and external shocks. Monetary policy is conducted through the Taylor interest rate rule. The model is made up of six equations: aggregate demand, aggregate supply, uncovered interest parity, external debt, commodity price dynamics and monetary policy reaction.

3.1.1 Households

The economy is made up of a representative household with the utility function:

$$U_t = \sum \beta^t \frac{1}{1-\sigma} \left[\left(\frac{C_t}{C_t^h} \right)^{1-\sigma} - \frac{N_t^{1+\psi}}{1+\psi} \right] \quad (1)$$

Where C_t , N_t , represent consumption and labour supply. The parameters are β^t which is the discount rate; σ is the relative risk aversion; ψ is the inverse of Frisch labour supply elasticity. The household has access to both domestic and international market and can borrow in domestic and foreign currencies.

The budget constraint is:

$$C_t + \frac{M_t}{P_t} + \frac{B_t}{P_t} - \frac{S_t D_t^*}{P_t} = \frac{W_t N_t}{P_t} + \frac{B_{t-1}}{P_t} (1 + r_{t-1}) + \frac{M_{t-1}}{P_t} - \frac{S_t D_t^*}{P_t} (1 + r_{t-1}^f) \quad (2)$$

Where B_t is the domestic bond; S_t is the nominal exchange rate; D_t^* is external debt; W_t is the wage rate; r_t is the domestic interest rate; r_{t-1}^f is the foreign interest rate.

3.1.2 The Firm

Similar to Andrés *et al.* (2009), the production function for firm j is given as:

$$Y_t(j) = a_t N_t(j)^{1-\alpha} \quad (3)$$

where $Y_t(j)$ represents output; a_t is the technology shock; $N_t(j)$ is the number of labour hours and $(1 - \alpha)$ is the elasticity of output with respect to labour hours. As in Calvo (1983), the representative firm sells its output in a monopolistically competitive market and sets prices on a staggered basis. Each firm has the probability $(1 - \theta)$ of adjusting the price at any given period and a probability θ that the firm keeps the price unchanged. The representative firm minimizes its cost of production and the real marginal cost is given as:

$$MC_t = \frac{1}{\alpha} \frac{W_t}{P_t} \left(\frac{Y_t}{A_t} \right)^{\left(\frac{1-\alpha}{\alpha} \right)} \frac{1}{A_t} \quad (4)$$

The New Keynesian Phillips Curve (NKPC) hybrid version with backward- and forward-looking components is stated:

$$\widehat{\pi}_t = \gamma_b \widehat{\pi}_{t-1} + \gamma_f \widehat{\pi}_{t+1} + \lambda \widehat{mc}_t \tag{5}$$

$$\begin{aligned} \gamma_b &\equiv \omega \{ \theta + \omega [1 - \theta (1 - \beta)] \}^{-1} ; \lambda \equiv (1 - \theta) (1 - f) (1 - \omega) \xi \\ \gamma_f &\equiv f \{ \theta + \omega [1 - \theta (1 - \beta)] \}^{-1} ; \xi \equiv \frac{(1 - \alpha)}{1 + \alpha(\epsilon - 1)} \{ \theta + \omega [1 - \theta (1 - \beta)] \}^{-1} \end{aligned}$$

where θ is the price stickiness, ω is the price indexation and ϵ is the goods elasticity of substitution. Expression (4) and (5) characterize the supply side of the model. Eq. (5) is the hybrid New Keynesian Phillips curve that includes past and expected inflation terms, and the real marginal cost (Galí and Gertler, 1999). The real marginal cost in turn depends on lag and current output and real balances. Real marginal cost also depends on foreign output (Galí & Monacelli, 2005). Moreover, our real marginal cost depends on real exchange rate shocks. African countries depend largely on foreign inputs for domestic production, hence real exchange rate affects domestic output.

3.1.3 Resource constraint

Similar to McCallum and Nelson (2000), the macro-balance for the domestic output is:

$$\widehat{y}_t = \omega_c \widehat{c}_t + \omega_x \widehat{x}_t - \omega_z \widehat{z}_t \tag{6}$$

where x_t is the export, z_t is the import and the parameters ω_c ; ω_x and ω_z are the steady-state ratio of consumption, export and import to domestic output. Hence, our net export is defined as:

$$\widehat{nx}_t = \omega_f \widehat{y}_t^f - \omega_y \widehat{y}_t + \omega_r \widehat{q}_t \tag{7}$$

where \widehat{y}_t^f is the foreign output, \widehat{q}_t is the real exchange rate, ω_f is the elasticity of net export with respect to foreign output, ω_y is elasticity of net export to domestic output,

and ω_r is the sum of elasticity substitution in production for home and abroad. The real exchange rate is defined as $\hat{q}_t = \hat{s}_t + \hat{p}_t^* - \hat{p}_t$ where \hat{s}_t is the nominal exchange rate, \hat{p}_t^* is the foreign index price, \hat{p}_t and is the domestic index price.

3.1.4 Commodity sector

Similar to Medina & Soto (2016), it is assumed that there is an exogenous endowment of the commodity good which is completely exported. Demand for the commodity good is perfectly elastic at price cp_t . The domestic price of the commodity good is given as:

$$dcp_t = s_t cp_t \quad (8)$$

We assume that the log-deviation of real commodity price (commodity prices deflated by the US general price level) can be represented as an AR(1) process:

$$rcp_t = \rho_{cp} rcp_{t-1} + \varepsilon_{cp,t} \quad (9)$$

Where $0 < \rho_{cp} < 1$

3.1.5 External debt and Exchange rate

Developing countries borrow at a premium and their borrowing behaviour is influenced by commodity price and foreign interest rate shocks (Senhadji, 2003). Thus, the interest rate on their foreign debt is made up of the foreign risk-free rate and the risk premium. The sovereign risk premium is a negative function of commodity prices and a positive function of the existing debt. Senhadji (2003) shows that a positive shock to commodity prices reduces the country spread and cost of borrowing for commodity exporting countries. Uribe & Yue (2006) conclude that a positive shocks to foreign risk free increases the country spread and cost of borrowing. The interest rate on external debt is defined as:

$$\hat{r}_t^d = \kappa_d \hat{r}_t^f - \kappa_c \hat{cp}_t + \kappa_d \hat{d}_t^* \quad (10)$$

