UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

ASSESSING ALTERNATIVE MONETARY POLICY FRAMEWORKS AND INSTRUMENTS IN SELECTED AFRICAN ECONOMIES

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Declaration

I declare that this thesis, which I hereby submit for the degree of Doctor of Philosophy (Economics) at the University of the Witwatersrand, Johannesburg, is my own work and has not been submitted by me for any degree or examination at any other University.

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Dedication

Dedicated to my wife Lonia, my daughters Taonga and Hannah and my son Vitumbiko.

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I thank God for his amazing grace. I also deeply thank my supervisor, Professor Christopher Malikane, for his technical guidance during the entire period of study. I equally thank the Reserve Bank of Malawi for granting me the scholarship to pursue this study. This work was going to be extremely difficult without support from my family. Ceaseless prayers, moral and financial support from my wife Lonia, our daughters Taonga and Hannah and our son Vitumbiko helped me to get this far. These family members endured my lengthy absence and sacrificed their time and resources.

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Abstract

This thesis contains three core chapters that assess the performance of alternative monetary policy frameworks and instruments in stabilizing 10 selected African economies. Literature and practice show that Advanced Economies (AEs) and Emerging Market Economies (EMEs) are mostly adopting the inflation targeting (IT) framework. This framework relies on active use of the interest rate as a policy instrument for macroeconomic stabilisation. Different from AEs and EMEs, the majority of African countries are characterized by low financial market development, frequent supply shocks and volatile terms of trade. These features impede the efficiency of the IT framework and the interest rate instrument. Supply shocks imply that inflation is not only demand driven. Volatile terms of trade translate into excessive exchange rate fluctuations.

Due to these factors, policy practice in Africa remains largely divergent from the global trend. Authorities still rely on monetary aggregate targeting (MAT) with de facto managed exchange rates. However, the MAT framework is also failing to stabilize economies. This follows instability of the key factors, such as the money demand, upon which the framework is anchored. Furthermore, controlling exchange rate movements is a challenge due to weak balance of payments positions. It is not surprising, therefore, that the majority of African economies still remain in the grip of macroeconomic instability. Inflation and GDP targets are rarely met and they also remain volatile. The perverse macroeconomic features and the perceived failure of the MAT regime have necessitated the search for alternative monetary frameworks and instruments.

In this study, we join the search by specifically focussing on three questions. First, given the macroeconomic landscape in Africa, what is the relative performance of the interest rate vis-à-vis the monetary aggregate as instru-

ments for macroeconomic stabilization? Secondly, how do these instruments perform when apart from inflation and output stabilization, monetary policy also engages in smoothing exchange rate fluctuations? Thirdly, what is the relative performance of inflation targeting vis-à-vis nominal GDP targeting as alternative monetary policy regimes for macroeconomic stabilization in African economies? Although the success of monetary policy largely relies on appropriate configuration of monetary policy frameworks and instruments, answers to these questions remain controversial and scanty for African economies.

In order to address these questions, we formulate a New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model. In this model, money is non-separable from consumption in the utility function. We estimate the model using the Maximum Likelihood method with quarterly data mostly from 1990 to 2014. The data is obtained from the International Financial Statistics (IFS). The thesis has five chapters. Chapter 1 is the general background to the research problem. Chapters 2, 3 and 4 are distinct but related core chapters addressing three specific research questions. Chapter 5 is the conclusion.

In Chapter 2, we compare the performance of the monetary aggregate and the interest rate as alternative instruments for stabilizing inflation and output in 10 selected countries. Results show that the monetary aggregate is superior in stabilizing 5 economies. In the other 5 countries, it is the interest rate instrument which performs better. In the former group of countries, the monetary aggregate plays a relatively large role in macroeconomic dynamics while in the latter the interest rate is more significant. These results partly reflect differences in financial market development between the two groups of countries. Overall, we find a weak role of the interest rate compared to the monetary aggregate in driving aggregate demand dynamics. The exchange rate is also found to be a key driver of macroeconomic dynamics. Our results suggest three things: First, authorities in Africa need to be cautious of a blanket adoption of the interest rate as a sole monetary policy instrument. Second, authorities will find it difficult to stabilize economies using the interest rate based frameworks. Third, exchange rate stability is key to macroeconomic stability in Africa.

In Chapter 3, we extend the authorities' objective function. In addition to minimizing inflation and output volatility, authorities also use the interest rate or money supply rules to smooth exchange rate fluctuations. The results show that macroeconomic performance is enhanced when authorities smooth exchange rate fluctuations in 4 of the 10 countries. The gains from exchange rate smoothing mostly arise from a reduction in inflation and exchange rate volatility but not from output. In the other 6 countries, exchange rate smoothing worsens macroeconomic performance. These results reflect the fact that the exchange rate exerts a relatively large influence in macroeconomic dynamics in the first group of countries compared to the latter. Exchange rate smoothing therefore minimizes the pass-through of the exchange fluctuations to inflation and output leading to better performance. Overall, the findings suggest that exchange rate smoothing is harmful in Africa. Where exchange rate smoothing delivers gains, appropriate thresholds of smoothing need to be observed to avoid policy induced macroeconomic instability. Authorities should also smooth temporal rather that structural shifts in the exchange rate level.

In Chapter 4, we compare the performance of inflation targeting (IT) vis-à-vis nominal GDP targeting (NGDPT) as alternative monetary policy frameworks for macroeconomic stabilization. We examine the strict and flexible versions of these policy regimes. We also include a hybrid regime which combines elements of IT and NGDPT. Results show that the hybrid regime performs better in 5 countries. In the other 4 countries, it is the strict inflation targeting that performs better. In 1 country, flexible inflation targeting is optimal. The results also reveal that demand shocks dominate but are closely trailed by supply and exchange rate shocks in explaining macroeconomic fluctuations. The multiplicity of significant shocks is key in explaining the dominance of the hybrid regime. The hybrid regime successfully handles shocks that can neither be optimally handled by the IT regime nor the NGDPT regime alone. These results have several implications. First, demand management alone is insufficient to stabilize African economies. Second, identifying dominant shocks is critical for choosing robust monetary policy regimes. Third, the multiplicity of significant shocks implies that choosing monetary policy frameworks and hence macroeconomic management process is more complex for African policy makers.

Overall, the results have several policy implications which are outlined in Chapter 5. First, they suggest a cautious approach towards generalized adoption of the interest rate over the monetary aggregate as a monetary policy instrument in African economies. This contradicts the current wave of monetary policy changes sweeping across African countries. Secondly, the significance of the exchange rate renders credence to exchange rate smoothing in Africa. The findings, however, suggest that exchange rate smoothing can either enhance or worsen macroeconomic performance. Where it enhances macroeconomic performance, authorities must carefully consider the thresholds of smoothing to avoid creating macroeconomic instability. Authorities need not fight structural shifts in exchange rates levels through smoothing. This would help to preserve the shock absorbing role of the exchange rate.

Finally, the prevalence of demand, supply as well as exchange rate shocks makes the hybrid monetary policy regime which combines elements of IT regime as well as NGDPT regime to perform relatively better in stabilizing the majority of the economies. Given the multiplicity of shocks, authorities in Africa need to complement demand management with policies that address supply side and exchange rate bottlenecks to ensure sustainable macroeconomic stability. Overall, the findings suggest that there is scope to improve monetary policy performance in Africa by adopting suitable frameworks and instruments. The results also highlight the problem of tackling monetary policy issues with a "one size fits all" approach.

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1 Introduction

1.1 Background to the study

Persistent shocks affect macroeconomic performance in several African countries. These shocks exert negative impact on macroeconomic stability and social welfare. In order to preserve and improve macroeconomic performance, authorities are increasingly searching for monetary policy frameworks and instruments that are robust to the prevailing shocks. As defined by Mishkin (1999), monetary policy frameworks are institutional arrangements which guide the conduct of monetary policy. Monetary policy instruments are defined as tools that central banks use to influence money market and credit conditions in order to meet monetary policy objectives.

