Assessing Alternative Monetary Policy Instruments in African Economies

Abstract

This study compares the performance of the monetary aggregate and the interest rate as policy instruments for macroeconomic stabilisation in African economies. We use a new-Keynesian model where money and consumption are non-separable in the utility function. We find that the monetary aggregate is superior in responding to a variety of macroeconomic shocks in six of the ten countries. We also find a weak role of the interest rate compared to the monetary aggregate in driving aggregate demand dynamics. These results throw caution against a generalised move towards adoption of the interest rate as a policy instrument in African economies.

JEL Classification: E31; E52

Keywords: Monetary aggregate, interest rate, DSGE Model, Maximum Likelihood Estimation.

1. Introduction

This study compares the performance of the monetary aggregate and the interest rate as policy instruments for macroeconomic stabilisation in Africa. The International Monetary Fund (IMF) (2014) notes that there has been a 25 percent global drop in the use of money based instruments towards interest rates between 2003 and 2011. This drop follows evidence from several studies e.g. Svensson (2002) and Ireland (2004), which show the declining significance of the monetary aggregates over time. As observed by Berg et al. (2010), this tilt in global policy conduct contradicts the practice in Africa which has perverse macroeconomic factors. Some studies e.g. (IMF, 2008) argue for the continued use of monetary aggregates. Others e.g. Peiris and Saxegaard (2010) suggest adopting interest rates. The choice between the two, therefore, remains a major unresolved issue in Africa.

The significance of this study is that it will help policy makers reduce macroeconomic instabilities that are induced by sub-optimal monetary policy choices.

As shown by Baldini et al. (2015), inappropriate monetary policy choices can worsen macroeconomic performance. Mishkin (1999) and Kasekende and Brownbridge (2011) argue that monetary policy implementation and effectiveness in low income countries (LICs) is affected by several structural factors. These factors, which tend to impede the adoption of the interest rate as a policy instrument, include underdeveloped financial markets, supply shocks and fiscal dominance. Therefore, by including Africa specific factors, this study will assist authorities to make evidence based options as they attempt to modernize monetary policy implementation processes.

The gap that is filled by this paper is that standard new Keynesian literature e.g. Clarida et al. (1999), Woodford (2003) and Ireland (2004) tends to assume that central banks use the interest rates as the policy instrument. Even single-equation studies that explore policy rules in emerging market economies, e.g. Mohanty and Klau (2004), Moura and de Carvallo (2010) and Frömmel et al. (2011) consider only the interest rate as a monetary policy instrument. The only exception is the single-equation study by Mehrotra and Sanchez-Fung (2010). From the standpoint of DSGE models, several recent studies, e.g. Castelnouvo (2012) and Araujo (2015) find that the monetary aggregate plays a significant role in driving macroeconomic fluctuations. These findings signal the need to re-examine the role of the monetary aggregate as a policy instrument. This need is stronger for African economies, where real rather than nominal shocks dominate. Under real shocks, Bhattacharya and Sigh (2008) argue that welfare is enhanced by using the monetary aggregate and not the interest rate. It is therefore important to examine the relative efficiency of the two policy instruments in African economies.

The contribution of this paper is four-fold: firstly, different from Berg et al. (2010), Baldini et al. (2015), Peiris and Saxegaard (2010) and Muhanji and Ojah (2011) who use one policy rule, this paper compares two policy rules, the monetary aggregate and the interest rate. Secondly, different from these studies, both policy rules are derived from the central bank's optimisation behavior. Thirdly, unlike vast literature in Africa which use vector autoregressive models, this paper uses a DSGE model that is formulated on the assumption that money and consumption are non-separable in the utility function. The model thus explicitly introduces the role of real balances as a pivotal variable in driving African macroeconomic dynamics. This work, therefore, lays out a candidate empirical framework for monetary policy analysis in African economies.

The rest of the paper is organised as follows: Section 2, reviews monetary and exchange rate policy instruments and frameworks in ten selected African countries. Section 3 reviews literature. Section 4 lays out the DSGE model. Section 5 describes data and the estimation technique. Section 6 discusses the results while section 7 concludes and lays out the policy options.

2. Monetary and exchange rate policies

Table 1 is based on the Annual Report on Exchange Rate Arrangements and Exchange Restrictions (AREAER) (2014). Monetary policy is mostly implemented using the monetary programming model. According to Berg et al. (2013), this is due to its ability to capture complex macroeconomic linkages. Countries feature four different IMF programmes; the Extended Credit facility (ECF), Policy Support Instrument (PSI), Stand-By Facility (SBF) and the Precautionary Liquidity Arrangement (PLL).

All countries use the interest rate alongside the monetary aggregate through open market operations. According to Dornbusch and Fischer (1992), central banks may not achieve their objectives if they actively deploy money and interest rate instruments, simultaneously. This is corroborated by Davoodi et al. (2013) who show that, in East Africa, the dual deployment of these instruments often results in divergent impacts on macroeconomic variables.

Table 1: Monetary Policy Frameworks and Instruments in Selected African Countries

	Pol. Fram.	Pol. Inst.	Op. Targ.	Int. Targ.	Main Pol. Goal	Ex. R. Pol.	IMF Prog.
Egypt	Other	a, b, e, f	RM	Broad	Price	SA	Art.4
	(2006)	c, d	IBR	Money	Stability		(2015)
Ghana	IT	a, b	IBR	Inflation	Price Stab.	Float	ECF
	(2007)	c, d		Forecast	$8.5(\pm2)$		(2015)
Kenya	MAT	a, b, f	IBR	Broad	Price Stab.	Float	SBF
	(1992)	SF, c, d	RM	Money	$5(\pm2)$		(2015)
Mal.	MAT	a, b, f	RM	Broad	Price & Fin.	Float	ECF
	(1994)	c, SF, d	IBR	Money	Stability		(2012)
Mor.	Ex. Targ.	a, b, f	-	-	Price	CP	PLL
		c, SF, d			Stability		(2015)
Nigeria	MAT	a, b, f,	RM	Broad	Price & Fin.	OMF	Art.4
		c, d	IBR	money	Stability		(2014)
S. Africa	IT	a, b	IBR	Inflation	Price	Float	None
	(2000)	SF		forecast	Stab. $(3-6)$		
Tanz.	MAT	a, b, f	RM	Broad	Price	Float	PSI
	(1992)	c, d	IBR	money	Stability		(2014)
Uganda	IT	a, b	IBR	Inflation	Price	Float	PSI
	(2014)	c, d		forecast	Stab. (5)		(2013)
Zambia	MAT	a, b, f	RM	Broad	Price &	Float	Art. 4
	(1994)	c, d	IBR	money	Stability		(2015)

Source: IMF 2014 AREAER and various central bank websites

Notes:

a⇒Policy rate, b⇒Open Market Operations, SF⇒Standing Facility,MAT⇒Monetary Aggregate Targeting, RM⇒Reserve Money, IT⇒Inflation Targeting, Exr, Tar⇒Exchange rate targeting, IBR=Interbank rate, c⇒Liquidity Reserve Requirement, d⇒Foreign Exchange Operations, OMF⇒Other Managed Float, SA⇒Stabilisation Arrangement, CP⇒Conventional Peg. Egypt and Zambia (Since 2014) have no explicitly stated nominal anchors i.e. "other" frameworks. frameworks. Article 4 are initial consultations with the IMF

3. Literature Review

Empirical evidence on the choice of money and interest rate instruments remains divided. The literature converges on the fact that when economic shocks are real, the use of money-based policy instruments is superior for macroeconomic stabilisation. On the contrary, when shocks are nominal, interest rate policy instruments perform better. Early evidence for this has been documented by Poole (1970), Gordon (1979) and Canzoneri and Dale (1989). Other earlier studies however e.g. Sargent and Wallace (1975) and Taylor (1999) argue that equilibrium indeterminacy gives interest rates a natural disadvantage. They argue that when inflation is very high or negative, inflation expectations are not stable. In such cases, the interest rate instrument loses its advantage over money supply.

The divergence on the role of monetary aggregates and interest rates in driving macroeconomic fluctuations is also reflected in recent literature. For example, Rudebusch and Svensson (2002) and Ireland (2004) use the new Keynesian framework and dispel the role of monetary aggregates in driving business cycles. Resurrecting a nearly concluded debate, Favara and Giordani (2009) argue that estimation techniques could be responsible for the insignificance of monetary aggregates. Indeed, recent studies e.g. Canova and Menz (2011), Benchimol and Forcas (2012), Castelnouvo (2012) and Araujo (2015) find significant role of monetary aggregates in driving macroeconomic dynamics. While alluding to the significance of monetary aggregates, these studies, however, do not examine the effectiveness of money-based instruments as stabilisation tools.

The divide in the literature on policy instruments also applies in Africa. For example, Berg et al. (2010), argue that strict adherence to interest rates is not beneficial for inflation and output stabilisation in Tanzania, Uganda and Ghana. On the contrary, Andrle et al. (2013), find that monetary targeting has not played a systematic role in Kenya. This is corroborated by Peiris and Saxegaard (2010) who show that due to higher interest rate volatility, the interest rate instrument performs better in stabilising the real sector in Mozambique. As shown by Baldini et al. (2015), high risk aversion influences liquidity conditions in Africa and hence credit, output and inflation. Given these conditions, interest rates alone fall short of dealing with macroeconomic fluctuations across countries.