where r_t^f is the foreign interest rate, cp_t is the commodity prices and d_t^* is the ratio of external debt to GDP. The equation shows that interest rate on external debt is a positive function of foreign interest rate and existing external debt and a negative function of commodity price. The external debt is made up of external imbalance and interest rate on existing debt. The external debt as a ratio of GDP is:

$$d_t^* = \frac{Z_t - X_t}{Y_t} + r_t^d d_{t-1}^* \tag{11}$$

where d_t^* is the ratio of external debt to GDP, $(Z_t - X_t)$ is the external imbalance. The equation is linearized to yield:

$$\hat{d}_t = \frac{1}{(1-\kappa_d)} \hat{d}_{t-1} + \frac{\omega_d}{(1-\kappa_d)} \hat{r}_t^f - \frac{\kappa_c}{(1-\kappa_d)} \hat{p}_t^c + \frac{\omega_f}{(1-\kappa_d)} \omega_f \hat{y}_t^f - \frac{\omega_y}{(1-\kappa_d)} \hat{y}_t + \frac{\omega_r}{(1-\kappa_d)} \hat{q}_t \tag{12}$$

Eq. (12) describes the external debt evolution. There is a negative relation between external debt and commodity prices. In addition, external debt to GDP depends negatively on domestic output and positively on foreign output. Lastly, external debt to GDP depends positively on foreign interest rate and real exchange rate. This suggests that as exchange rate rises (depreciates), external debt increases in value.

The uncovered interest parity (UIP) condition is given as:

$$\hat{s}_t = E_t \hat{s}_{t+1} - \left(\hat{r}_t - \hat{r}_t^f \right) - \alpha_c \hat{p}_t^c \tag{13}$$

where \hat{s} is the nominal exchange rate, $\left(\hat{r}_t - \hat{r}_t^f \right)$ is the risk premium, is the elasticity of exchange rate with respect to commodity prices and is the elasticity of exchange rate with respect to external debt.

3.1.6 Central Bank Reaction Function

We specify a Taylor rule reaction function. Policy rate is not only driven by inflation gap and output gap but also by exchange rate gap. Empirical evidence has shown that monetary authorities in developing countries react to real exchange rate deviations (Mohanty, 2004; Muhanji and Ojah, 2011).

$$\widehat{r}_t = \rho_r \widehat{r}_{t-1} + (1 - \rho_r) (\rho_\pi \widehat{\pi}_t + \rho_y \widehat{y}_t + \rho_q \widehat{q}_t) + \varepsilon_t^r \quad (14)$$

where all the variables are in the steady states. r_t represents interest rate π_t is inflation rate; y_t is output gap; q_t is the real exchange rate gap. The uncorrelated monetary disturbance follows an ARMA(1) process: $\varepsilon_t^r = \rho_a \varepsilon_{t-1}^r + \mu_t^c$ The parameters ρ_r is the policy rate smoothing, ρ_π is policy response to inflation gap, ρ_y is policy response to output gap, ρ_q is policy response to real exchange rate shocks.

The log-linearized equations for the study are:

$$\begin{aligned} \widehat{y}_t = & \frac{(\sigma-1)}{\sigma+h(\sigma-1)} \widehat{y}_{t-1} + \frac{\sigma}{\sigma+h(\sigma-1)} \widehat{y}_{t+1} - \frac{\omega_c}{\sigma+h(\sigma-1)} (\widehat{r}_t - E \widehat{\pi}_{t+1}) - \frac{h(\sigma-1)\omega_r}{(1+\omega_y)(\sigma+h(\sigma-1))} \widehat{q}_{t-1} + \\ & \frac{\omega_r}{(1+\omega_y)} \widehat{q}_t - \frac{\sigma\omega_r}{(h+\omega_y)(\sigma+h(\sigma-1))} \widehat{q}_{t+1} - \frac{h(\sigma-1)\omega_f}{(1+\omega_y)(\sigma+h(\sigma-1))} \widehat{y}_{t-1}^f + \frac{\omega_f}{(1+\omega_y)} \widehat{y}_t^f - \\ & \frac{\sigma\omega_f}{(1+\omega_y)(\sigma+h(\sigma-1))} \widehat{y}_{t+1}^f \end{aligned} \quad (15)$$

$$\widehat{\pi}_t = \gamma_b \widehat{\pi}_{t-1} + \gamma_f \widehat{\pi}_{t+1} + \lambda \widehat{m}c_t \quad (16)$$

$$\widehat{m}c_t = \beta_a \widehat{y}_t - \beta_b \widehat{y}_{t-1} - \beta_c \widehat{m}_t + \beta_d \widehat{q}_{t-1} - \beta_e \widehat{q}_t + \beta_f \widehat{y}_{t-1}^f - \beta_g \widehat{y}_t^f - \beta_h \widehat{a}_t \quad (17)$$

$$\widehat{d}_t = \frac{1}{(1-\kappa_d)} \widehat{d}_{t-1} + \frac{\omega_d}{(1-\kappa_d)} \widehat{r}_t^f - \frac{\kappa_c}{(1-\kappa_d)} \widehat{p}_t^c + \frac{\omega_f}{(1-\kappa_d)} \omega_f \widehat{y}_t^f - \frac{\omega_y}{(1-\kappa_d)} \widehat{y}_t + \frac{\omega_r}{(1-\kappa_d)} \widehat{q}_t \quad (18)$$

$$\widehat{s}_t = E_t \widehat{s}_{t+1} - (\widehat{r}_t - \widehat{r}_t^f) - \alpha_c \widehat{rcp}_t \quad (19)$$

$$\widehat{rcp}_t = \rho_{cp} \widehat{rcp}_{t-1} + \varepsilon_{cp,t} \quad (20)$$

$$\widehat{r}_t = \rho_r \widehat{r}_{t-1} + (1 - \rho_r) (\rho_\pi \widehat{\pi}_t + \rho_y \widehat{y}_t + \rho_q \widehat{q}_t) + \varepsilon_t^r \quad (21)$$

Equation (15) is our dynamic IS equation featuring output as a positive function of lead and lag of domestic output. Further, it features output as a negative function of real interest rate showing that higher interest rate lowers output. Output is also a positive function of contemporaneous money supply, indicating that when money supply increases, interest rate declines, investment rises and output increases. But it is a negative function of lag money supply. Moreover, output is a positive function

of contemporaneous real exchange rate and foreign output. This suggests that when exchange rate depreciates, output increases through the export channels. Also, a rise in global output results in an increase in domestic output through increased demand for exports. Equation (17) represents the hybrid NKPC where inflation is both backward and forward looking and also as a function of marginal cost (unit cost). The unit cost is a positive function of output, implying that an increase in aggregate demand leads a rise in consumer prices.