Literature on monetary policy frameworks can be located in the Mundell-Flemming theory. In this theory, an economy is typically deemed to be unable to simultaneously pursue three objectives. These objectives are: a fixed exchange rate system, an open capital account and an independent monetary policy. This theory is also known as the Impossible Trinity or the Trilemma. It is a hypothesis based on two factors. First, is the Uncovered Interest rate Parity condition (UIP). Second, is the finding from empirical studies where countries that have tried to simultaneously pursue all three objectives have failed. There are various monetary policy regimes. The popular ones are: i) Exchange Rate Targeting (ERT) which is mostly implemented when a country has chosen to lose monetary policy independence. In this study, we assume that authorities have chosen independent monetary policy. Therefore, they can implement monetary policy using any of the following regimes: (ii) Monetary Aggregate Targeting (MAT), (iii) Inflation Targeting (IT) and (iv) Nominal GDP Targeting (NGDPT). The choice of any of these frameworks together with the instruments used to achieve policy objectives ideally depends on a country's macroeconomic conditions.

According to Mishkin (1999), ERT involves fixing the value of a domestic currency to a low inflation currency. In this framework, authorities rely on information conveyed by the exchange rate. The ERT is quite successful in anchoring inflation expectations in small open economies (Frankel 2014). However, by definition, the exchange rate target does not allow the exchange rate to move in line with changes in macroeconomic fundamentals. For example, a demand shock arising from increased demand for domestic exports should result in an appreciation of the domestic currency. However, the exchange rate will not be allowed to appreciate in order to absorb the shock. Instead, authorities will buy foreign exchange on the market to defend it. In Africa, poor terms of trade, weak balance of payments positions and weak central bank balance sheets make defending the exchange rate an extremely difficult task. Furthermore, the shocks that hit the anchor country are directly transferrable to the domestic economy under the ERT. Under these circumstances, the ERT poses particular challenges since African countries may lack the capacity to withstand imported shocks. Therefore, the ERT regime may not be a feasible option in many African countries.

After the collapse of the Bretton Woods system around 1971, several countries opted for the MAT. The MAT is based on the quantity theory of money. It basically involves estimating potential output growth and velocity trends. Then through a quantity-equation framework, the target growth rate of the monetary aggregate is backed out. Authorities then withdraw or inject liquidity to ensure that the actual growth in the monetary aggregate is consistent with the backed out target. The MAT involves reliance on information conveyed by a monetary aggregate. Berg et al. (2010) argue that one key advantage of this framework is that under imperfect information, monetary aggregates may contain information about aggregate demand and interest rates that can not be conveyed by interest rates or the exchange rate and can also not be readily observed in real time. In addition, interest rates may not be market clearing in shallow financial markets such as in the majority of African economies. In which case, it becomes difficult to infer the true opportunity cost of future consumption based on prevailing interest rates.

Furthermore, the use of MAT also results from the authorities' unpreparedness to implement forward looking regimes. This may be due to lack of operational and fiscal independence. Under these constraints, strict monetary targeting provides a bulwark against fiscal dominance. However, as observed by Mishkin (1999), the effectiveness of the MAT relies on the stability of velocity and money multiplier. Some studies, such as Sichei and Kamau (2010) find that the velocity and the money multiplier are unstable in Africa. Under a demand shock, authorities find it increasingly difficult to determine the exact amount of liquidity to withdraw from the economy in order to remain consistent with the policy targets. Countries which pursue the MAT also suffer a number of other drawbacks. These include poor liquidity management and absence of well-articulated frameworks for assessing how monetary policy should respond to shocks (Mishra et al. 2012). These challenges are rendering the MAT framework ineffective and have generated a quest for alternative regimes. One of the alternatives to the MAT is the IT framework.

A key feature of the IT regime is the announcement of a numerical target for inflation. The announcement comes with an institutional commitment by the monetary authority to achieve the target. Monetary policy decisions are guided by the deviation of forecasts of future inflation from the announced target and deviation of actual output from trend. Taylor (1993) provides useful empirical insight to this. He states that actual monetary policy decisions could be usefully approximated by a simple interest-rate rule that is increasing in the expected inflation-rate gap and output gap. According to Frankel (2014), the IT framework is gaining more popularity in AEs and EMEs. This follows its robustness to aggregate demand shocks. Demand shocks are dominant in these economies. Under IT, central banks typically treat the nominal interest rate as their policy instrument.

The characterization of monetary policy conduct under IT shows that when inflation is rooted in demand factors, the IT regime together with the interest rate instrument do not generate policy trade-offs. When there is a demand shock, contractionary monetary policy closes both the output gap as well as the inflation gap. The challenge occurs when an economy is faced with a negative shock to output due for example, to droughts or collapse in terms of trade. In such cases, monetary policy conduct is not straight forward. Strict adherence to IT which calls for a rise in interest rates may worsen output gap and exacerbate inflationary pressures. In Africa, several studies, such as Heintz and Ndikumana (2011) show that inflation is driven by supply or trade shocks. IMF (2011) also shows that the probability of terms of trade and disaster shocks are higher in Africa compared to AEs and EMEs. Furthermore, fiscal dominance and financial stability concerns compel African authorities not to strictly adhere to interest rates rules.

Frankel (2014) shows that when supply shocks dominate, NGDP targeting performs better in reducing macroeconomic volatility than the IT. A supply shock will reduce real GDP and raise inflation. This implies that the inflation gap as well as the output gap will rise. The difference occurs in the way authorities under the IT and the NGDP regimes respond to this shock. Under NGDPT, monetary policy response ensures that the supply shock is apportioned between prices and the real GDP. Authorities will allow inflation to rise to compensate for a fall in real GDP thereby maintaining the NGDP target. Allowing the inflation to rise implies that monetary policy response will relatively be less hawkish under the NGDPT compared to the IT. Under the IT, a supply shock is borne by prices alone. Authorities will tighten monetary policy which deals with inflation threats but doing so tends to worsen the performance of GDP.

The inefficiency of the IT regime and the interest rate instruments in Africa can also be analyzed via the transmission process of the interest rate signals. Under the interest rate instrument, authorities typically conduct monetary policy by buying and selling short-term government securities in a well-functioning financial market. In doing so, the objective is to control the value of some financial market variable, such as the interbank interest rate (IBR). The IBR is assumed to influence long-term retail rates and hence output and inflation (Mishra et al. 2012). This process is buttressed by the exchange rate channel. Under floating exchange rates and perfect capital mobility, arbitrage between domestic and foreign short-term government securities causes incipient capital flows which change the equilibrium value of the exchange rate. However, the effectiveness of the exchange rate channel depends on several factors. These include the authorities' willingness to allow the exchange rate to move, the degree of capital mobility and the strength of expenditure switching effects.

As shown by Mishra et al. (2012), the conventional description of interest rate and exchange rate transmission relies on effective arbitrage along several margins. These include arbitrage between different short-term securities, short-term and long-term securities, long-term securities and equities, domestic and foreign securities and financial and real assets. This transmission process is thus intended for economies with developed and competitive financial systems, independent central banks, high degree of international capital mobility and floating exchange rate systems. African economies do not compete favorably in most of these features. For example, Fig. 5 shows that financial market development has largely stagnated in Africa. To the extent that the features that characterize African countries differ from those of the developed economies, it would be expected that the standard policy transmission process will also differ. Under these circumstances, monetary policy conduct using the IT and the interest rate instruments may fail to successfully stabilize economies.

Frankel et al. (2008), also shows that the appeal of the interest rate rules over money-targeting rules as a means of delivering lower inflation and output volatility only holds when demand shocks dominate. When supply shocks dominate, interest rates continue to deliver lower inflation volatility but at the cost of higher output volatility. Under these circumstances, a conventional money-based rule will result in lower output volatility and the unambiguous welfare-based argument in favour of the IT and interest rates disappears. Figs. 2 and 3 capture the contribution of food to inflation while Fig. 4 shows the contribution of agriculture to GDP in Africa. These figures reveal that supply side factors can not be dispelled in Africa. As observed by IMF (2015) and Berg et al. (2010), these factors also explain why the MAT regimes and money supply rules remain a common practice in Africa.