A number of other authors have examined the role of respective monetary policy instruments in Africa. For example, Rasaki and Malikane (2015) identify monetary aggregates as significant contributors to business cycle fluctuations in Africa. Muhanji et al. (2013) combine the Taylor (1993) and McCallum (1994) rules and argue that to design context specific optimal policy in Africa, there is need to correctly configure key policy parameters. Davoodi et al. (2013) show that in the East African Community, the reserve money and policy rate are often deployed simultaneously. Most often, these instruments exert divergent impacts on macroeconomic dynamics. Although these studies have assisted in understanding monetary policy dynamics in Africa, they do not directly address the question of the choice between the monetary aggregate and the interest rate as policy instruments.

4. The model

4.1 Households

We specify a DSGE model where real balances enter the utility function with non-separable argument. As argued by O'Conell (2011) and Berg et al. (2010), Africa is largely a cash continent and monetary aggregates may still play an important role. This role, as argued by Canova and Menz (2011), can result from the effect that real balances have on the marginal rate of substitution between consumption and leisure and hence the real wage. Changes in real wage affects marginal costs and hence can have impact on the IS and Phillips curves. Given the importance of imports in Africa, as observed by Senbeta (2011), we assume that household consumption is composed of domestically produced goods, C_t^d and imports, C_t^m. Using a constant relative risk aversion (CRRA) utility function, the representative household's preferences are given as follows:

$$U_t = E_t \sum_{j=0}^{\infty} \beta^j \left\{ \frac{1}{1-\sigma} \left[\left(C_t^d - hC_{t-1}^d \right)^{1-\sigma} + \left(C_t^m - hC_{t-1}^m \right)^{1-\sigma} \right] \left(\frac{M_t}{P_t} \right)^{\phi} - \frac{N_t^{1+\varphi}}{1+\varphi} \right\} \quad (1)$$

where $\beta^j \in (0,1)$ is the intertemporal discount factor, $1/\sigma$ is the elasticity of intertemporal substitution, ϕ is the elasticity of money demand, M_t represent nominal money balances, h is a measure of habit formation as in Smets and

Wouters (2003). Household labour supply is represented by N_t while φ is the inverse of the Frisch labour supply elasticity.

Households hold their current assets in three forms, money M_t, domestic bonds B_t and foreign bonds B_t^f. The household budget constraint is therefore given as:

$$\frac{M_t}{P_t}+\frac{B_t}{P_t}+\frac{Z_tB_t^f}{P_t} = \frac{W_tN_t}{P_t}+\frac{M_{t-1}}{P_t}+\frac{(1+r_{t-1})B_{t-1}}{P_t}+\frac{Z_t(1+r_{t-1}^f)B_{t-1}^f}{P_t}-C_t^d-Q_tC_t^m \tag{2}$$

where W_t is nominal wage, Z_t is the nominal exchange rate measured as domestic currency per unit of foreign currency, $Q_t = \frac{Z_tP_t^f}{P_t}$ stands for real exchange rate, P_t is the overall domestic price level, P_t^f stands for foreign price level. The variables r_t and r_t^f denote returns on the domestic and foreign bonds, respectively. It is assumed that $\sigma > 0$ and $0 \leq \phi \leq 1$.

The household problem constitutes choosing intertemporal levels of C_t^d, C_t^m, B_t, B_t^f, M_t and N_t that maximise the expected utility in eq.(1) subject to budget constraint set in eq.(2). The resulting first order conditions are:

$$\left(C_t^d - hC_{t-1}^d\right)^{-\sigma}\left(\frac{M_t}{P_t}\right)^{\phi} = \lambda_t \tag{3}$$

$$\left(C_t^m - hC_{t-1}^m\right)^{-\sigma}\left(\frac{M_t}{P_t}\right)^{\phi} = Q_t\lambda_t \tag{4}$$

$$\beta E_t\lambda_{t+1}\left(\frac{1+r_t}{1+\pi_{t+1}}\right) = \lambda_t \tag{5}$$

$$\beta E_t\lambda_{t+1}\left(\frac{1+r_t^f}{1+\pi_{t+1}}\right)\left(\frac{Z_{t+1}}{Z_t}\right) = \lambda_t \tag{6}$$

$$\frac{\phi}{1-\sigma}\left(\frac{M_t}{P_t}\right)^{\phi-1}X_t = \lambda_t - \beta E_t\left\{\lambda_{t+1}\left(\frac{1}{1+\pi_{t+1}}\right)\right\} \tag{7}$$

$$\frac{N_t^{\varphi}}{\lambda_t} = \frac{W_t}{P_t} \tag{8}$$

where λ_t is the Lagrangian multiplier and $X_t = \left[\left(C_t^d - hC_{t-1}^d\right)^{1-\sigma} + \left(C_t^m - hC_{t-1}^m\right)^{1-\sigma}\right]$.

4.2 Aggregate demand

The Taylor approximation of eq.(3) to eq.(7) around the steady state yields the following:

$$\begin{aligned}\hat{c}_t^d &= \frac{1}{1+h}E_t\hat{c}_{t+1}^d + \frac{h}{1+h}\hat{c}_{t-1}^d - \frac{(1-h)}{\sigma(1+h)}(\hat{r}_t - E_t\hat{\pi}_{t+1}) \\ &\quad + \frac{\phi(1-h)}{\sigma(1+h)}(\hat{m}_t - E_t\hat{m}_{t+1}) \end{aligned} \tag{9}$$

$$\begin{aligned}\hat{c}_t^m &= \frac{1}{1+h}E_t\hat{c}_{t+1}^m + \frac{h}{1+h}\hat{c}_{t-1}^m - \frac{(1-h)}{\sigma(1+h)}(\hat{r}_t - E_t\hat{\pi}_{t+1}) \\ &\quad + \frac{\phi(1-h)}{\sigma(1+h)}(\hat{m}_t - E_t\hat{m}_{t+1}) - \frac{(1-h)}{\sigma(1+h)}(\hat{q}_t - E_t\hat{q}_{t+1}) \end{aligned} \tag{10}$$

Eq.(9) and eq.(10) are Euler equations for domestic and imported consumption. An accent above the variable stands for the percentage deviation of the variable from its steady state.

In order to derive aggregate demand dynamics, we follow McCallum and Nelson (2000) and state the following open economy resource constraint equation:

$$\hat{y}_t = \tau_c\hat{c}_t^d + \tau_x\hat{x}_t - \tau_m\hat{c}_t^m \tag{11}$$

where $\hat{x}_t$ is the deviation of exports from their steady state. The terms $\tau_c = \frac{\hat{c}_0^d}{\hat{y}_0}$, $\tau_x = \frac{\hat{x}_0}{\hat{y}_0}$, and $\tau_m = \frac{\hat{c}_0^m}{\hat{y}_t}$ are steady state ratios of the adjacent variables to total output. Following Woodford (2000), we abstract from the inclusion of investment in the resource balance equation. As in McCallum and Nelson (2000) we further specify the following export function:

$$\hat{x}_t = \gamma_q\hat{q}_t + \gamma_f\hat{y}_t^f \tag{12}$$

Substituting eq.(10) and eq.(12) into eq.(11) and using the fact that $\tau_c \hat{y}_t = \hat{c}_t^d$, $\tau_x \hat{y}_t = \hat{x}_t$,and $\tau_m \hat{y}_t = \hat{c}_t^m$ yields the following expression:

$$\begin{aligned} \hat{y}_t &= \kappa_1 E_t \hat{y}_{t+1} + \kappa_2 \hat{y}_{t-1} - \kappa_3(\hat{r}_t - E_t \hat{\pi}_{t+1}) + \kappa_4 \left(\hat{m}_t - E_t \hat{m}_{t+1}\right) \\ &\quad + \kappa_5 \left(\hat{q}_t - E_t \hat{q}_{t+1}\right) + \kappa_6 E_t \hat{q}_{t+1} + \kappa_7 \hat{q}_t + \kappa_8 \hat{q}_{t-1} + \kappa_9 E_t \hat{y}_{t+1}^f \\ &\quad - \kappa_{10} \hat{y}_t^f - \kappa_{11} \hat{y}_{t-1}^f + \varepsilon_{yt} \end{aligned} \tag{13}$$

where

$$\begin{aligned} \kappa_1 &= \frac{1}{(1+h)},\ \kappa_2 = \frac{h}{(1+h)},\ \kappa_3 = \frac{(1-h)}{\sigma(1+h)\Lambda},\ \kappa_4 = \frac{\phi(1-h)}{\sigma(1+h)\Lambda}, \\ \kappa_5 &= \frac{(1-h)}{\sigma(1+h)\Upsilon},\ \kappa_6 = \frac{\tau_x \gamma_q}{\Lambda},\ \kappa_7 = \frac{\tau_x \gamma_q}{\Lambda},\ \kappa_8 = \frac{\tau_x \gamma_q}{\Lambda}, \\ \kappa_9 &= \frac{\gamma_f \tau_x}{\Lambda},\ \kappa_{10} = \frac{\tau_x \gamma_f}{\Lambda},\ \kappa_{11} = \frac{\tau_x \gamma_f}{\Lambda},\ \Lambda = \tau_c \tau_c - \tau_m \tau_m \end{aligned}$$

Eq.(13) is a hybrid IS curve. As in Ireland (2004), it has real money balances. It also features the exchange rate and foreign output to capture the open economy effects. As observed by O'Conell (2011), such features are considered pivotal in driving output dynamics in African economies. The term ε_{yt} captures exogenous government expenditure effects.