Marginal cost is also a positive function of lagged real exchange rate and foreign output. Further, the marginal cost is a positive function of exchange rate, indicating that a rise in exchange rate increases the unit cost of production and hence price level. Equation (18) is the external debt dynamics equation. It shows that current external debt is a positive function of existing stock of debt, foreign interest rate, foreign output and exchange rate. This indicates that as foreign interest rate rises, the cost of servicing debt increases and the current debt.

Further, the depreciation of the exchange rate increases the cost of servicing debt if the debts are denominated in foreign currencies and hence, increases the stock of debt (Korinek, 2011) Equation (19) is the uncovered interest parity (UIP) equation showing the dynamics of exchange rate. It shows that exchange is a negative function of the risk premium and commodity prices. A rise in the risk premium occasioned by an increase in the foreign interest rate will lead to exchange rate depreciation (García & González, 2013). Lastly, equation (21) represents the central banks reaction function. It shows interest rate smoothing and policy reaction to inflation gap, exchange rate gap and exchange rate gap. Findings have shown that monetary authorities in African countries react to exchange rate gap (Muhanji & Ojah, 2011; Rasaki & Malikane, 2015).

3.2 Data

The study employed quarterly data for 5 African countries that are commodity-exporting countries. The 5 countries are Kenya, Malawi, Nigeria, South Africa, and Uganda. The quarterly data cover the period 1995q1-2021q4. The macroeconomic variables include GDP, CPI, money supply, interest rates, commodity prices,

external debt, exchange rate, foreign interest rates proxied by LIBOR and foreign output proxied by the US GDP. The data for external debt is annual; we extrapolate it into quarterly data. The sample size differs among countries based on the availability of data. For Nigeria, South Africa and Uganda, the sample size covers 1995q1-2021q4. But for Kenya and Malawi, the sample size covers 2000q1-2021q4. The study employed Bayesian technique.

3.3 Estimation methodology

In line with existing studies on DSGE model estimation (Smets & Wouters, 2003; Boileau & Normandin, 2017), we estimate our model using Bayesian technique. We estimate posterior mean of the parameters and shocks obtained from random walk Metropolis-Hasting (M-H) algorithm. The posterior estimates are based on the likelihood function generated by the DSGE model, and we use a prior distribution that incorporates additional information in the estimation. The estimated posterior mean is obtained by maximizing the log of posterior distribution with respect to the parameters. From the reduced form solution of the model, we compute a state space representation of the model where unobserved state variables are mapped into the observed data.

The Kalman filter technique is applied to the reduced form in order to calculate the likelihood function of the observed data. To obtain posterior mean, a numerical optimization of the likelihood function is multiplied by the prior. In our estimates, we generate 250,000 draws from the posterior distribution using a random walk chain with a normal distribution. The first 100,000 draws were dropped as the burn-in period and the remaining parameter draws were used to compute the posterior estimates and impulse responses. The impulse-response functions are derived from the posterior mean of the Bayesian estimates.

The measurement equation links the observed variables with the model variables. The measurement equation is given as:

$$\begin{bmatrix} \Delta \ln RGDP_t \\ \Delta \ln MS_t \\ \Delta \ln Extdebt_t \\ \Delta \ln Comprice_t \\ \Delta \ln P_t \\ \Delta \ln RER_t \\ \Delta \ln r_t \\ \Delta \ln RGDP_t^* \\ \Delta \ln r_t^* \\ \Delta \ln P_t^* \end{bmatrix} = \begin{bmatrix} \hat{y}_t - \hat{y}_{t-1} \\ \hat{m}_t - \hat{m}_{t-1} \\ \hat{d}_t^* - \hat{d}_{t-1}^* \\ \hat{c}p_t - \hat{c}p_{t-1} \\ \hat{\pi}_t \\ \widehat{RER}_t - \widehat{RER}_{t-1} \\ r_t \\ \hat{y}_t^* - \hat{y}_{t-1}^* \\ \hat{r}_t^* \\ \hat{P}_t^* \end{bmatrix} \tag{21}$$

3.4 Calibrated parameters

Table 2: Correlation between commodity price shocks and macroeconomic aggregates

parameters	Description of parameters	Value of parameters
σ	Relative risk aversion	1.5
ψ	Inv. of Frisch lab. elasticity	2.00
φ	Interest rate elasticity of money demand	0.25
ω_c	elasticity of consumption to output	0.4
ω_y	elasticity of net export to domestic output	0.4
ω_r	Sum of elasticity of sub. in prod. for home and abroad	0.4
ω_f	elasticity of net export to foreign output	0.4
γ_r	External debt exchange rate elasticity	0.7
γ_y	Commodity-exchange rate elasticity	0.7

Table 3 presents the estimates for the structural parameters. The habit formation parameter is estimated to be more than 50% in all the countries. The estimate of Calvo pricing, representing degree of price stickiness, θ ranges around 0.9 for all the countries while the degree of price indexation is around 0.5. The parameter estimates of central bank reaction functions indicate evidence of high degrees of policy smoothing by monetary authorities. Similarly, the parameter estimates for reactions to inflation, ρ_π , suggest strong long run reaction of monetary policy to inflation in African countries except in Morocco. However, the policy response to output gap

is found to be mild in all the African countries suggesting minimal policy reaction to output gap. Lastly, the estimates show moderate policy reaction to exchange rate gap.