This notwithstanding, the global direction in monetary policy conduct towards inflation targeting and interest rate rules is exerting significant influence on policy direction in Africa. Although the success of monetary policy largely relies on the appropriate configuration of monetary policy frameworks and instruments, abundant research on the subject is only available for AEs and some EMEs, but little on Africa. Besides, the available literature is also not synchronized. This lack of synchrony compounded by the paucity of literature is putting speed bumps on the monetary policy modernization process in Africa.

1.2 Stylized facts

1.2.1 Volatile macroeconomic performance

African countries still remain in the grip of macroeconomic instability. Country-specific analysis reveals that the majority of African countries struggle to meet their inflation objectives using the prevailing monetary policy frameworks and instruments. For example, Ghana adopted an inflation target of

Table 1: Inflation developments

	Mean					Standard Deviation				
	90-95	96-99	00-05	06-10	11-14	90-95	-99	-05	-10	-14
Egy.	13.9	4.7	4.7	11.7	9.2	5.2	1.7	3.3	4.5	1.9
Gha.	27.3	25.9	21.3	13.6	11.2	18.2	16.3	9.2	3.9	3.0
Ken.	25.3	8.2	8.3	12.7	9.1	17.5	3.6	4.5	8.2	4.8
Mal.	35.4	31.3	17.3	9.3	20.3	26.8	20.2	7.4	2.8	9.4
Mor.	6.0	1.8	1.5	2.2	1.1	1.6	1.2	1.1	1.4	0.8
Nig.	48.9	13.9	14.3	10.1	9.9	22.6	11.5	6.4	3.6	1.9
S.Afr.	11.3	7.0	5.2	6.9	5.6	3.11	2.2	3.3	2.8	0.8
Tanz.	31.1	14.5	5.3	8.6	10.7	11.0	5.4	1.2	2.6	4.9
Ugan.	6.14	5.3	4.3	8.5	10.8	4.8	4.2	4.3	4.1	8.5
Zam.	39.2	29.9	21.3	10.8	6.9	12.8	9.4	3.8	2.5	0.6
Ave.	24.5	14.3	10.4	9.4	9.5	12.4	7.6	4.5	3.6	3.6

Source: International Financial Statistics

8.5 percent (± 2) in 2007 with active use of the interest rate instrument. In 2008, the country was faced with severe oil and food price shocks which persistently led to inflation deviating from the target. Even prior to 2007 when Ghana was using the monetary aggregate targeting framework, her inflation remained fairly high (see Table 1).

Table 1 also reveals that there has been some decline in aggregate inflation over time with more stability registered in the past decade. Similarly, real GDP has been on the rise with substantial growth registered in the past decade (see Table 2). According to O'Connell (2011) this macroeconomic progress places many African countries on the right path to use interest rate instruments and inflation targeting frameworks. However, risks to sustained macroeconomic stability remain elevated. Nguyen et al. (2017) identify high vulnerability to natural disasters, oil price shocks and terms of trade shocks as some key risks. It is not surprising, therefore that Tables 1 and 2 also show that inflation rates have mostly been above targets while real GDP growth rates are mostly below the conventional 6 percent mark.

Table 2: Real GDP growth

	Mean					Standard Deviation				
	90-95	96-00	00-05	06-10	11-14	90-95	-99	-05	-10	-14
Egy.	3.8	5.9	3.7	6.2	2.3	1.6	1.0	0.6	1.2	1.0
Gha.	4.1	4.3	5.1	7.9	6.3	0.8	0.2	0.6	3.7	2.2
Ken.	2.0	2.0	3.8	4.7	4.5	2.1	1.7	2.1	2.4	0.9
Mal.	3.1	1.9	2.5	7.4	3.3	10.6	6.4	4.0	1.8	1.4
Mor.	1.7	4.0	4.9	5.0	3.8	6.9	5.6	1.8	1.7	1.5
Nig.	3.7	3.2	4.0	7.4	4.6	2.6	0.6	0.2	0.6	1.9
S.Afr.	0.7	2.8	3.8	3.2	2.4	2.2	1.5	1.1	3.0	0.5
Tanz.	4.1	4.3	5.2	8.3	5.3	0.6	0.2	0.5	3.5	2.0
Ugan.	13.6	18.2	6.7	8.2	5.2	24.7	6.4	1.1	1.8	1.8
Zam.	-0.3	2.8	4.8	6.4	6.7	3.7	3.2	0.9	0.7	2.7
Ave.	3.7	4.9	4.5	6.5	4.4	5.6	2.7	1.3	2.0	1.6

Source: International Financial Statistics

1.2.2 Weak interest rate transmission

According to IMF (2015), while the majority of African countries still use the MAT regime some have introduced policy rates for signaling the stance of monetary policy. However, these countries often do not have the operational support required to align market rates with the policy rate. For example, Fig. 1 shows that Kenya and Uganda have largely succeeded in aligning central bank rates (CBR) with the interbank rate. However, there still remains a divergence between the interbank rate and the retail rates (lending and savings rates). This implies that the de facto and de jure policy stance are different. This leaves questions regarding the effectiveness of interest rate instruments in fragmented markets. Other countries, such as Malawi, Zambia and Tanzania which use the MAT system also have a disjoint between the operating targets and the retail rates.

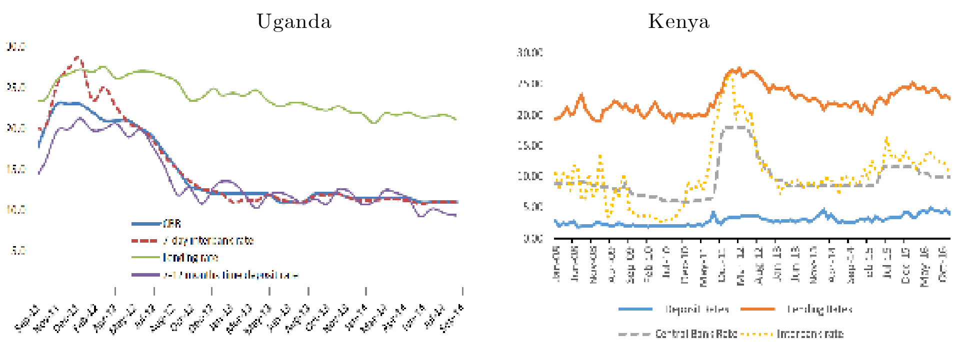


Figure 1: Policy rates and market interest rates (Kenya and Uganda)