4.3 Exchange rate determination

Following Gali (2008), we assume that the domestic economy has access to complete international financial markets. Combining Taylor approximation around steady state of eq.(5) and eq.(6) yields:

$$E_t \Delta \hat{z}_{t+1} = \hat{r}_t - \hat{r}_t^f \tag{14}$$

Eq.(14) is the uncovered interest rate parity (UIP) condition which states that the nominal exchange rate is determined by interest rate differentials between domestic and foreign countries. Equivalently, the fact that $Q_t = \frac{Z_t P_t^f}{P_t}$ and following Bukhari and Khan (2010), eq. (14) can be transformed to describe real exchange rate dynamics as a function of real interest rate differential as follows:

$$E_t \Delta \hat{q}_{t+1} = -(\hat{r}_t - \hat{\pi}_{t+1}) - (\hat{r}_t^f - \hat{\pi}_{t+1}^f) \tag{15}$$

4.4 Money market equilibrium

We combine steady state forms of eq.(7) and eq.(5) and use the economy wide resource balance in eq.(11) to derive the following money market equilibrium conditions:

$$\begin{aligned} \hat{m}_t &= \Psi_1 \hat{y}_t + \Psi_2 \hat{y}_{t-1} - \Psi_3 (\hat{r}_t - E_t \hat{\pi}_{t+1}) - \Psi_4 E_t \hat{\pi}_{t+1} + \Psi_5 \hat{q}_t + \Psi_6 \hat{q}_{t-1} - \Psi_7 \hat{y}^f \\ &\quad + \Psi_8 \hat{y}_{t-1}^f + \varepsilon_{mdt} \end{aligned} \tag{16}$$

Equivalently, eq.(16) can be specified with $\hat{r}_t$ as an endogenous variable where monetary authorities set money supply levels and leave interest rate to be determined by the market as follows:

$$\begin{aligned} \hat{r}_t &= \beta_1 \hat{y}_t + \beta_2 \hat{y}_{t-1} - \beta_3 \hat{m}_t - \beta_4 \hat{\pi}_{t+1} + \beta_5 \hat{q}_t + \beta_6 \hat{q}_{t-1} + \beta_7 \hat{y}_t^f \\ &\quad - \beta_8 \hat{y}_{t-1}^f + \varepsilon_{rdt} \end{aligned} \tag{16.1}$$

The reduced form parameters in eq.(16) and eq.(16.1) are defined as follows:

$$\begin{aligned}
\Psi_1 &= \frac{(\tau_x-\tau_m)(1-\sigma)(\tau_x\tau_x-\tau_m\tau_m)}{2(1-\phi)(1-h)}, \quad \Psi_2=\frac{h(1-\sigma)(\tau_x-\tau_m)(\tau_x\tau_x-\tau_m\tau_m)}{2\,(1-\phi)\,(1-h)}, \\
\Psi_4 &= \frac{1}{2(1-\phi)}, \ \Psi_5=\frac{\gamma_q(1-\sigma)(\tau_x-\tau_m)\tau_x}{2\,(1-\phi)\,(1-h)}, \ \Psi_6=\frac{\gamma_q(1-\sigma)(\tau_x-\tau_m)\tau_x h}{2\,(1-\phi)\,(1-h)}, \\
\Psi_7 &= \frac{\theta_f(1-\sigma)(\tau_x-\tau_m)\tau_x}{2\,(1-\phi)\,(1-h)}, \ \Psi_8=\frac{\gamma_f h(1-\sigma)(\tau_x-\tau_m)\tau_x}{2\,(1-\phi)\,(1-h)}, \ \beta_1=\frac{\Psi_1}{\Psi_3}\ , \\
\beta_2 &= \frac{\Psi_2}{\Psi_3}\ , \beta_3=\frac{1}{\Psi_3}\ , \beta_4=\frac{1+\Psi_4}{\Psi_3}\ , \beta_5=\frac{\Psi_5}{\Psi_3}\ , \beta_6=\frac{\Psi_6}{\Psi_3}, \beta_7=\frac{\Psi_7}{\Psi_3}\ , \\
\beta_8 &= \frac{\Psi_8}{\Psi_3}, \ \Psi_3=\frac{1}{2(1-\phi)},
\end{aligned}$$

The terms ε_{rdt} and ε_{mdt} are money demand shocks. As in Castelnouvo (2012), eq. (16) is a dynamic money demand function. It determines real money balances as a function of output, interest rates, expected inflation and exchange rate. It follows from this specification that propensities to import, export and consume domestically produced goods do influence money market dynamics.

4.5 Firms

Following Batini et al. (2005) and Malikane (2014) , we assume that the production function of firms is nonlinearly related to input demand. The input demand takes the following form: $X_{jt} = Y_t^{\eta j}$ where X_{jt} stands for inputs other than labour and η_j is the proportion of input j in the production process. Following Batini et. al (2005) and Baldini et. al (2015), we attach a unit value to capital. The production function is thus specified as follows:

$$Y_t = A_t N_t^{\alpha}\left[\prod_{j=1}^{m} Y_t^{\theta_j \eta_j}\right] \tag{17}$$

Similar to Andrės et al. (2006), A_t is an AR (1) technological process. Parameter $0<\alpha<1$ measures the labour share in income, and θ_j is the elasticity of output with respect to input j. The reduced form for eq.(17) is given by:

$$Y_t = \acute{A}_t N_t^{\Upsilon} \tag{18}$$

Where $\Upsilon = \frac{\alpha}{1-\Psi}$, $\Psi = \sum_{j=1}^{m} \theta_j \eta_j$, $\acute{A}_t = A_t^{\frac{1}{1-\Psi}}$. The firms's real total costs can be expressed as the sum of real wage and non-labour factor costs as follows:

$$TC_t = \frac{W_t Y_t^{\frac{1}{\Upsilon}}}{P_t \acute{A}^{\frac{1}{\Upsilon}}} + \sum_{j=1}^{m} \frac{P_{jt} Y_t^{\eta_j}}{P_t} \tag{19}$$

Combining eq.(8) and eq.(18) yields the following real wage expression

$$\frac{W_t}{P_t} = \left(\frac{Y_t}{\acute{A}_t}\right)^{\frac{\varphi}{\Upsilon}} \frac{1}{\lambda_t} \tag{20}$$

Combining eq.(19) and eq.(20), and letting p_{it} denote real price of non-labour input yields the following real marginal cost expression:

$$rmc_t = \beta_1 \frac{Y_t^{\beta_2}}{A_t^{\beta_3}} \frac{1}{\lambda_t} + \sum_{j=1}^{m} \eta_j p_{jt} Y_t^{\eta_i - 1} \tag{21}$$

where $\beta_1 = \frac{\varphi+1}{\Upsilon}$, $\beta_2 = \frac{1-\Upsilon+\varphi}{\Upsilon}$ and $\beta_3 = \frac{\Upsilon+(1-\Psi)(1+\varphi)}{\Upsilon(1-\Psi)}$. The Taylor approximation of eq.(21) yields:

$$r\hat{m}c_t = \phi_1 \hat{y}_t - \phi_2 \hat{a}_t - \phi_3 \hat{\lambda}_t + \sum_{j=1}^{m} \phi_4 \hat{p}_{jt} \tag{22}$$

Where

$$\phi_1 = \frac{1}{MC_0}\left[\frac{\beta_2 Y_0^{\beta_2 - 1}}{\Upsilon A_0^{\beta_3} \lambda_0} + \sum_{j=1}^{m} (\eta_j - 1)\eta_j p_{j0} Y_0^{\eta j - 1}\right], \ \phi_2 = \frac{1}{MC_0}\left[\frac{\beta_3 Y_0^{\beta_2}}{\Upsilon A_0^{\beta_3} \lambda_0}\right],$$

$$\phi_3 = \frac{1}{MC_0}\left[\frac{1}{\Upsilon \lambda_0} \frac{Y_0^{\beta_2}}{A_0^{\beta_3}}\right], \ \phi_4 = \frac{1}{MC_0}\left[\sum_{j=1}^{m} \eta_j Y^{\eta j - 1} P_{i0}\right]$$