Table 3: Estimates of Structural Shock Parameters

Par.	Prior		Posterior mean				
	Mean	Std.	Kenya	Malawi	Nigeria	South Africa	Uganda
h	0.70	0.1	0.692	0.794	0.605	0.585	0.824
α	0.33	0.1	0.576	0.252	0.314	0.497	0.284
ω	0.50	0.1	0.314	0.654	0.59	0.351	0.469
θ	0.70	0.1	0.569	0.62	0.666	0.732	0.345
κ_c	0.50	0.1	0.6	0.377	0.289	0.048	0.696
κ_d	0.50	0.1	0.051	0.251	0.354	0.049	0.413
α_c	0.50	0.1	0.479	0.368	0.1	0.048	0.143
α_d	0.50	0.1	0.704	0.54	0.312	0.512	0.623
ρ_r	0.75	0.1	0.706	0.503	0.913	0.634	0.685
ρ_π	1.50	0.125	1.351	1.591	1.259	1.301	1.319
ρ_y	0.12	0.05	0.05	0.133	0.244	0.342	0.142
ρ_q	0.50	0.2	0.126	0.41	0.474	0.785	1.035
ρ_a	0.70	0.1	0.738	0.783	0.967	0.786	0.854

Table 4: Estimates of Structural Shock Parameters

Shocks	Prior		Posterior mean				
	Mean	Std.	Kenya	Malawi	Nigeria	South Africa	Uganda
η_y	0.1	2.0	0.066	0.05	0.084	0.585	0.037
η_r	0.1	2.0	0.026	0.036	0.032	0.2	0.027
η_d	0.1	2.0	0.492	2.93	2.172	0.415	2.78
η_q	0.1	2.0	0.07	0.128	0.101	0.044	0.047
η_a	0.1	2.0	0.145	0.014	0.171	0.032	0.025
η_{cp}	0.1	2.0	0.263	1.668	0.203	0.111	0.421
η_{rf}	0.1	2.0	0.012	0.014	0.012	0.012	0.014
η_{yf}	0.1	2.0	0.093	0.102	0.111	0.095	0.106
$\eta_{f\beta}$	0.1	2.0	0.015	0.015	0.022	0.013	0.014

Table 4 presents the estimates for the quantitative contributions of internal and external shocks to macroeconomic fluctuations in African countries. Since our variable of interest is commodity price shocks, we focus on its estimates. The results indicate that the effects of commodity price shocks on aggregate fluctuations is significantly different from zero in all the 5 African countries. The results show that commodity

price shocks have the greatest effects on economic fluctuations in Malawi and the least effects in South Africa.

4. Results and Discussion

4.1 Impulse response functions

This sub-section analyzes the impulse response functions of macroeconomic aggregates to commodity price shocks in African countries. Figure 1 displays the Bayesian estimates of impulse response functions of macroeconomic aggregates to commodity price shocks. Generally, the results show that commodity price shocks have the greatest effects on exchange rate movements in all the countries. Positive shocks to commodity prices lead to appreciation (fall) of the exchange rate, showing that these countries' currencies are commodity currencies.

Further, the impulse response functions show that positive commodity price shocks result in output decline in all the countries except Kenya, suggesting evidence of Dutch disease problem. In addition, the results suggest that positive commodity price shocks result in positive inflationary trends in all the countries.

Figure 2 shows the responses of macroeconomic aggregates to commodity price shocks under different monetary policy rules- inflation targeting (IT), exchange rate targeting (ERT) and nominal GDP targeting (NGDPT). We calibrate our parameter to simulate alternative policy rule to commodity price shocks in African countries. To gain more insights on the alternative policy rules, we consider best policy responses to positive and negative commodity price shocks. The simulations show that NGDPT is the best monetary rule to stabilize output in response to positive commodity price shocks. Positive commodity price shocks result in positive and lower output volatility under NGDPT rule but negative and higher output volatility under the IT and ERT rules. The largest fall in output occurs under the ERT rule. This is in contrast to the findings by Hove et al. (2015) for South Africa.

Further, the figure shows that the best policy rule to stabilize exchange rate under positive commodity price shocks is the IT rule. The highest volatility in exchange rate occurs under the ERT rule.