1.2.3 Dominant agriculture/food sectors

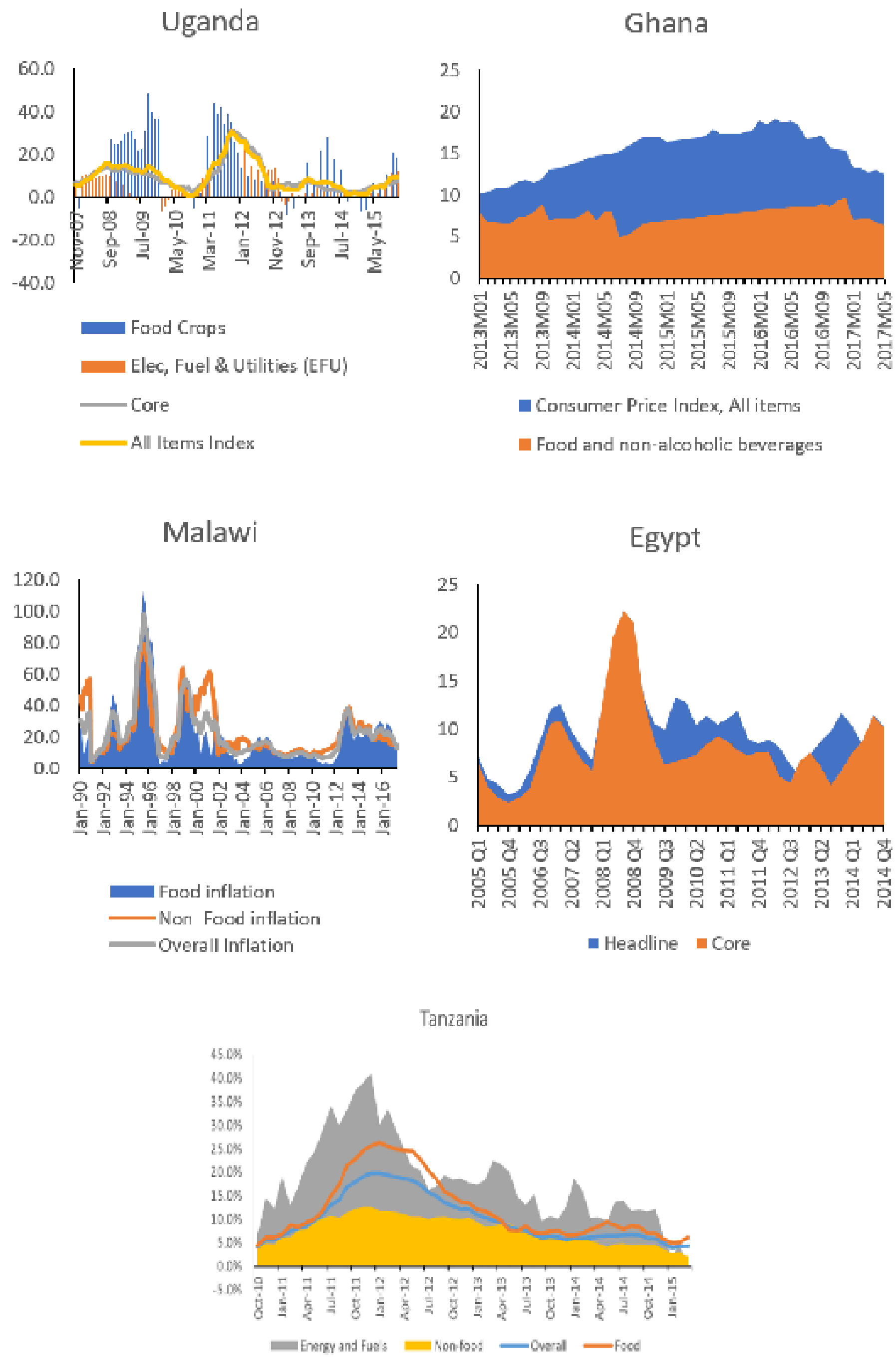
Figs. 2 and 3 show that food prices significantly contribute to overall Consumer Price Index (CPI) in all countries. According to the International Financial Statistics (IFS), the 2016 weights of food and beverages in the overall CPI are recorded as follows (from highest to lowest): Zambia (53.5%), Nigeria (51.8%), Malawi (50.2%), Tanzania (47.8%), Egypt (44.4%), Ghana (43.9%), Morocco (39.3%), Kenya (36%), Uganda (28.5%) and South Africa (17.2%). This data shows that in Zambia, Nigeria, Malawi and Tanzania food prices contribute nearly half to the overall price dynamics. In the other countries, food inflation still contributes more to overall inflation but comparatively less than in the first five countries. Even though South Africa has the smallest weight on food compared to the rest of the countries, it is still higher than many AEs. These weights suggest that supply factors can not be ignored in the fight against inflation. This data is consistent with Nguyen et al. (2017) who show that 45 percent of inflation variations in Africa arise from general supply shocks. Of the 45 percent, two thirds is attributed to domestic supply and commodity price shocks.

According to the 2011 World Bank Development Indicators, expenditures on food in AEs are estimated as follows: Japan (14.7%), Germany (11.5%), Australia (10.8%), Canada (9.3%), United Kingdom (8.8%) and United States

(5.7%). These figures show that fluctuations in food prices may have negligible impact on overall inflation. This suggests that inflation is largely demand driven in these countries. These statistics do not compare favorably with those from African economies where food expenditures are relatively large. Large food sectors imply that non-monetary GDP is relatively large. Monetary policy implemented using the IT framework and the interest rate instrument is likely to succeed in countries with smaller expenditures on food than in the majority of African economies. Durevall et al. (2012) argue that traditional interest rate channels make less sense in countries that predominantly dependent on agricultural sector with huge informal sector. Given these observations, identifying monetary policy frameworks and instruments which are consistent with the inflation dynamics in African economies remains an empirical issue.

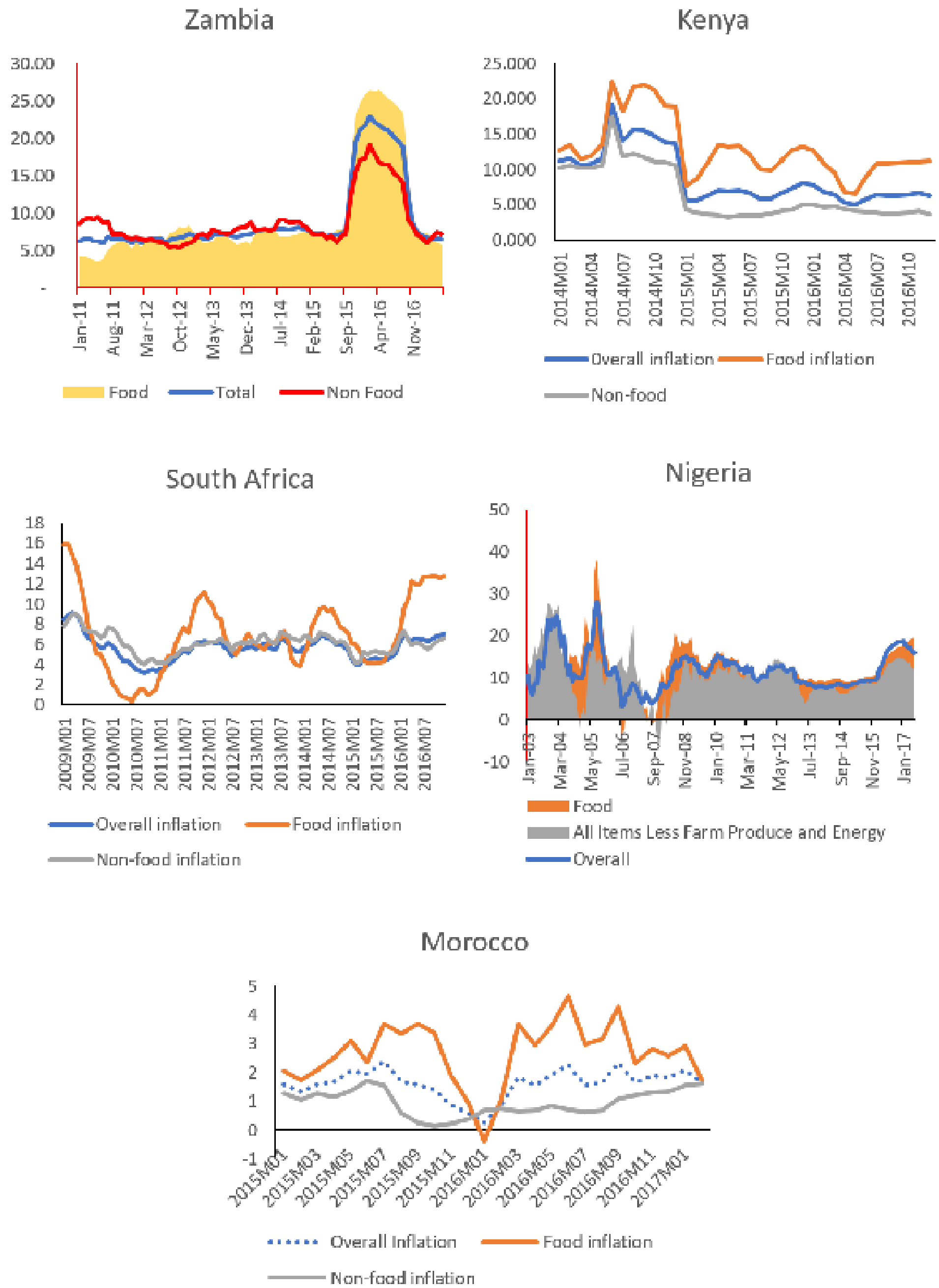
Similarly, Table 3 reveals that as a single item, agriculture commands a huge share of output in African economies[1]. It literally surpasses the contribution of industry in Malawi, Kenya, Tanzania and Uganda. The relatively large share of agriculture implies that output and inflation fluctuations are not entirely under the control of monetary policy. Considering that the agricultural sector is largely small scale and rain driven makes overall GDP and inflation susceptible to weather shocks. This raises a critical question of whether standard monetary policy frameworks and instruments which are effective in handling aggregate demand shocks in AEs and EMEs can equally perform well in these circumstances.