Next, we combine the steady state form of eq.(4) and eqs.(11) and (12) and substitute the result in eq.(22) to get the following expression:

$$
\begin{aligned}
r\hat{m}c_t \;=\;& \phi_1 \hat{y}_t + \left(\frac{\phi_3 + \sigma\tau_m\Lambda}{1-h}\right) E_t\hat{y}_{t+1} - \left(\frac{\phi_3 + \sigma h\tau_m\Lambda}{1-h}\right)\hat{y}_{t-1} - \phi_3\hat{q}_t \\
&+\frac{\phi_3\gamma_q\sigma\tau_x\tau_m}{1-h}E_t\hat{q}_{t+1} - \frac{\phi_3\gamma_q\sigma h\tau_x\tau_m}{1-h}\hat{q}_{t-1} - \phi_3\phi\hat{m}_t \\
&+\frac{\phi_3\gamma_f\sigma\tau_x\tau_m}{1-h}\;E_t\hat{y}^f_{t+1} - \frac{\phi_3\gamma_f\sigma h\tau_x\tau_m}{1-h}\;\hat{y}^f_{t-1} + \phi_4\hat{p}_{jt} \;-\phi_2\hat{a}_t \qquad (23)
\end{aligned}
$$

Eq.(23) states that real marginal costs are driven by the output gap, real exchange rate, real money balances, foreign output, cost of raw materials and technology. Substituting eq.(23) into the baseline hybrid new-Keynesian phillips curve proposed by Gali and Gertler (1999) yields the following hybrid Phillips curve:

$$
\begin{aligned}
\hat{\pi}_t \;=\;& \chi_f E_t\hat{\pi}_{t+1} + \chi_b\hat{\pi}_{t-1} + \delta_1\hat{y}_t + \delta_2 E_t\hat{y}_{t+1} + \delta_3\hat{y}_{t-1} + \delta_4\hat{q}_t \\
&+\delta_5 E_t\hat{q}_{t+1} - \delta_6\hat{q}_{t-1} + \delta_7\hat{m}_t + \delta_8 E_t\hat{y}^f_{t+1} - \delta_9\hat{y}^f_{t-1} \\
&+\;\delta_{10}\hat{p}_{jt} + \varepsilon_{\pi t} \qquad (24)
\end{aligned}
$$

where

$$
\begin{aligned}
\delta_1 &= \chi_c\phi_1,\;\; \delta_2 = \frac{\chi_c\sigma\phi_3\tau_m(\tau_m\tau_m - \tau_c\tau_c)}{1-h},\;\; \delta_3 = \frac{\chi_c\phi\sigma h(\tau_m\tau_m - \tau_c\tau_c)}{1-h}, \\
\delta_3 &= \frac{\chi_c\phi\sigma h)(\tau_m^2 - \tau_c^2)}{1-h},\;\; \delta_4 = \chi_c\phi_3,\quad \delta_5 = \frac{\chi_c\phi_3\sigma\tau_x\tau_m\gamma_q}{1-h}, \\
\delta_6 &= \frac{\chi_c\phi_3\sigma\tau_x\tau_m\gamma_q}{1-h}, \delta_7 = \chi_c\phi_3\sigma\theta,\quad \delta_8 = \frac{\chi_c\phi_3\gamma_f\sigma\tau_x\tau_m}{1-h}, \\
\delta_9 &= \frac{\chi_c\phi_3\gamma_f\sigma\tau_x\tau_m}{1-h}, \delta_{10} = \chi_c\phi_4,\;\; \chi_c = (1-\theta)(1-\beta\theta)(1-\omega)\zeta, \\
\zeta &= \frac{1-\alpha}{1+\alpha(\epsilon-1)}\left\{\theta + \omega\left[1-\theta\left(1-\beta\right)\right]\right\}^{-1}
\end{aligned}
$$

Consistent with Ireland (2004), our Phillips curve also features the real money balances to capture direct effect of money on inflation. It also includes cost of imported inputs as a direct determinant of inflation. We assume one major imported input (fuel). We thus drop the summation from the marginal cost equation. Additional factors of production can be added without loss of generality. We include a technology or cost push shock $\varepsilon_{\pi t}$. According to Clarida, Gali and Gertler (2001), such a shock may arise from stochastic wage mark-up in imperfect labour markets.

4.6 Monetary Policy Reaction Function

Consistent with exposition by McCallum (2000) and Liu and Zhang (2010), we characterize monetary policy conduct by specifying two alternatives, money and interest rate rules. This is also in line with the current debate and monetary policy conduct in most African countries. According to Rotemberg and Woodford (1998) and Dale and McKibbin (1993), the central bank can optimize monetary policy instead of following an adhoc approach. We follow Svensson(1999) and Woodford (2003) and specify the following central bank loss function:

$$L_t = E_t \sum_{j=0}^{\infty} \beta^j \frac{1}{2} (\hat{\pi}_{t+j}^2 + \Theta \hat{y}_{t+j}^2) \tag{25}$$

where $0 < \beta < 1$ is the policy maker's discount factor similar to the private sector discount factor in eq.(1). Parameter $\Theta > 0$ signifies that authorities place some weight on output stabilisation. The central bank seeks to minimize eq.(25) subject to eqs. (13) and (24) where it can either control $\hat{r}_t$ or $\hat{m}_t$ at any point. We follow Svensson (1999) who argues that to increase efficiency, monetary policy must respond to drivers of target variables as described by eqs.(13) and (24). We therefore minimize eq.(25) subject to eqs.(13) and (24) and get the FOCs for $\hat{\pi}_t$, $\hat{y}_t$, $\hat{q}_t$, $\hat{r}_t$ as follows:

$$\begin{aligned}
\hat{\pi}_t + \beta\chi_b\lambda_{1t+1} - \lambda_{1t} &= 0 \qquad (26)\\
\theta_y\hat{y}_t + \beta\kappa_2\lambda_{2t+1} - \lambda_{2t} + \delta_1\lambda_{1t} + \beta\delta_3\lambda_{1t+1} &= 0 \qquad (27)\\
-\lambda_{2t}\kappa_5 - \kappa_7\lambda_{2t} + \beta\kappa_8\lambda_{2t+1} - \delta_4\lambda_{1t} - \beta\delta_6\lambda_{1t+1} &= 0 \qquad (28)\\
\lambda_{2t}\kappa_3 &= 0 \qquad (29)
\end{aligned}$$

where λ_{1t} and λ_{2t} are Lagrangian multipliers. Eqs. (26)-(29) represent period t optimal discretionary policy conditions which yield the following reduced form optimal relationship between inflation and output:

$$\theta_y\hat{y}_t + \gamma_1\hat{\pi}_t + \gamma_2\hat{\pi}_{t-1} = 0, \qquad (30)$$

where $\gamma_1 = \frac{\delta_4\delta_3}{(\delta_6-\delta_4\chi_b)}$ and $\gamma_2 = \frac{\delta_4\delta_1}{\beta(\delta_6-\delta_4\chi_b)}$.

Following Evans and Honkapohja (2003), we combine the real sector equilibrium dynamics described by eq.(13) with the optimal condition (30) to derive the central bank's optimal interest rate reaction function as follows:

$$\begin{aligned}
\hat{r}_t \;=\; & \delta_{1y}\hat{y}_{t+1} + \delta_{2y}\hat{y}_{t-1} + \delta_{1\pi}\hat{\pi}_t + \delta_{2\pi}\hat{\pi}_{t-1} + \delta_{3\pi}\hat{\pi}_{t+1} + \delta_m(\hat{m}_t - \hat{m}_{t+1})\\
& + \delta_{1q}(\hat{q}_t - \hat{q}_{t+1}) + \delta_{2q}\hat{q}_{t+1} + \delta_{3q}\hat{q}_t + \delta_{4q}\hat{q}_{t-1} + \delta_{1f}\hat{y}^f_{t+1}\\
& - \delta_{2f}\hat{y}^f_t - \delta_{3f}\hat{y}^f_{t-1} + \varepsilon_{rt} \qquad (31)
\end{aligned}$$

Where

$$\begin{aligned}
\delta_{1y} &= \frac{\kappa_1}{\kappa_3}, \delta_{2y} = \frac{\kappa_2}{\kappa_3}, \delta_{1\pi} = \frac{\gamma_2}{\kappa_3}, \delta_{2\pi} = \frac{\gamma_1}{\kappa_3}, \delta_{3\pi} = 1, \delta_m = \frac{\kappa_4}{\kappa_3}, \delta_{1q} = \frac{\kappa_5}{\kappa_3}\\
\delta_{2q} &= \frac{\kappa_6}{\kappa_3}, \delta_{3q} = \frac{\kappa_7}{\kappa_3}, \delta_{4q} = \frac{\kappa_8}{\kappa_3}, \delta_{1f} = \frac{\kappa_9}{\kappa_3}, \delta_{2f} = \frac{\kappa_{10}}{\kappa_3}, \delta_{3f} = \frac{\kappa_{11}}{\kappa_3}
\end{aligned}$$

Eq. (31) is a reduced form Taylor type optimal policy reaction function (IRR) with interest rate $\hat{r}_t$ as the policy instrument.