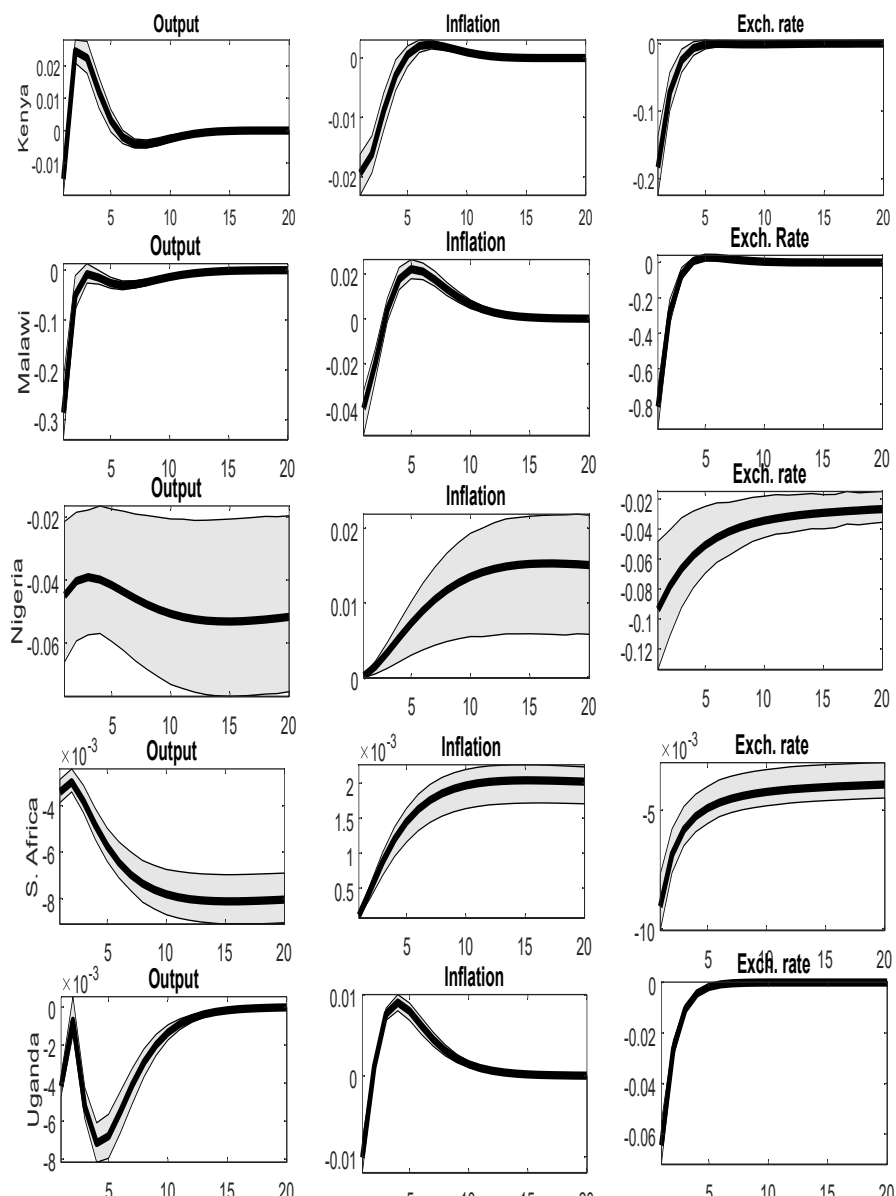


Fig 1: Impulse response functions to positive commodity price shocks.

For inflation, the analysis shows that positive commodity price shocks on impact leads to higher inflation under ERT and IT rules but lower inflation under NGDPT rule. This suggests that NGDPT rule is the best policy rule to stabilize price increases occasioned by positive commodity price shocks.

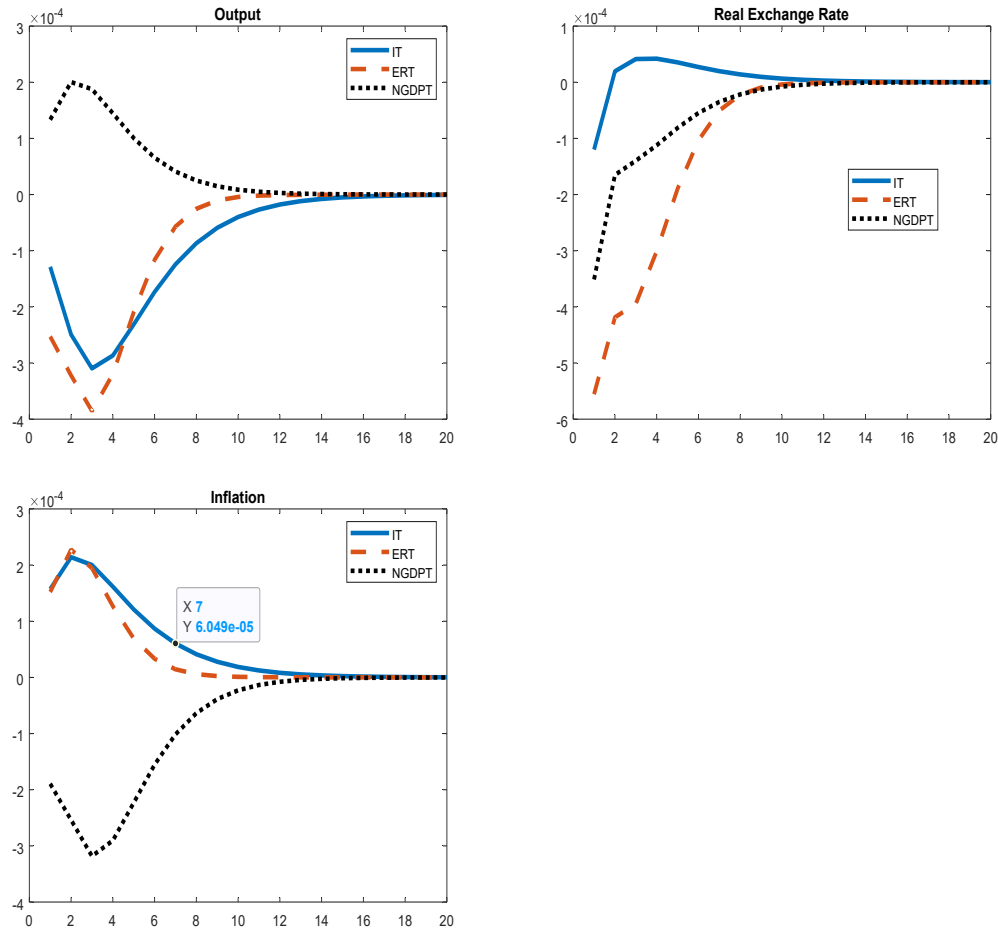


Fig. 2: Impulse response to commodity price shocks under alternative monetary policy rules with different values of ρ_π

Figure 3 displays the simulation analyses to negative commodity price shocks under different policy rules. The analysis shows that IT and NGDPT rules are the best policy responses to negative commodity price shocks as they have similar impacts on output. This indicates that IT and NGDPT rules are the best policies to stabilize output against negative commodity price shocks. To stabilize exchange rate against negative commodity price shocks, the ERT rule is the best policy. Lastly, the best policy rule to stabilize prices against negative commodity price shocks are IT and NGDPT rules.