[1] The classification is based on the United Nations Industry Classification System called the International Standard Industrial Classification (ISIC) of Economic Activities.



Source: International Financial Statistics

Figure 2: Contribution to overall inflation (percent)



Source: International Financial Statistics

Figure 3: Contribution to overall inflation (percent)

Table 3: Sectoral contribution to GDP (percent)

	Zam.	S.Af	Mor.	Mal	Egy.	Gha.	Kenya	Tanz.	Nig.	Uga.
Serv.	56.5	68.1	57.7	49.7	49.9	49.9	50.4	43.5	55.5	50.8
Industry	33.8	29.5	29.3	17.0	39.0	27.7	19.4	25.0	24.3	22.0
Agric.	9.64	2.5	12.9	33.3	11.1	22.4	30.3	31.5	20.2	27.2

Source: 2011Word Bank Development Indicators

1.2.4 Frequent terms of trade (ToT) shocks

The top part of Fig. 4 shows fluctuations in ToTs while the bottom part shows fluctuations in exchange rates. ToTs are defined as the ratio of an index of the country's exports to the index of the country's imports. The ToTs are mostly driven by fluctuations in prices and demand for commodity exports. The higher the ratio, the better the ToTs as this entails that a country generates enough export proceeds to sustain its import bills. This is a necessary condition for exchange rate stability. Declining ToTs signal pressure on the exchange rate. In addition to volatility, Fig. 4 also shows that the ToTs for Nigeria, Zambia, Malawi, Kenya, South Africa, Egypt and Tanzania have been declining after the 2009 financial crisis.

The majority of African countries are commodity exporters and the plunge in global commodity prices had considerable negative effects on ToTs in Africa. Thus, a key feature of Fig. 4 is that the majority of African countries suffer volatile and declining ToTs. Volatile and declining ToTs result into frequent exchange rate fluctuations and depreciations. The bottom part of Fig. 4 shows that the exchange rates in the selected countries exhibit significant fluctuations. These fluctuations as argued by Sanchez (2008) have negative implications for macroeconomic performance. This raises another critical question for policy makers in Africa: should monetary policy respond to exchange rate fluctuations to mitigate the impact of terms of trade shocks? Again, literature on this question is mostly available on AEs and EMEs but not Africa.

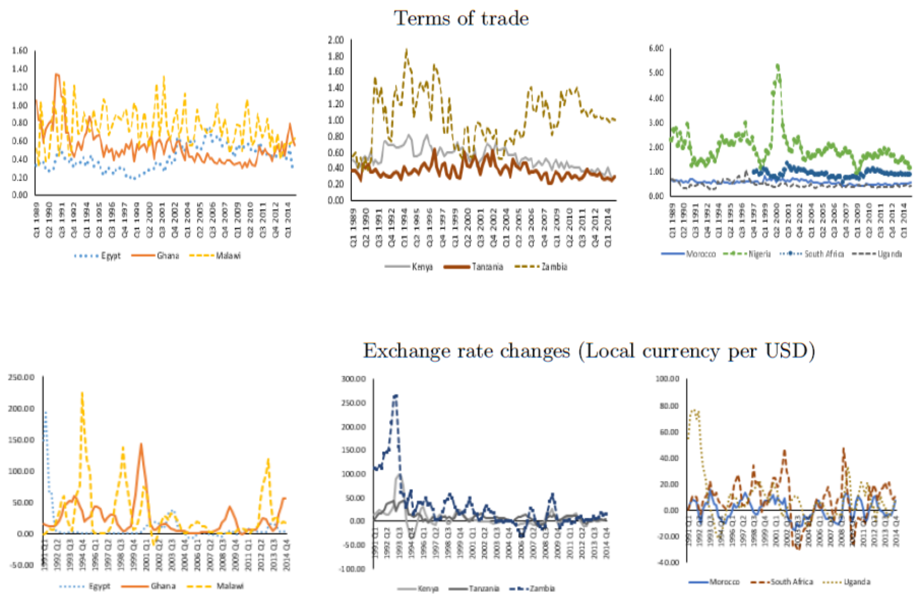


Figure 4: Terms of trade and exchange rate developments

1.2.5 Low financial market development

We use an index of financial development (FDI) developed by Svirydzenka (2016) to compare the status of financial development in the selected African countries. We compare these indices with that of Norway, representing AEs. We also include the FDI for Newzealand which was the first country to practice IT. The FDI combines two indices, namely financial institutions index (FII) and financial markets index (FMI). The FII further combines financial institutions access index and financial institutions efficiency index (FIEF). The FMI combines financial market development, financial market access and financial market efficiency. The resulting aggregate index, namely the FDI is therefore more representative than the traditionally used measures, such as the ratio of private sector credit to GDP and the ratio of stock market to GDP. The higher the index the better the financial market development[2].

[2]See Svirydzenka (2016) for detailed derivations.

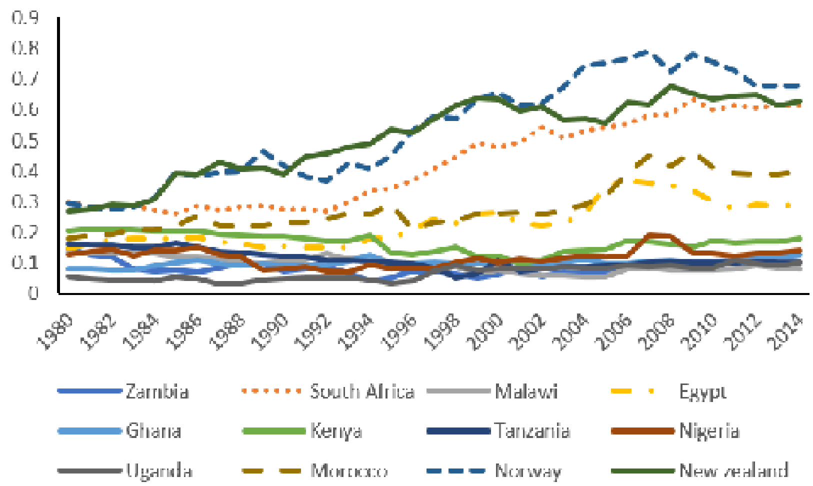


Figure 5: Financial market development

Fig. 5, reveals that financial market development has largely stagnated in Malawi, Zambia, Kenya, Uganda, Tanzania, Ghana and Nigeria. However, South Africa, Morocco and Egypt display some upward trend in financial development. South Africa compares favorably with some AEs. Morocco and Egypt appear to be below South Africa and above the rest of the countries in our sample. According to Mishra et al. (2012), financial market development is key in transmitting interest rate signals under interest rate frameworks. The status of Africa's financial market development, therefore, raises critical questions on whether interest rate instruments would be effective in dealing with output and inflation fluctuations.

1.2.6 Attempts to migrate to inflation targeting

Within the described unique macroeconomic landscape that characterize African countries, there are still significant attempts to migrate to inflation targeting and interest rate instruments. A summary of the current monetary policy frameworks and instruments in the selected African economies is presented in Table 4. The Table is based on the 2016 International Monetary Fund Annual Report on Exchange Rate Arrangements and Exchange Restrictions (IMF AREAER-2016). The classification used is based on each country's actual or de-facto arrangement. This implies that the officially announced or de jure arrangement may differ from the de facto policy conduct. For example, Kenya is denoted as an IT country by authorities as well as by IMF (2015). However, based on the IMF AREAER (2016) Kenya's status has changed from pursuing MAT as categorized in IMF AREAER (2014) to pursuing "Other" monetary policy framework. Authorities in Kenya have only taken preliminary steps toward inflation targeting.