Alternatively, McCallum (2000) states the central bank's reaction function can be described in terms of monetary aggregates where interest rates now become endogenous. We combine the optimal dynamics in eq. (30) with the Phillips curve described by eq. (24) to get the following:

$$\begin{aligned}\hat{m}_t &= -\sigma_{3y}\hat{y}_{t-1} - \sigma_{1y}\hat{y}_t - \sigma_{2y}\hat{y}_{t+1} - \sigma_b\hat{\pi}_{t-1} - \sigma_f\hat{\pi}_{t+1} - \sigma_{3q}\hat{q}_{t-1} \\ &\quad -\sigma_{1q}\hat{q}_t - \sigma_{2q}\hat{q}_{t+1} + \sigma_{2ff}\hat{y}^f_{t-1} - \sigma_{1ff}\hat{y}^f_{t+1} - \sigma_o\widehat{oilp}_t + \varepsilon_{mt}\end{aligned} \tag{32}$$

where

$$\begin{aligned}\sigma_{3y} &= \frac{\delta_3}{\delta_7},\ \sigma_{1y} = \frac{\theta_y + \delta_1}{\gamma_1\delta_7},\ \sigma_{2y} = \frac{\delta_2}{\delta_7},\ \sigma_b = \frac{\chi_b + \gamma_2}{\delta_7}\ ,\ \sigma_f = \frac{\chi_f}{\delta_7}, \\ \sigma_{3q} &= \frac{\delta_6}{\delta_7},\ \sigma_{1q} = \frac{\delta_4}{\delta_7},\ \sigma_{2q} = \frac{\delta_5}{\delta_7},\ \sigma_{2ff} = \frac{\delta_9}{\delta_7},\ \sigma_{1ff} = \frac{\delta_8}{\delta_7},\ \sigma_o = \frac{\delta_{10}}{\delta_7}\end{aligned}$$

Eq. (32) is an optimal Taylor type money aggregate rule (MAR). It is consistent with Taylor's (1979) proposal that the optimal money supply can be set as a function of inflation and output gap. Furthermore this rule incorporates the exchange rate, which is pivotal in driving macroeconomic dynamics in LICs such as those in the African context. As pointed out by Svensson (1999), eq.(32) represents pragmatic monetary targeting where additional information beyond output and inflation is considered when undertaking policy decisions.

Eqs.(31) and (32), therefore, describe monetary policy conduct under flexible inflation targeting. The two rules are both of a Taylor-type and according to Adam (2011), they can be compared in terms of their implication for macroeconomic outcomes in Africa. In our estimation of the model, we assume that the following stochastic process drive shocks to the system: $\varsigma_t = \rho_\varsigma\varsigma_{t-1} + \upsilon_{\varsigma t}$ and $\vartheta_t = \rho_{\vartheta t}\vartheta_{t-1} + \mu_t$, where $\varsigma_t = \left(\hat{y}^f_t, \hat{r}^f_t, \hat{\pi}^f_t, \widehat{oilp}_t\right)$ and $\vartheta_t = (\varepsilon_{yt}, \varepsilon_{\pi t}, \varepsilon_{rt}, \varepsilon_{mt}, \varepsilon_{mdt},\ \varepsilon_{rdt})$. Furthermore, $\upsilon_{\varsigma t} \sim N(0, \sigma^2_\varsigma)$ and $\mu_{\vartheta t} \sim N(0, \sigma^2_\vartheta)$.

5. Data

We use nine macroeconomic variables defined as follows: Inflation is calculated as a change in log of CPI. Real balances are calculated by deflating broad nominal supply with the CPI. Output is defined as real GDP growth. Real exchange rate is calculated as the nominal bilateral US dollar exchange rate multiplied by the US CPI divided by the domestic CPI. The foreign interest rate is proxied by the London Interbank Offer Rate. Foreign output is proxied by the US real Gross Domestic Product. We use the US inflation to proxy foreign inflation. Brent crude oil price is used as a proxy for the price of imported raw material. Short-term nominal interest rates take the form of either treasury bill rates or policy rates. Data is obtained from the IMF, the World Bank and the Federal Reserve Bank of St. Louis.

The model is estimated using quarterly data on 10 African countries. The countries were chosen to reflect various stages of economic developments as well as different monetary policy frameworks. Consistent with data availability, estimation is done using different sample periods. In countries where quarterly GDP statistics are not available e.g. Malawi, Tanzania, Morocco, Zambia and Nigeria, we interpolate the data. We follow Del Negro and Schorfheide (2003) to detrend the data using HP filter to extract the business cycle.

Table 2: The Sample

Country	Sample period
South Africa	1990:Q1–2014:Q4
Ghana	1990:Q1–2014:Q4
Uganda	1990:Q1–2014:Q4
Nigeria	1992Q1-2014:Q4
Malawi	1990:Q1–2014:Q4
Morocco	1994:Q1–2014:Q4
Egypt	1990:Q1–2014:Q4
Kenya	1995:Q1–2014:Q4
Tanzania	1993:Q1–2014:Q4
Zambia	1993:Q1–2014:Q4

5.1 Estimation

There are several techniques to estimate DSGE models. Ruge-Murcia (2007) provides a succinct summary of them. Among these methods, the Bayesian technique, Generalized Method of Moments (GMM) and Maximum Likelihood Estimation (MLE) are the most popular. The Bayesian technique is applied by Smets and Wouters (2003). This method combines the information contained in the model's likelihood function with some prior distribution of the parameters to provide the posterior distribution of the parameters. In general, the Bayesian method is useful to address identification issues. Its major shortfall however is on how to generate the priors.

The GMM can be estimated as a system as in Christiano and Eichenbaum (1992) or as single equations as in Braun (1994). In the former, the solution seeks to minimise the distance between empirical moments of the actual data and the theoretical moments. In the latter, each equation is estimated separately. As explained by Ruge-Murcia (2007), both methods are not without shortfalls. The system GMM may suffer from weak instrument problem when the moments in the objective function do not carry sufficient information about the structural parameters. The single equation GMM does not exploit cross-equation restrictions. As a result the GMM estimates tend to be less efficient and suffer identification problems. In addition, using instruments to deal with endogeneity may lead to biased estimates.

The third method is the MLE technique, used by Ireland (2004). Hansen and Sargent (2007) show that this estimator is consistent and asymptotically efficient in DSGE models. This paper uses the MLE method and applies the Kalman (1960) filtering technique. This allows us to deal with unobserved or poorly measured predetermined variables and yields the optimal solution to the problem of predicting and updating the state-space. This enables the construction of inferences about the unobserved state vector. It also allows the evaluation of the joint likelihood function of observable endogenous variables.

One major draw back of the MLE method is the singularity problem. However, literature suggests three strategies to deal with this problem. First, is to estimate the model using as many observable variables as structural shocks as in Boukez, Cardia and Ruge-Murcia (2005). Second, is to extend the model to permit additional structural shocks as in Leeper and Sims (1994). However, as indicated by Ruge-Murcia (2007), additional shocks may only reduce, but not eliminate, the stochastic singularity problem.

In this study, we follow Ireland (2004) and use a third method which adds error terms to the observation equations of the state-space representation. This limits the effects of specification errors in the estimates and helps to deal with identification issues. This representation may also capture the limitations of the modelling framework to exhaustively capture macroeconomic dynamics in African context. We are interested in estimating the parameters that characterize the stochastic processes jointly. The state space form of the model is expressed as follows:

$$E_t\hat{X}_{t+1} = \Gamma_1\hat{X}_t + \Gamma_2\varepsilon_t \tag{33}$$

where $\hat{X}_{t+1} = [\hat{y}_{t-1}, \hat{\pi}_{t-1}, \hat{r}_{t-1},\ \hat{m}_{t-1}]'$ is a state vector, and $\varepsilon_t = [\varepsilon_{yt}, \varepsilon_{\pi t}, \varepsilon_{rt}, \varepsilon_{mdt}]'$ is a vector of errors.

Using the Blanchard-Khan (1980) solution, we can solve for the elements in matrices Γ_1 and Γ_2 in each iteration of the optimisation process maximizing the Loglikelihood function. The system computes standard errors by taking the square root of the diagonal elements of the inverted Hessian of the log likelihood function evaluated at the maximum. The equilibrium condition of our stochastic model does not have an analytical solution. Instead, the dynamics are characterised by linearising them around the steady state. The model is solved using a pure pertubation algorithm developed by Schmitt-Grohe and Uribe (2004). The solution is found when the number of explosive characteristic roots of the system of linear difference equations equals the number of non-predetermined variables.

We are interested in policy implications of the system rather than recovering the underlying parameters. We therefore follow Zanetti (2012) and estimate a reduced form model. We follow Woodford (2003) and seek to identify the policy instrument that i) yields lower variance in output and inflation, and ii) restores the economy back to the steady state in a comparatively shorter period. We thus analyse impulse responses which represent the expected path of the endogenous variables conditional on a one standard deviation shock in period one. Since our model is up to a first order, these impulse responses are simply the algebraic forward iteration of the model under a policy rule. We follow several other studies e.g. Leitemo and Söderström (2005) and calibrate the output smoothing parameter at $\theta_y = 0.5$ as originally proposed by Taylor (1993).

6. Results

Estimates for the IS curve are presented in Table 3 . We find a relatively low but theoretically consistent reaction of aggregate demand to changes in interest rates, κ_3, in 7 countries. This parameter is statistically insignificant in South Africa, Tanzania and Malawi. Counterintuitively, aggregate demand is seen to react positively to policy rate changes in Egypt, Nigeria and Zambia. Goodhart and Hofman (2005) find similar result for the United Kingdom. Similarly, Furher and Rudebusch (2004) find conflicting signs and relatively low estimates for this parameter. They argue that the relatively small size of this parameters is reminiscent of a weak transmission and signals difficulties in the use of monetary policy to control economies. The estimated coefficients of real money balances, κ_4, ranges between 0.02 in Ghana to 0.63 in Uganda. The exchange rate is statistically significant in all countries. Lagged foreign output influences aggregate demand in Morocco, Nigeria, South Africa and Zambia. Other measures of foreign output are mostly insiginificant across countries.