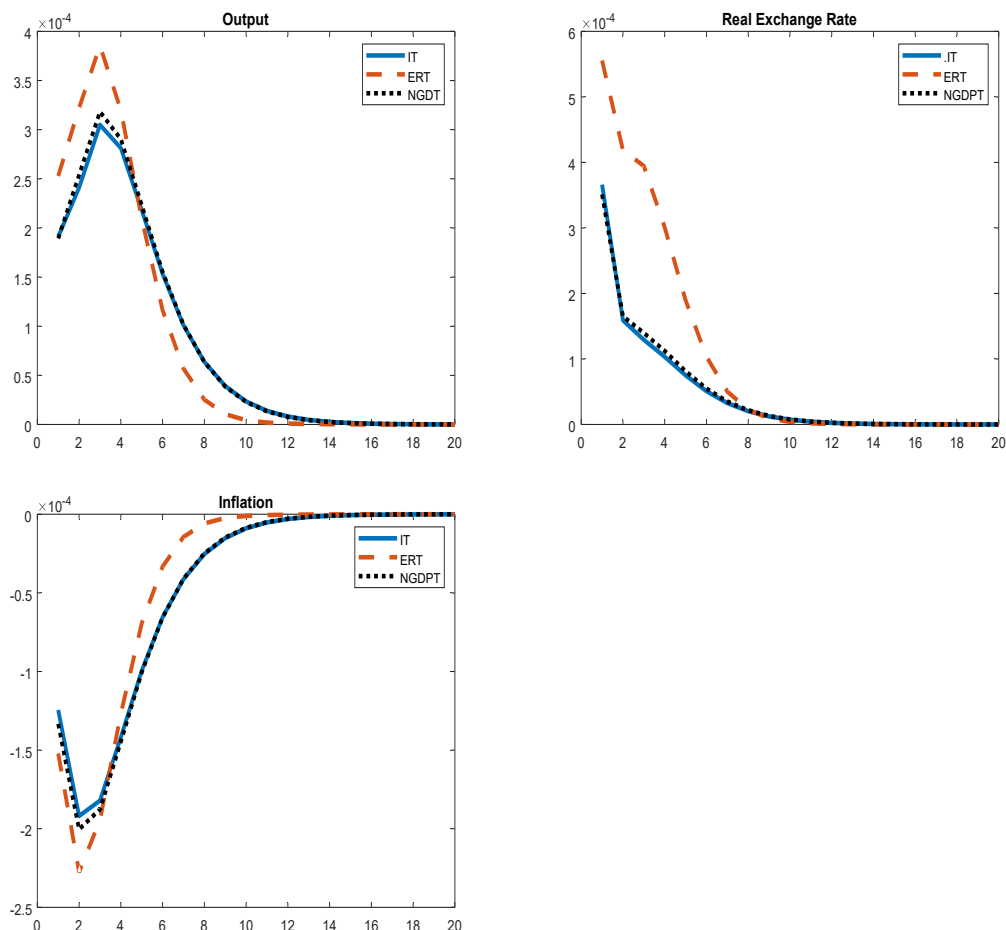


Fig. 3: Impulse response to negative commodity price shocks under alternative monetary policy rules.

4.2 Alternative monetary policy rules and central bank loss function

Most derivations of optimal monetary policy rule in the conduct of monetary policy have adopted the linear quadratic (LQ) approach which combines a quadratic objective function of the policy maker and a linear dynamic system capturing the economy (Benigno & Woodford, 2012). The LQ formulation of the optimal policy problem makes it possible to sort suboptimal policy rules by a criterion, consistent with the characterization given of optimal policy. The LQ approximation makes it easy to analyze if a solution to the first-order conditions for optimal policy also satisfies the relevant second-order conditions for optimality (Benigno & Woodford, 2012).

In line with the existing literature, we assume that the central bank minimizes a loss function (Hove et al., 2015). The central bank minimizes losses of deviation of inflation, output and exchange rate from their steady state values. The loss functions have been identified as a method of characterizing welfare loss. For instance, loss functions capture the main cost of inflation uncertainty; they allow the incorporation of policy smoothing (Clarida et al., 1999). The central bank loss function can be formulated as:

$$L_t = \vartheta_y y^2 + \vartheta_\pi \pi^2 + \vartheta_q q^2$$

After taking unconditional expectations, the loss function can be written as:

$$E(L_t) = \lambda_y \text{Var}(y_t) + \lambda_\pi \text{Var}(\pi_t) + \lambda_q \text{Var}(q_t)$$

where y_t is the output, π_t is inflation and q_t is real exchange rate. $\text{Var}(y_t)$, $\text{Var}(\pi_t)$ and $\text{Var}(q_t)$ are the unconditional variances of output, inflation and real exchange rate respectively. In the choice of weight in the loss function, we follow Alpanda et al. (2010), Hove et al. (2015). We set alternative value of relative loss function from 0.5 to 2.0 with a margin of 0.5. The relative weights attached to each variable in the loss function indicate the preference of central bank in terms of stabilizing the variables.

Table 5 presents the results of the central bank loss function under different alternative policy rules. When the central bank places lower weight and equal weight on output, real exchange rate and GDP, NGDPT rule is the best policy. But as the central bank attaches greater weight to inflation, IT rules becomes the optimal policy.

Table 5: Central bank loss under alternative monetary policy rules

Weight on loss function			Central bank losses		
λ_π	λ_y	λ_q	IT	ERT	NGDT
0.5	0.5	0.5	0.000277	0.000528	0.000253
0.5	1.0	1.0	0.000312	0.000485	0.00462
1.0	0.5	1.0	0.000312	0.000485	0.000462
1.0	1.0	0.5	0.000277	0.000541	0.000369
1.5	1.0	1.5	0.000469	0.000573	0.000555
1.5	1.5	1.0	0.000431	0.000612	0.0004777
2.0	1.5	2.0	0.000626	0.000626	0.000685
2.0	2.0	1.5	0.000587	0.000685	0.000587

5. Conclusions and Recommendations

The paper formulates and simulates an open economy DSGE model to investigate an appropriate monetary response to commodity price shocks in 5 commodity-exporting African countries. First, we estimate the effects of commodity price shocks business cycle fluctuations in African counties. Then, we compare the effectiveness of IT, ERT and NGDPT rules against commodity price shocks. Lastly, using the central bank loss functions, we evaluate the optimal monetary responses to commodity price shocks.

The findings show that commodity price shocks contribute significantly to macroeconomic fluctuations in commodity-exporting African countries. Commodity price shocks impact output, inflation and real exchange rate in African countries. The results on alternative monetary policy rule are mixed. The findings show that NGDPT is the best policy rule to minimize output volatility and price variations against positive commodity price shocks. However, if the objective is to minimize the effects of positive commodity price shocks on exchange rate, the IT is the best policy rule. Further, the findings shows that IT and NGDPT are the best policy rules to stabilize output and prices against negative commodity price shocks while ERT is the best policy rule to stabilize exchange rate against negative commodity price shocks.

The estimates from the central bank loss functions show that central bank record lower losses under IT and NGDPT rules when the weight attached to inflation is lower while the central bank losses are lower under ERT rule when weights attached to inflation is higher. These results have important implication for monetary author-

ities in African countries. The findings imply that the policy rule to be adopted will depend on the objectives of the central banks. A single monetary policy rule cannot stabilize output, inflation and exchange rate instabilities occasioned by commodity price shocks. To mitigate the adverse effects of commodity price shocks, we hereby recommend that monetary authorities in African countries should adopt mixed policy rules based on the monetary policy objectives.