A part from monetary policy regimes, IMF AREAER (2016) also classifies the exchange rate systems. The classification is primarily based on the degree to which the exchange rate is determined by the market rather than by official action-the market-determined rates being on the whole more flexible. The presentation of exchange rate arrangements alongside monetary policy frameworks in Table 4 highlights that similar exchange rate regimes can be consistent with different monetary policy frameworks.

Table 4 further shows that 3 countries, namely South Africa, Ghana and Uganda are pursuing the IT regime. The other 3 countries, namely Egypt, Kenya and Zambia are characterized as pursuing "Other" monetary regimes. "Other" regimes imply that these countries have no stated nominal anchor. In practice, this has been a transitory stage from MAT to IT. The other 3 countries, namely Tanzania, Malawi and Nigeria are using the MAT regime

Table 4: Monetary policy frameworks and instruments

	Pol. Fram.	Pol. Inst.	Op. Targ.	Int. Targ.	Main Pol. Goal	Ex. R. Pol.	IMF Prog.
Egypt	Other	a, b,	RM	Broad	Price	OMF	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 ± 2)		(2015)
Kenya	Other	a, b,	IBR	Broad	Price Stab.	Float	SF
	(2011)	c, d	RM	money	(5 ± 2)		2015
Mal.	MAT	a, b,	RM	Broad	Price & Fin.	Float	ECF
	(1994)	c, d	IBR	money	Stability		2012
Mor.	Ex. Targ.	a, b,	-	-	Price	CP	PLL
		c, d			Stability		2015
Nigeria	MAT	a, b,	RM	Broad	Price & Fin.	SA	Art.4
		c, d	IBR	money	Stability		2014
S. Africa	IT	a, b,	IBR	Inflation	Price	Float	None
	(2000)			forecast	Stab. $(3-6)$		
Tanz.	MAT	a, b,	RM	Broad	Price	Float	PSI
	(1992)	c, d	IBR	money	Stability		2014
Uganda	IT	a, b,	IBR	Inflation	Price, XR	Float	PSI
	(2014)	c, d		forecast	Stab. (5)		2013
Zambia	Other	a, b,	RM	Broad	Price & Fin.	Float	Art. 4
	(2015)	c, d	IBR	money	Stability		2015

Notes: MAT⇒Monetary Aggregate Targeting, RM⇒Reserve Money, IT⇒Inflation Targeting, Exr, Tar⇒Exchange rate targeting, IBR=Interbank rate, CP=Convetional peg, a=Policy rate, b=Open Market Operations,c=Liquidity Reserve Requirement, Fin=Financial, d=Forex Exchange Operations, ECF=Extended Credit Facility, SA=Stabilisation. Arrangement, OMF=Other Managed Float, Art.4=Article 4 consultations, PSI=Policy Support Instrument, SF=Standing Facility, Pol.=Policy, Inst.=Instrument, Targ.=Target, Prog.=Programme, PLL=Precautionary and Liquidity Line int=interest, XR=exchange rate stability. () inflation targets while Morocco is implementing the ERT. The diversity in monetary policy frameworks is a reflection of diverse challenges that these economies are facing. Contrary to AEs, which recently have been using the interest rate instrument only, Table 4 shows that several African countries tend to use the interest rate alongside the monetary aggregate instruments to deal with macroeconomic fluctuations (see also Davoodi et al. 2013 and IMF 2015). Recently, there has been greater use of the interest rate as an operating target while weight is placed on both the interest rate and the monetary aggregates in setting the monetary policy stance. Dornbusch and Fischer (1992) argue that central banks may not achieve their objectives if they actively deploy money and interest rate instruments, simultaneously.

The correlation coefficients between the policy instruments, inflation and output are presented in Table 27. These coefficients suggest that there is a negative relationship between output and interest rate in all the countries. The magnitude is estimated at a relatively high value of -0.25 for the IT countries, followed by those pursuing other regimes at -0.14. The correlation between output and interest rate in countries that pursue MAT is estimated at -0.07. In Morocco which pursues conventional peg, it is estimated at -0.01. These correlations suggest that authorities raise interest rates when faced with aggregate demand pressures. The correlation between money and inflation is negative. At -0.55, the correlation is strongest in countries that pursue other regimes. This is followed by those that pursue IT regimes whose correlation is estimated at -0.35. The correlation in MAT countries is estimated at -0.26 whilst for Morocco which pursues conventional peg it is estimated at -0.15. These correlations suggest that authorities contract money supply when faced with inflation threats. Except in the MAT countries, in all the other countries, authorities inject money supply to support growth. This is suggested by the positive correlations between money and output.

1.2.7 Multiple monetary policy objectives

According to IMF (2015) Low Income Countries including those from Africa place price stability as a prime objective of monetary policy. However, in practice they pursue additional objectives, such as exchange rate stability (see also Table 4). At times, concerns over the exchange rate supersede price stability concerns. As a result, monetary policy in many African countries can go through periods of excessive accommodation or tightening and contribute to inflation and output volatility. The pursuit of multiple policy objectives which are more than available policy instruments (violation of the Timbergen principle) complicates policy design and is often a recipe for policy ineffectiveness. Although these challenges are present for all central banks, they are more pronounced in Africa, given the absence of clear frameworks. According to Zhang (2009), these features may also reflect imperfect monetary policy transmission mechanism.

1.3 Motivation of the study

This study is motivated by three key issues pertaining to monetary policy instruments and frameworks in Africa. First is the contradiction in the global trend in monetary policy research and conduct vis-à-vis the practice in Africa. Conventional new Keynesian literature on AEs, such as Ireland (2004) and Woodford (2003) and literature on emerging economies, like Frömmel et al. (2011) and Mohanty and Klau (2004), largely assume that central banks use the interest rate policy instrument. Recent studies, such as Araujo (2015) and Castelnouvo (2012), find that the monetary aggregate plays an important role in driving macroeconomic dynamics. These findings gesture the need to re-look at the monetary aggregate as a policy instrument. The need is stronger for Africa.

As demonstrated by Kasekende and Brownbridge (2011), Africa has weak financial markets which can impair interest rate transmission (see also Figs. 1 and 5). Furthermore, Africa is characterized by the dominance of agriculture and hence large supply shocks (see Figs. 2, 3 and Table 4). According to Bhattacharya and Sigh (2008) when real shocks dominate, authorities can improve welfare by using the monetary aggregate instead of interest rate instruments. Despite the divergence in views, there is no literature in Africa which compares the performance of the monetary aggregate and the interest rate rules to aid monetary policy decisions. This question is tackled in Chapter 2.

Chapter 3 is motivated by the controversy surrounding the configuration of the monetary policy instruments, particularly, whether engaging in exchange smoothing using monetary policy rules is consistent with the goals of macroeconomic stabilization. This question is critical for African economies due to frequent ToTs Shocks (see Fig. 4) and also volatility in commodity prices which together with the "Fear of Floating" make policy makers in Africa to be sensitive to exchange rate movements. Some studies, e.g. Mohanty and Klau (2004) and Hufner (2004), estimate simple policy rules and find that the exchange rate is significant. This class of studies only addresses the question of whether monetary authorities react to the exchange rate and not the impact of this reaction on macroeconomic stability.

The studies that examine the effect of exchange rate smoothing on macroeconomic stability also produce conflicting results. For example, Batini et al. (2000) argue in favour of exchange rate smoothing while Garcia et al. (2011) argue against it. Apart from this dichotomy in literature, the majority of these studies are either on developed or emerging market economies. Alpanda et al. (2009) examines this question for South Africa. They find no evidence that the South African Reserve Bank reacts to the exchange rate. However, Gupta and Jooste (2014) provide this evidence. Four limitations appear in the literature on Africa: First, the studies are few. Second, the few available studies are only on South Africa. Third, these studies find divergent results. Finally, these studies do not examine whether exchange rate smoothing has implications for macroeconomic performance.