The Phillips curve estimates are presented in Table 4. Measured by χ_f, economic agents are forward looking in forming expectations in Ghana, Egypt, Kenya, Morocco, Uganda, Tanzania and Zambia. On the contrary, South Africa, Nigeria and Malawi display higher backward looking bahaviour with $\chi_b > \chi_f$. Another parameter of interest is δ_7 which captures how inflation reacts to the monetary aggregate. This parameter is statistically significant across all countries. In Kenya, Nigeria and Tanzania, a rise in real balances is found to be deflationary. The impact of crude oil price on inflation, $\delta_{10,}$ is significant in South Africa, Kenya, Malawi, Tanzania, Uganda and Zambia. The output gap δ_1 is significant across countries and is theoretically consistent except in Nigeria. Rudd and Whelan (2005) also find a positive impact of output gap on inflation when lagged inflation is incorporated in the Phillips curve.

Estimates for money demand are presented in Table 5. Ghana and South Africa display overreaction of the money demand to changes in output, with parameter Ψ_1 estimated at greater than unity. Near unity estimates are also obtained for Kenya, Nigeria and Zambia. The estimate for this parameter ranges from 0.53 in Egypt to 1.83 in Ghana. These findings are in line with the unity value found by Chari et al. (2000) and also the long-run calibrated values in literature. The interest rate elasticity of money demand ranges from 0.02 for Egypt to 1.38 for Uganda. This variable is poorly estimated for Tanzania. Counterintuitively, money demand rises in Ghana and Zambia in response to an interest rate hike, a feature akin to liquidity puzzle.

Following Zanetti (2012), we directly estimate parameters of the policy rule and present results in Table 6. This approach is consistent with a black box search for an appropriate policy rule. Parameters δ_{1y}, δ_{2y} and $\delta_{1\pi}$, $\delta_{2\pi}$ and $\delta_{3\pi}$ which measure policy reaction to output and inflation are mostly significant and near or above unity. This suggests that central banks strongly penalise output and inflation fluctuations in Africa. For Ghana, Houssa *et. al* (2010) find a similar result on inflation. With values of over unity for δ_m, monetary policy in Uganda and Morocco reacts strongly to money supply growth compared to other countries. In South Africa, authorities do not react to the growth in monetary aggregates. They however aggressively penalise inflation and output deviations.

6.1 The monetary aggregate or the interest rate?

We analyze the impact of one standard deviation shock to the two policy rules on inflation and output. Both shocks are contractionary and are represented by a rise in the policy rate and decrease in money supply. The majority of impulse responses are theoretically consistent, except in Nigeria where output counterintuively rises after increasing the policy rate. Similarly, in Ghana inflation rises after reducing money supply, a feature known as price puzzle. For purposes of space we scale the impulse responses by 10^3.

Figures 1 and 2 and Table 8 show that the monetary aggregate (MAR) performs better in macroeconomic stabilisation than the interest rate (IRR) in South Africa, Nigeria, Tanzania, Malawi, Zambia and Morocco. In these countries, the MAR minimises the absolute loss compared to the IRR. Besides, it take less time for output and inflation to return to the steady state after pertubation under the MAR than under the IRR. However, the IRR is superior in stabilising the economy in Egypt, Ghana, Uganda and Kenya. In these countries, the economy reverts to steady state earlier under the IRR than under the MAR. Similarly, in these countries, the IRR minimises the absolute loss compared to the MAR.

In South Africa, both rules lead to output and inflation stability after 22 quarters. However, the MAR yields lower volatility for both inflation and output leading to an absolute loss of 0.00022 compared to 0.00048 under the IRR. This decline is driven by lower inflation volatility under the MAR compared to the IRR. In Malawi, the MAR stabilizes output after 11 quarters while it takes 21 quarters under the IRR. However, under both rules, inflation reverts to steady state after 18 quarters. The absolute loss is estimated at 0.2569 under the MAR owing to a significant decline in inflation volatility compared to 1.1184 under the IRR. In Zambia, output reverts to steady after 55 quarters under both rules. Inflation however stabilises after 27 quarters under the MAR compared to 55 quarters under the IRR. The MAR leads to lower volatility in both inflation and output with absolute loss estimated at 0.0141 compared to 0.0318 under the IRR.

In Tanzania, it takes 16 quarters for output to revert to steady state under the MAR and 28 quarters under the IRR. Under both rules, shocks dissipate after 28 quarters. The absolute loss is estimated at 0.3189 under the MAR compared to 0.3453 under the IRR. In Nigeria, the absolute loss is estimated at 0.00963 under the IRR compared to 0.00257 under the MAR. Output stabilises after 19 quarters under the IRR while its takes 13 quarters under the MAR. The absolute loss for Morocco is estimated at 0.0008 under the MAR compared to 1.4755 under the IRR. It takes about 13 quarters for output to stabilise under the IRR compared to about 25 quarters under the MAR.

In Egypt, output reverts to steady state after 25 quarters under the IRR while it takes 42 quarters under the MAR. Inflation reverts to steady state after 37 quarters under the IRR compared to 55 quarters under the MAR. At 0.093, the variance of inflation is higher under IRR compare to 0.02 under the MAR. The two rules however generate similar output volatility of 0.0001. In Ghana, output stabilizes after 11 quarter under the IRR compared to 26 quarters under the MAR. Inflation stabilizes after 21 quarters under the MAR and 26 quarters under the IRR. However the monetary aggregate rule generates higher volatility in both inflation and output compared to the interest rate.

In Uganda, output reverts to steady state after 31 quarters under MAR compared to 36 quarters under IRR. However, inflation stabilizes after 28 quarters under the IRR compared to 16 quarters under the MAR. The absolute loss function value is estimated 0.0022 under IRR compared to 0.09 under MAR implying that the IRR performs better. Results for Kenya show that the MAR yields lower output fluctuations and higher inflation fluctuations while the IRR yields lower inflation fluctuations and higher output fluctuations. Output reverts to steady state after 16 quarters under the MAR compared to 22 quarter under the IRR. Under both rules, inflation reverts to steady state after 25 quarters. The absolute loss is estimated at 0.00073 under the IRR compared to 0.0113 under the MAR.

Table 3: The IS Curve estimates

	Egypt	Ghana	Kenya	Malawi	Morocco	Nigeria	S. Africa	Tanzania	Uganda	Zambia
κ_1	0.73	0.39	0.87	0.58	0.67	0.44	0.49	0.40	1.18	0.59
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.02]
κ_2	0.51	0.65	1.04	0.52	0.66	0.61	0.49	0.62	0.33	0.51
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.02]
κ_3	-0.01	0.15	0.18	0.03	0.00	-0.13	0.00	0.06	0.07	-0.00
	[0.00]	[0.00]	[0.00]	[0.06]*	[0.00]	[0.00]	[0.06]*	[0.08]*	[0.06]*	[0.00]
κ_4	-0.10	0.02	-0.12	0.047	-0.09	0.28	0.17	-0.05	-0.63	-0.00
	[0.00]	[0.00]	[0.00]	[0.03]	[0.00]	[0.00]	[0.06]	[0.04]	[0.00]	[0.00]
κ_5	0.02	-0.14	-0.51	0.06	0.04	0.23	0.06	0.09	0.60	-0.01
	[0.00]	[0.00]	[0.00]	[0.13]	[0.00]	[0.00]	[0.06]	[0.08]	[0.41]	[0.00]
κ_6	0.07	0.26	0.55	-0.07	0.01	-0.04	0.00	0.49	0.37	-0.01
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.01]
κ_7	0.00	0.14	-0.04	0.04	-0.03	0.16	0.03	-0.22	-0.18	0.01
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
κ_8	-0.01	0.01	-0.08	0.09	0.02	-0.15	-0.03	0.02	0.09	0.00
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
κ_9	0.17	0.35	0.31	0.05	0.23	0.30	0.1	0.21	0.37	0.08
	[69.21]*	[118.22]*	[92.34]*	[55.13]*	[5.47]*	[13.72]	[1.73]	[25.14]*	[0.00]	[0.00]
κ_{10}	0.31	0.11	0.15	0.20	0.23	-0.25	-0.06	0.26	0.86	-0.14
	[62.21]*	[45.45]*	[44.34]*	[41.23]*	[0.56]*	[18.21]*	[0.84]*	[0.00]	[0.00]	[0.03]
κ_{11}	0.24	0.09	-0.28	0.27	0.04	0.12	0.05	0.12	-0.03	-0.10
	[0.09]	[0.75]*	[0.00]	[0.23]*	[0.00]	[0.00]	[0.00]	[63.42]*	[0.34]*	[0.02]

Notes: [ ] Denote standard errors, * not significant, otherwise significant at 1 percent.