References

- Abdulkareem, A. & Abdulhakeem, K. (2016). Analyzing oil price-macroeconomic volatility in Nigeria. *CBN Journal of Applied Statistics*, 7(1a), 1-22.
- Allegret, J. P. & Benkhodja, M. T. (2015). External shocks and monetary policy in an oil exporting economy (Algeria). *Journal of Policy Modeling*, 37, 652-677.
- Alpanda, S., Kotzé, K., & Woglom, G. (2010). The role of the exchange rate in a New Keynesian DSGE model for the South African economy. *South African Journal of Economics*, 78(2), 170-191.
- Andres, J., Lopez-Salido, J.D. & Valles, J. (2006). Money in an estimated business cycle model of the euro area. *Economic Journal*, 116, 457-477.
- Arezki, R. & Ismail, K. (2013). Boom-bust cycle, asymmetrical fiscal response to and the Dutch disease. *Journal of development economics*, 101, 256-267.
- Baunsgaard, T. (2003). Fiscal policy in Nigeria: Any role for rules. *IMF working paper* (03), 155.
- Bawa, S, Abdullahi, I. S., Tukur, D., Barda, S. I. & Adams, Y. J. (2020). Asymmetric impact of oil price on inflation in Nigeria. *CBN journal of applied statistics*, 11(2), 85-113.
- Ball, L (2000). Policy rules and external shocks. *National Bureau of Economic Research*, Working paper, 7910.
- Benigno, P. & Woodford, M. (2012). Linear-quadratic approximation of optimal policy problems. *Journal of Economic Theory*, 147, 1-42.
- Benkhodja, M. T. (2014). Monetary policy and the Dutch disease effect in an oil exporting economy. *International Economics*, 138, 78-102.

- Boileau, M., & Normandin, M. (2017). The price of imported capital and consumption fluctuations in emerging economies. *Journal of International Economics*, 108, 67-81.
- Böwer, U., Geis, A., & Winkler, A. (2007). Commodity price fluctuations and their impact on monetary and fiscal policies in Western and Central Africa. *ECB Occasional Paper*, (60).
- Calvo, G.A. (1983). Staggered prices in a utility-maximizing framework. *Journal of Monetary Economics*, 12 (3), 383–398.
- Castelnuovo, E. (2012). Estimating the evolution of money’s role in the US monetary business cycle. *Journal of Money, Credit and Banking*. 44 (1), 23–52.
- Céspedes, L.F. & Velasco, A. (2014). Was this time different? fiscal policy in commodity republics. *Journal of Development Economics*, 106(C),92–106.
- Chen, K., & Lee, D. (2023). Commodity currency reactions and the Dutch disease: the role of capital controls. *Empirical Economics*, 1-25.
- Chen, Y., Rogoff, K., 2003. Commodity currencies. *Journal of International Economics* 60, 133–160. [https://doi.org/10.1016/S0022-1996\(02\)00072-7](https://doi.org/10.1016/S0022-1996(02)00072-7).
- Chia, W. & Alba, J. (2006). Terms of trade shocks and exchange rate regimes in a small open economy. *Economics Records*, 82, S41–S53.
- Cuche-Curti, N., Dellas, H. & Natal, J. (2008). Inflation targeting in a small open economy. *International Finance*, 11 (1), 1–18.
- Chuku, C., Simpasa, A. & Oduor, J. (2018). Macroeconomic consequences of commodity price fluctuations in African economies. *African Development Review*, 30(4), 329–345.
- Chukwu, A.B., & Malikane, C. (2017). Real exchange rate (RER) as a policy tool for diversification and growth in Africa. *The Journal of International Trade & Economic Development (RJTE)*, 27(5), 504–520.
- Clarida, R., Gali, J., & Gertler, M. (1999). The science of monetary policy: a new Keynesian perspective. *Journal of economic literature*, 37(4), 1661-1707.
- Devereux, M. (2004). Monetary policy rules and exchange rate flexibility in a simple dynamic general equilibrium model. *Journal of Macroeconomics*, 26 (2), 287–308.

- Drechsel, T., & Tenreyro, S. (2018). Commodity booms and busts in emerging economies. *Journal of International Economics*, 112, 200-218.
- Diao, X., Kennedy, A., Mabiso, A., & Pradesha, A. (2013). Economy-wide impact of maize export bans on agricultural growth and household welfare in Tanzania. international food policy Research Institute (IFPRI) *Discussion Paper*, 1287.
- Edwards, S. & Yeyati, L. (2005). Flexible exchange rates as shock absorbers. *European Economic Review*, 49, (8), 2079–2105.
- Englama, A., Duke, O. O., Ogunleye, T. S. & Ismail, F. U. (2010). Oil prices and exchange rate volatility in Nigeria: An empirical investigation. *CBN Economic and Financial Review*, 48(3), 31-48.
- Ferero, A. & Seneca, M. (2018). Notes on the Underground: Monetary Policy in Resource-Rich Economies. *Journal of Money, Credit and Banking*, 51(4), 953-976.
- Filardo, A. J., Lombardi, M. J., Montoro, C. & Ferrari, M. M. (2000). Monetary policy, commodity prices, and misdiagnosis risk. *International Journal of Central Banking*, 16(2), 45-79.
- Frankel, J. (2003). A proposed monetary regime for small commodity exporters: Peg the export price ('PEP'). *International Finance*, 6(1), 61-88.
- Galí, J. & Gertler, M. (1999). Inflation dynamics: a structural econometric analysis. *Journal of Monetary Economics*, 44, 195–222.
- Garcia, C. J., & González, W. D. (2013). Exchange rate intervention in small open economies: The role of risk premium and commodity price shocks. *International Review of Economics & Finance*, 25, 424-447.
- Gonzalez, A., Hamann, F. & Rodriguez, D. (2015). Macroprudential policies in a commodity exporting economy. *BIS Working Papers*, No. 506.
- Hove, S., Mama, A. T. & Tchana, F. T. (2015). Monetary policy and commodity terms of trade shocks in emerging market economies. *Economic Modelling*, 49, 53-71.
- Ighobor, K. (2017). Commodity prices crash hits Africa. African Renewal. <https://www.un.org/africarenewal/magazine/december-2016-march-2017/commodity-prices-crash-hits-africa>