Lastly, research and practice on monetary policy regimes is concentrated on the IT. Despite en masse adoption of the IT regime, recent studies such as Summers (2015), Woodford (2014) and Frankel (2014), have raised concerns on its success. For example, Frankel (2014) argues that the performance of IT regime is subdued when shocks relating to supply or terms of trade dominate. In Africa, several studies, such as Heintz and Ndikumana (2011) and Loening et al. (2009) show that inflation is mostly driven by supply shocks. The findings from these studies are corroborated by the inflation decomposition presented in Figs. 2 and 3. In the many African countries, food inflation which largely depends on supply factors is a major contributor to overall inflation.

IMF (2011) further argues that the probability of terms of trade and disaster shocks are higher in Africa than in AEs and EMEs. This again is supported by Fig. 4 which shows significant fluctuations in ToTs. Despite this evidence, there is paucity of literature in Africa on alternative frameworks like the NGDP targeting. According to Jensen (2002), the NGDP targeting is superior to the IT regime in handling supply shocks. The global direction of research and practice is thus at odds with the prevailing macroeconomic landscape and policy practice in many African economies. Therefore, Chapter 4 is motivated by the lopsidedness in literature and the practice in favour of the IT regimes and AEs.

1.4 Objectives of the study

The broad objective of this study is to compare the performance of alternative monetary policy instruments and frameworks in macroeconomic stabi-

lization in 10 selected African economies.[3] Specifically, the study seeks to:
i) Compare the performance of the monetary aggregate and the interest rate as alternative instruments for macroeconomic stabilization in the selected African economies.
ii) Assess the implications of exchange rate smoothing by central banks on macroeconomic performance in the selected African economies.
iii) Compare the performance of Inflation Targeting and Nominal GDP Targeting as alternative monetary policy frameworks for macroeconomic stabilization in the selected African economies.

1.5 Research questions

The study addresses the following specific research questions:
i) Which of the monetary policy instruments, between the monetary aggregate and the interest rate, performs better in macroeconomic stabilization of the selected African economies?
ii) Does including exchange rate smoothing as an objective of monetary policy affect macroeconomic performance in the selected economies?
iii) How does macroeconomic performance under the IT regime compare with the performance under the NGDP targeting regime in the selected countries?

1.6 Contribution of the study

This thesis contributes to the current state of knowledge on monetary policy frameworks and instruments in Africa. Theoretically, unlike vast literature in Africa which uses vector autoregressive models, our study uses a New Keynesian DSGE model. The model is formulated on the assumption that

[3] The 10 selected countries are: Egypt, Nigeria, Ghana, South Africa, Zambia, Uganda, Tanzania, Malawi, Morocco and Kenya

money and consumption are non-separable in the utility function. Therefore, the model explicitly introduces the role of real balances as one of the critical variables driving macroeconomic dynamics in Africa.

Furthermore, most standard new Keynesian DSGE studies e.g. Gali et al. (2001) give prominence only to inertial behavior in both inflation and output. Others, such as Benchimol and FourÇans (2012), de-emphasize inertial behavior in order to assess the role of the monetary aggregates. We build on these studies and combine inertial behavior and the monetary aggregates in order to examine the possible role of both, the interest rate and the monetary aggregates in Africa. Also different from standard literature in AEs and EMEs, our model features the exchange rate, foreign inflation and foreign input prices. These variables are considered critical in driving macroeconomic dynamics in Africa. In addition, unlike the majority of the studies, e.g. Baldini et al. (2015), all our policy rules are derived from the central bank's optimization behavior. The study thus advances a potential theoretical framework for monetary policy analysis in African countries.

Specifically, in Chapter 2, we build on other studies like Baldini et al. (2015), Muhanji and Ojah (2011), Peiris and Saxegaard (2010) and Berg et al. (2010). These studies use one policy rule. This chapter extends this literature by empirically examining the performance of two alternative policy rules, the interest rate and the monetary aggregate. In Chapter 3, we build on similar studies like Wollmershäuser (2006) who examine macroeconomic performance under the interest rate rule. We also build on studies, such as Alpanda et al. (2010) who examine the significance of the exchange rate in the policy rule. We extend this literature by responding to a question raised by Taylor (2001) on how the monetary aggregate can respond to the exchange rate. We thus extend literature by including a comparison of the performance of the interest rate and money supply rules when exchange rate smoothing features as a central bank objective. In Chapter 4, we recognize the paucity of studies on monetary policy frameworks. Therefore, we empirically contribute to literature by comparing two potential monetary policy regimes for Africa, namely the IT and the NGDP targeting regimes.

1.7 Significance of the study

The significance of the study is threefold. Firstly, it will assist authorities to minimize macroeconomic instability that results from suboptimal monetary and exchange rate policy choices in Africa. According to Baldini et al. (2015), inappropriate policy choices can worsen macroeconomic performance. Secondly, the study will assist authorities to improve the credibility of monetary policy in Africa. When authorities use appropriate monetary policy instruments and frameworks, monetary policy credibility is enhanced. With credible policies, the chances of achieving policy objectives rise. Thirdly, the study proposes a theoretical model which can prove useful to African authorities as they seek assistance from international partners to improve the performance of monetary policy. This is particularly important at this point in time when several African countries are seeking assistance to their modernize monetary policy conduct.

2 Assessing alternative monetary policy instruments in selected African economies

2.1 Introduction

In this chapter, we compare the performance of the monetary aggregate and the interest rate as policy instruments for macroeconomic stabilization in 10 selected African economies. 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, such as Svensson (2002) and Ireland (2004), which show the declining significance of monetary aggregates in driving macroeconomic dynamics.

As observed by Berg et al. (2010), this tilt in global policy conduct contradicts the practice in Africa where policymakers have to contend with perverse macroeconomic factors. Some studies, therefore, such as IMF (2008) argue that the continued use of monetary aggregates as policy instruments is consistent with macroeconomic stabilization in Africa. Others, such as Peiris and Saxegaard (2010) suggest the adoption of interest rates as instruments for monetary policy. In this vein, a number of countries, such as Kenya, Uganda and Ghana have recently started to implement regimes that increase the role of the interest rate in monetary policy conduct.

However, IMF (2015) observes that these countries still lack the operational support necessary to align market rates with the policy rate. While some countries, such as, Uganda have succeeded in aligning short-term rates with the policy stance, ultimately it is the transmission from short-term rates to retail rates that matters for policy effectiveness. There are often large and persistent deviations of the market rates from the policy rates. The corresponding huge gap between the de facto and de jure policy stance tends to weaken the transmission mechanism. According to Mishra et al. (2012), this raises questions on the effectiveness of the transmission of interest rate signals to aggregate demand and inflation. With such unclear outcomes, the choice between the monetary aggregate and the interest rate as instruments of macroeconomic stabilization remains a major unresolved issue in Africa.

The importance of this study is that it will assist policymakers to reduce macroeconomic instability that is induced by sub-optimal choices of monetary policy instruments. As shown by Baldini et al. (2015), inappropriate instrument choice can worsen macroeconomic performance. Furthermore, Mishkin (1999) and Kasekende and Brownbridge (2011) argue that monetary policy implementation and effectiveness in low income countries (LICs) are affected by several structural factors which are absent in AEs. Therefore, by including some Africa-specific features, this study will assist authorities to make evidence-based choices between the two policy instruments. Furthermore, when authorities use appropriate monetary policy instruments, the chances of achieving policy objectives tend to rise. When this happens, monetary policy credibility is enhanced.