Table 4: The Phillips Curve estimates

	Egypt	Ghana	Kenya	Malawi	Morocco	Nigeria	S. Africa	Tanzania	Uganda	Zambia
χ_f	0.79	1.01	0.61	0.53	0.61	0.40	0.35	0.71	0.53	0.66
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.03]
χ_b	0.24	0.19	0.45	0.58	0.40	0.55	0.60	0.31	0.39	0.35
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.03]
δ_1	0.79	1.96	1.04	0.89	0.854	-0.01	0.26	0.62	0.96	0.88
	[0.00]	[0.00	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
δ_2	0.12	0.15	0.57	0.38	0.22	0.28	0.52	0.25	1.39	0.73
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
δ_3	0.66	0.92	-0.26	0.41	0.71	-0.13	0.15	0.69	0.81	0.55
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
δ_4	0.01	0.59	0.43	0.80	-0.08	0.43	0.31	0.25	-0.36	0.53
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
δ_5	-0.13	0.32	-0.55	0.35	-0.10	-0.55	-0.33	0.39	0.10	0.43
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
δ_6	-0.02	0.79	-0.11	0.38	0.15	-0.09	0.03	0.27	-0.01	0.34
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
δ_7	0.29	0.16	-0.35	0.16	0.23	-0.16	0.02	-0.48	0.08	0.50
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
δ_8	0.14	0.78	0.20	0.64	0.18	0.56	0.33	0.18	1.02	0.81
	[35.13]*	[109.21]*	[0.00]	[5.50]*	[0.00]	[92.92]*	[0.00]	[52.51]*	[0.00]	[0.03]
δ_9	0.194	0.17	0.67	0.01	0.18	0.85	0.22	0.18	0.85	1.09
	[26.91]*	[61.83]*	[0.00]	[1.66]*	[0.00]	[18.20]*	[0.96]*	[32.92]*	[0.00]	[0.02]
δ_{10}	0.02	0.08	0.00	0.01	0.08	-0.00	0.05	0.01	0.02	0.02
	[0.24]*	[1.18]*	[0.00]	[0.00]	[0.12]*	[0.01]*	[0.01]	[0.01]	[0.01]	[0.01]

Note: [ ] Denote standard erros, * not significant, otherwise significant at 1 percent.

Table 5: Estimated Parameters for Money Demand

	Egypt	Ghana	Kenya	Malawi	Morocco	Nigeria	S. Africa	Tanzania	Uganda	Zambia
Ψ_1	0.53	1.83	0.87	0.67	0.54	0.73	1.58	0.54	0.39	0.81
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.23]
Ψ_2	0.59	0.53	0.94	0.22	0.61	0.81	2.55	0.63	0.48	0.35
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.23]
Ψ_3	0.02	-0.45	0.37	0.51	0.06	0.32	0.01	3.75	1.38	-0.07
	[0.00]	[0.00]	[0.00]	[0.01]	[0.00]	[0.00]	[0.01]	[0.00]	[0.95]	[0.01]
Ψ_4	0.03	-0.12	0.04	0.00	0.19	0.83	1.76	0.02	1.75	-0.49
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.01]	[0.00]	[0.00]	[0.00]
Ψ_5	0.15	-0.84	0.51	0.03	0.27	0.66	0.31	-0.14	0.37	0.31
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Ψ_6	0.0120	-0.17	0.18	-0.03	0.26	0.36	-0.06	0.20	0.32	-0.01
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Ψ_7	0.9093	3.16	2.00	1.33	2.90	0.83	0.82	0.90	1.29	0.49
	[2.80]*	[81.56]*	[0.00]	[0.25]	[0.00]	[54.18]*	[0.00]	[45.22]*	[0.00]	[0.14]
Ψ_8	0.91	2.42	0.48	1.40	3.29	0.48	0.39	0.90	0.95	1.14
	[0.20]*	[13.02]*	[0.00]	[0.16]	[0.00]	[0.00]	[0.00]	[20.60]*	[0.79]*	[0.15]

Note: [ ] Denote standard errors, * not significant, otherwise significant at 1 percent

Table 6: Estimated Parameters for the Interest Rate Policy Rule

	Egypt	Ghana	Kenya	Malawi	Morocco	Nigeria	S. AFrica	Tanzania	Uganda	Zambia
δ_{1y}	0.90	0.89	0.78	1.19	2.10	0.80	0.18	1.11	0.99	1.14
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
δ_{2y}	0.91	0.97	0.70	1.39	7.89	0.68	3.16	1.05	0.99	0.76
	[0.00]	[0.00]	[0.00]	[0.00]	[0.01]	[0.00]	[0.01]	[0.00]	[0.00]	[0.00]
$\delta_{1\pi}$	0.96	0.42	1.18	-0.02	1.79	0.87	1.97	0.41	0.33	0.17
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.01]	[0.00]	[0.00]	[0.00]
$\delta_{2\pi}$	0.86	-0.02	0.84	1.05	1.020	0.83	2.34	-0.09	0.21	0.35
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.01]	[0.00]	[0.00]	[0.00]
$\delta_{3\pi}$	0.75	0.76	1.14	0.19	5.60	8.99	1.07	0.69	0.45	0.42
	[0.00]	[0.00]	[0.00]	[0.00]	[0.01]	[0.02]	[0.00]	[0.00]	[0.00]	[0.00]
δ_{m}	0.95	0.88	0.61	0.55	1.10	0.09	0.31	0.20	1.13	0.51
	[0.00]	[0.00]	[0.00]	[0.14]	[0.00]	[0.00]	[0.79]*	[0.09]	[0.00]	[0.01]
δ_{1q}	1.00	0.73	1.06	0.37	2.70	0.40	0.23	0.83	0.51	0.68
	[0.00]	[0.00]	[0.00]	[0.16]	[0.00]	[0.00]	[0.08]	[0.17]	[0.39]	[0.02]
δ_{2q}	0.61	0.84	0.66	0.25	2.69	0.17	0.09	0.06	0.18	0.64
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
δ_{3q}	0.91	0.74	0.62	0.30	1.50	0.69	0.45	-0.21	-0.21	0.41
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
δ_{4q}	0.77	0.85	0.45	0.31	3.75	-0.14	-0.01	0.04	0.40	0.69
	[0.00]	[0.00]	[0.00]	[0.00]	[0.01]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
δ_{1f}	0.67	0.83	0.63	3.30	9.10	4.48	4.50	0.90	0.92	0.15
	[31.32]*	[24.98]*	[71.34]*	[54.11]*	[13.48]*	[154.60]*	[38.64]*	[45.20]*	[0.00]	[0.02]
δ_{2f}	0.93	0.86	1.27	2.29	2.30	0.62	0.6024	0.91	0.64	0.69
	[67.09]*	[73.79]*	[0.00]	[40.33]*	[79.96]*	[122.71]*	[32.42]*	[15.18]*	[0.00]	[0.04]
δ_{3f}	0.92	0.93	1.07	1.89	[2.50]	1.96	2.0145	0.89	0.98	0.79
	[98.56]*	[65.87]*	[0.00]	[2.15]*	[551.10]*	[27.61]*	[4.3548]*	[19.91]*	[0.00]	[0.02]

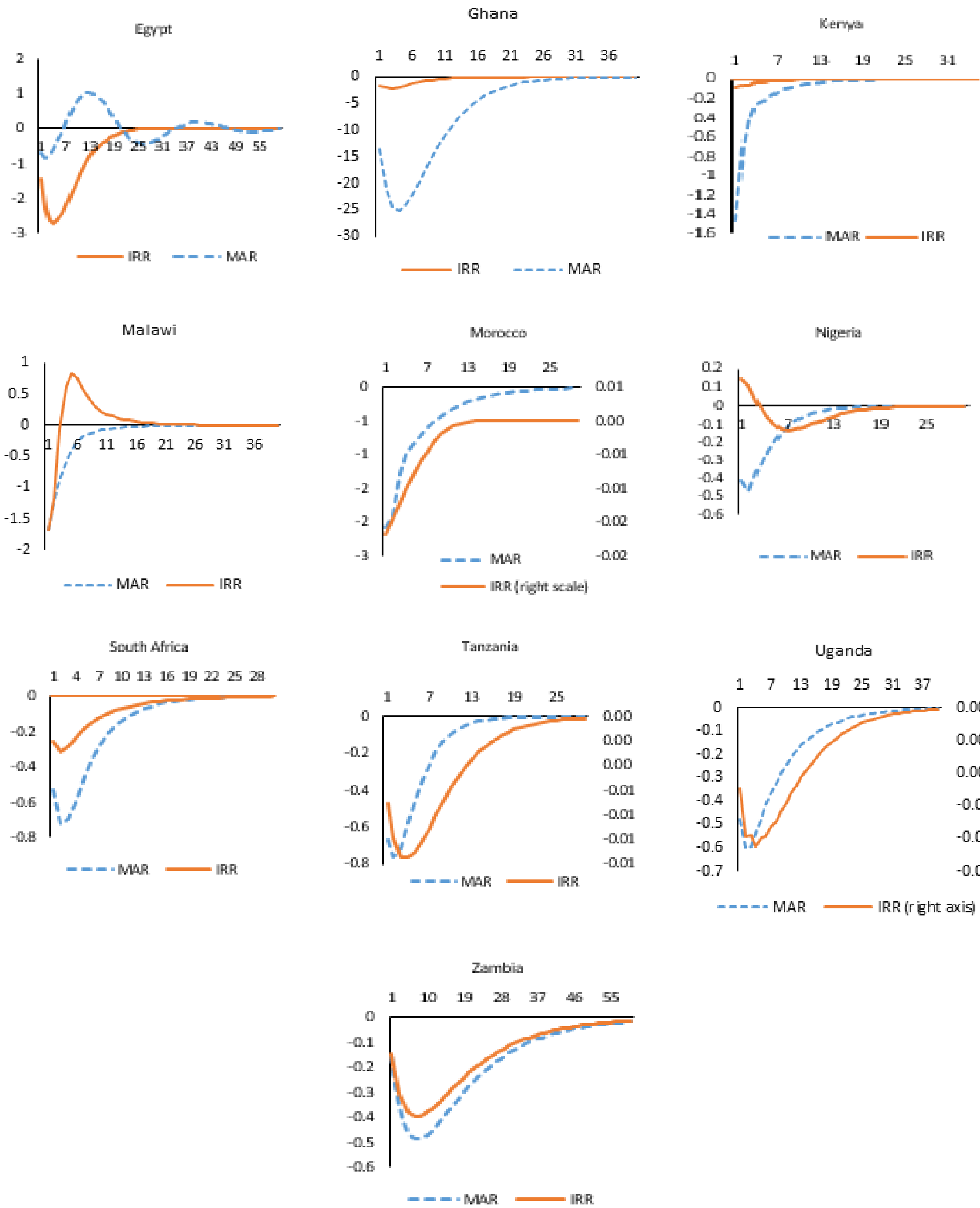
Note: [ ] Denote standard errors, * not significant, otherwise significant at 1 percent.