- Iwayemi, A. & Fowowe, B. (2011). Impact of oil price shocks on selected macroeconomic variables in Nigeria. *Energy Policy* 39,603–612.
- Jimenez-Rodriguez, R. & Morales-Zumaquero, A. (2020). Impact of commodity prices on real exchange rate in commodity exporting countries. *The World Economy*, 43(7), 1868-1906.
- Kalyuzhnova, Y. (2011). The National Fund of the Republic of Kazakhstan (NFRK): From accumulation to stress-test to global future. *Energy policy*, 39(10), 6650-6657.
- Kassouri, Y. & Altintas, H. (2020). Commodity terms of trade shocks and real effective exchange rate dynamics in Africa's commodity-exporting countries. *Resource Policy*, 68, 101801.
- Keho, Y (2017). The impact of trade openness on economic growth: The case of Cote d'Ivoire. *Cogent Economics & Finance*, 5(1), 1332820, DOI:10.1080/23322039.2017.1332820
- Korinek, A. (2011). Foreign currency debt, risk premia and macroeconomic volatility. *European Economic Review*, 55, 371-385.
- Kormilitsina, A. (2011). Oil price shocks and the optimality of monetary policy. *Review of Economics Dynamics*, 14, 199-223.
- Leduc, S. & Sill, K. (2004). A quantitative analysis of oil price shocks, systematic monetary policy, and economic downturns. *Journal of Monetary Economics*, 51, 781-808.
- McCallum, B., & Nelson, E. (2000). Monetary policy for an open economy: an alternative framework with optimizing agents and sticky prices. *Oxford Review of Economic Policy*, 16(4), 74-91.
- Medina, J. P. & Soto, C. (2016). Commodity prices and fiscal policy in a commodity exporting country. *Economic Modelling*, 59, 335-351.
- Medina, J. P., & Soto, C. (2005). Oil shocks and monetary policy in an estimated DSGE model for a small open economy Central Bank of Chile Working Paper n°353.
- Mohtadi, S. & Castells-Quintana, D. (2021). The distributional dimension of the resource curse: Commodity price shocks and income inequality. *Structural Change and Economic Dynamics*, 59, 63–78.

- Montoro, C. (2012). Oil shocks and optimal monetary policy. *Macroeconomic Dynamics*, 16, 240-277.
- Muhanji, S. & Ojah, K. (2011). External shocks and persistence of external debt in open vulnerable economies: the case of Africa. *Economic Modeling*, 28, 1615–1628.
- Naraidoo, R. & Paez-Farell (2023). Commodity price shocks, labour market dynamics and monetary policy in small open economies. *Journal of Economics Dynamics & Control*, 151 (104654), 1-26.
- Neary, J. P., & Van Wijnbergen, S. (1986). Natural resources and the macroeconomy (No Title)
- Rasaki, M.G. & Malikane, C. (2015). Macroeconomic shocks and fluctuations in African economies. *Economic System*, 39, 675-696.
- Richaud, C, Galego, A. G. M., Ayivodji, F., Matta, S. & Essl, S. (2019). Fiscal vulnerability in commodity exporting countries and the role of fiscal policy. *World Bank Group Discussion Paper*, No. 115.
- Roch, F. (2019). The adjustment to commodity price shocks, *Journal of Applied Economics*, 22(1), 437-467.
- Sachs, J. D. & Warner, A. M. (2001). The curse of natural resources. *European Economic Review*, 45, 827- 838.
- Sanchez, M. (2005). The link between interest rates and exchange rates. Do contractionary depreciations make a difference? *ECB Working Paper Series*, No. 548.
- Sangaré, I. (2016). External shocks and exchange rate regimes in Southeast Asia: A DSGE analysis. *Economic Modelling*, 58, 365-382.
- Senhadji, A.S. (2003). External shocks and debt accumulation in a small open economy. *Review of Economics Dynamics*. 6, 207–239.
- Shao, S., Zhang, Y., Tian, Z., Li, D., & Yang, L. (2020). The regional Dutch disease effect within China: A spatial econometric investigation. *Energy Economics*, 88, 104766.
- Smets, F., & Wouters, R. (2003). An estimated dynamic stochastic general equilibrium model of the euro area. *Journal of the European economic association*, 1(5), 1123-1175.

- Svensson, L. (2000). Open-economy inflation targeting. *Journal of International Economics*, 50 (1), 155–183.
- Snudden, S. (2016). Cyclical fiscal rules for oil-exporting countries. *Economic Modeling*, 59, 473-483.
- Tule, M. K. (2014). Oil price shocks and real exchange rate movements in Nigeria. *CBN Economic and Financial Review*, 52(1), 29-45.
- Tule, M. K., Afangideh, U. J., Adeleke, A. I. & Ujunwa, A. (2017). Macroeconomic effects of commodity price shocks in ECOWAS. *The West African Economic Review*, 4(2), 1-27.
- UNCTAD (2022). The state of commodity dependence. United Nations Statistics, Geneva. <https://unctad.org/topic/commodities/state-of-commodity-dependence> Accessed online 27/7/2023.
- UNCTAD (2023). United Nations Statistics, Geneva. <https://unctadstat.unctad.org/wds/-ReportFolders/reportFolders.aspx?sCS`ChosenLang=en>. Assessed online: 22/6/2023.
- Uribe, M. & Yue, V.Z. (2006). Country spreads and emerging countries: who drives whom? *Journal of International Economics*. 69, 6–36.
- Valejo, L. A. P. (2017) Assessing the effects of commodity price shocks in the macroeconomic performance and fiscal outcomes in Latin American countries. *Cuestiones Economicas*, 27, (2:2), 143-170.
- Xu, X. & Xu, X. (2022). External shocks in a small open economy: an evaluation of monetary policy rules, *Economic Research-Ekonomska Istraživanja*, 1-27.
- Yamout, N. (2022). Potential output in a commodity-exporting economy. *Economic Record*, 98(320), 42-62.
- Yildirim, Z. & Arifli, A. (2021). Oil price shocks, exchange rate and macroeconomic fluctuations in a small oil exporting economy, *Energy*, 219, 119527s