Table 7: Variance of Inflation (Var π) and Output (var y)

	Egypt		Ghana		Kenya		Malawi		Morocco	
	IRR	MAR	IRR	MAR	IRR	MAR	IRR	MAR	IRR	MAR
(var π)	0.0103	0.0289	0.1122	1.4117	0.0013	0.0076	1.1257	0.2282	1.4753	0.0006
(var y)	0.0001	0.0001	0.0001	0.003	0.0001	0.00075	0.1164	0.0574	0.0004	0.0004
Loss	0.0104	0.0290	0.11225	1.4132	0.00135	0.00798	1.11839	0.2569	1.4755	0.0008
Rank	1	2	1	2	1	2	2	1	2	1

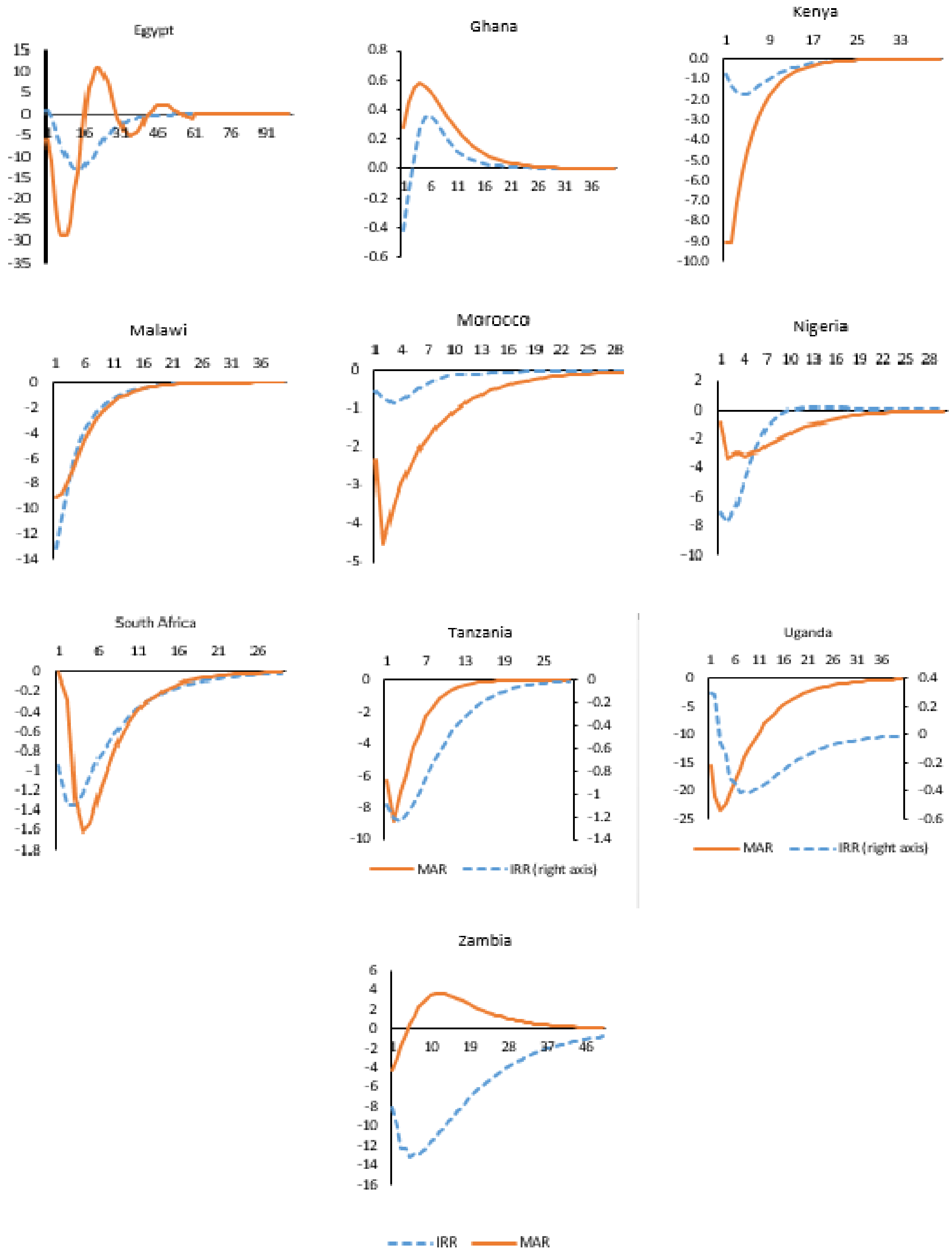
	Nigeria		South Africa		Tanzania		Uganda		Zambia	
	IRR	MAR	IRR	MAR	IRR	MAR	IRR	MAR	IRR	MAR
(var π)	0.0095	0.00254	0.00043	0.0002	0.3453	0.31892	0.0020	0.09007	0.0304	0.01370
(var y)	0.00026	0.00005	0.0001	0.00004	0.00001	0.00003	0.00030	0.00006	0.0028	0.00080
Loss	0.00963	0.00257	0.00048	0.00022	0.34531	0.31894	0.00215	0.0901	0.0318	0.0141
Rank	2	1	2	1	2	1	1	2	2	1

Figure 1: Impulse Responses of Output Gap to Monetary Policy Shocks



Note: Percentage deviations from steady state (x10^3)

Figure 2: Impulse Responses of Inflation to Monetary Policy Shocks



Note: Percentage deviations from steady state (x10^3)

7. Conclusion

This study compares the performance of the monetary aggregate and the interest rate as policy instruments for macroeconomic stabilisation in 10 African economies. To do this, we estimate the new-Keynesian DSGE model where real balances are non-separable from consumption in the utility function. This feature serves to capture the role of money in driving macroeconomic dynamics in Africa. The models also feature the real exchange rate, foreign output and crude oil prices as additional drivers of macroeconomic dynamics. We estimate and compare two models, one with the interest rate and another with the monetary aggregate as policy instruments.

The main result is that in South Africa, Nigeria, Malawi, Tanzania, Morocco and Zambia it is the monetary aggregate instrument that performs better in macroeconomic stabilisation than the interest rate. In Egypt, Ghana, Uganda and Kenya, it is the interest rate that performs better. These results reflect the fact that output responds strongly to the monetary aggregate than to the interest rate. Our findings imply that the current monetary policy conduct in South Africa, Kenya and Egypt might be suboptimal. Rather than active use of the interest rate instrument, South Africa can improve monetary performance by using the monetary aggregate instrument. Similarly, although Kenya and Egypt are actively using the monetary aggregate instruments, they can enhance macroeconomic performance by using the interest rate instrument. We therefore find the current drives in Kenya and Egypt to migrate to active use of the interest rate instrument consistent with the predictions of our model.

Our results also support the current monetary policy conduct in Ghana and Uganda. Similarly, our model's predictions are consistent with the monetary policy conduct in Nigeria, Malawi, Tanzania, Morocco, Uganda and Zambia. Given the diversity in results, we caution policy makers against generalised adoption of the interest rate instrument. This process must be guided by country specific analysis. The weak role of the interest rate in driving aggregate demand dynamics signals a weaker interest rate transmission mechanism. On the contrary, the larger economic significance of the monetary aggregate implies that the abandonment of the monetary aggregate as a policy instrument in Africa is not appropriate for macroeconomic stabilistaion.

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