The gap that is filled by this paper is that standard New Keynesian literature, such as Ireland (2004), Woodford (2003), and Clarida et al. (1999), tends to assume that central banks use the interest rate as the policy instrument. Even single-equation studies that explore policy rules in emerging market economies, such as Mohanty and Klau (2004), Moura and Frömmel et al. (2011) and de Carvallo (2010), consider only the interest rate as a monetary policy instrument. In this regard, Mehrotra and Sanchez-Fung (2010) stand out in that they provide a comprehensive assessment of policy rules under different instruments across countries. These authors, however, conduct their study in a single-equation framework. From the standpoint of New Keynesian models, several recent studies, like Araujo (2015) and Castelnouvo

(2012), find that the monetary aggregate plays a significant role in driving macroeconomic dynamics.

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 and also supply rather than demand factors dominate. Under real shocks, Bhattacharya and Sigh (2008) argue that welfare is enhanced by using the monetary aggregate and not the interest rate. Furthermore, although the monetary aggregate has been a dominant policy instrument in Africa, its operability is increasingly being questioned due to the perceived shift in the velocity of money and the money multiplier. It is therefore important to examine the relative efficiency of the two policy instruments in African economies in light of the perceived shift.

The contribution of this paper is fourfold: First, different from Baldini et al. (2015), Muhanji and Ojah (2011), Berg et al. (2010) and Peiris and Saxegaard (2010) who use one policy instrument, this paper compares two policy instruments, the monetary aggregate and the interest rate. Secondly, different from these studies, we derive both policy instruments from the central bank's optimization behavior. Thirdly, unlike the vast literature in Africa which uses vector autoregressive models, this paper uses a New Keynesian model that is formulated on the assumption that money and consumption are non-separable in the utility function.

Finally, our model explicitly introduces the role of real balances as a pivotal variable in driving macroeconomic dynamics in Africa. Most standard New Keynesian DSGE models, such as Gali et al. (2001), give prominence to inertial behavior in both inflation and output. Others, such as Benchimol and FourÇans (2012), de-emphasize inertial behavior in order to analyze the role of the monetary aggregates. In our study, we combine inertial and the monetary aggregate in the same framework and proceed to investigate the possible role of the interest rate and the monetary aggregates in African economies.

The rest of the Chapter is organized as follows: Section 2.2 reviews the literature. Section 2.3 lays out the theoretical model. In Section 2.4, we derive the model. Section 2.5 describes the data and the estimation technique. Section 2.6 discusses the results while Section 2.7 concludes with policy options.

2.2 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 in macroeconomic stabilisation. On the contrary, when shocks are nominal, interest rate policy instruments perform better. Early evidence for this has been documented by Canzoneri and Henderson (1989), Gordon (1979) and Poole (1970). However, other earlier studies, such as Taylor (1999) and Sargent and Wallace (1975), argue that equilibrium indeterminacy gives interest rates a natural disadvantage. They contend 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 of views on the role of monetary aggregates and interest rates in driving macroeconomic fluctuations is also reflected in recent literature. For example, Ireland (2004) and Rudebusch and Svensson (2002) use the New Keynesian framework and reject 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. Araujo (2015), Benchimol and FourÇans (2012), Castelnouvo (2012) and

Canova and Menz (2011), find a significant role of monetary aggregates in driving macroeconomic dynamics. While reporting the significance of monetary aggregates, these studies, however, do not examine the effectiveness of money-based instruments as stabilization tools.

The divide in the literature on policy instruments also applies to Africa. For example, Berg et al. (2010) argue that strict adherence to interest rates is not beneficial for inflation and output stabilization 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 compare the exchange rate with the interest rate and show that due to higher interest rate volatility, the interest rate performs better in stabilizing the real sector in Mozambique. Furthermore, 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 in dealing with macroeconomic dynamics across different countries.

A number of other scholars 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. Muhanji et al. (2013) combine the Taylor (1993) and McCallum (1994) rules and argue that to design context-specific optimal policy, 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 instruments are often deployed simultaneously. Most often, these instruments exert divergent impacts on macroeconomic dynamics. We build on these studies which do not directly compare the performance of the interest and the monetary aggregate in stabilizing African economies.

Several factors make the examination of the two instruments in African context compelling. Firstly, the key feature under interest rate rules in New

Keynesian models is that they focus on management of aggregate demand represented by output gap. In these models, inflation is positively related to output gap and output gap is negatively related to interest rates. When monetary policy is tightened, both gaps close. Frankel et al. (2008), show that the appeal of interest rate rules over money-targeting rules as a means of delivering lower inflation volatility and lower output volatility only holds true when demand shocks dominate. When supply shocks dominate, strict interest rate rules continues to deliver lower inflation volatility but at the cost of higher output volatility. In these circumstances, a conventional money-based anchor will result in lower output volatility and the unambiguous welfare-based argument in favour of interest rates rules disappears.

From a policy perspective, there is need to design specific policy rules focusing on African countries operating under conditions of imperfect financial markets, dependence on commodity exports and imports, volatile terms of trade and fiscal slippages. The policy instruments debate must therefore recognize that the majority of authorities in Africa are still pursuing monetary policy objectives via balance-sheet instruments rather than the interest rate instruments adopted in more conventional New Keynesian models and in AEs. Meanwhile, while pursuing monetary policy through balance-sheet instruments remains common practice, the global direction in policy conduct that uses interest rate instruments is exerting significant influence on policy direction in Africa.

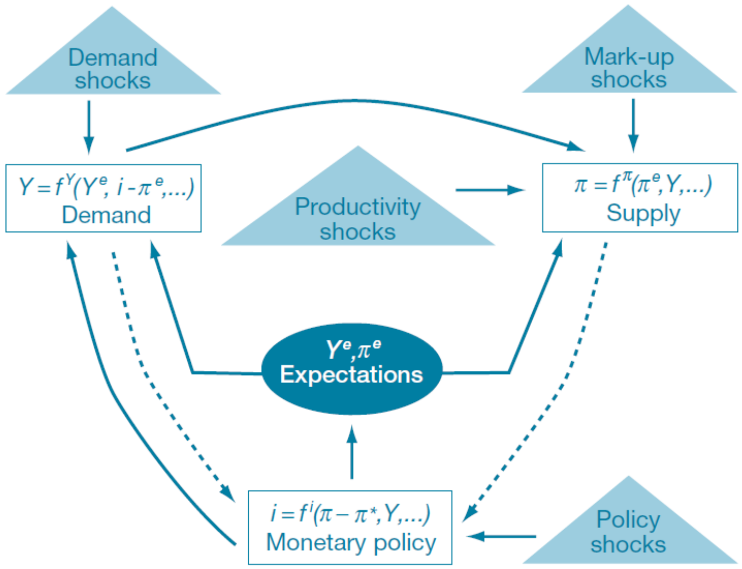
2.3 Theoretical exposition

The theoretical discussion assumes that a country has chosen a flexible exchange rate system and therefore has room to implement independent monetary policy with the broad objective of stabilizing output, inflation and exchange rate. There are contending views regarding the impact of monetary policy on output and inflation. These views are reflected in the real business cycle (RBC) and the New Keynesian (NK) schools. The RBC school proposed by Prescott (1986) contends that inflation and output fluctuations are a true reflection of decisions undertaken by rational economic agents. This implies that there is no role for monetary policy because economies tend to achieve self equilibrium without policy intervention.

The RBC firmly establishes the use of the Dynamic Stochastic General Equilibrium (DSGE) models for macroeconomic analysis. On the other hand, the New Keynesian school argues that monetary policy can yield dividends in the short-run. Proponents of this school extend the RBC-DSGE model to include assumptions of nominal wage and price rigidities-a la Calvo features. According to Mankiw (1985), price rigidities can be exploited so that monetary policy affects output and inflation. The New Keynesian framework is located within the traditional IS-LM model, but is grounded in dynamic general equilibrium theory.

2.3.1 Basic tenets of a New Keynesian DSGE model

In a typical New Keynesian model, the economy is described by three interrelated equations, namely aggregate demand (IS curve), aggregate supply (Phillips curve) and the monetary policy reaction function (see Fig. 6). The equations that define these blocks are derived from micro-foundations which detail explicit assumptions about the behavior of the main economic agents in the economy, namely households, firms and the monetary authorities. Households and firms interact in markets that clear every period leading to the general equilibrium feature of the models. Based on Sbordone (2010), we use Fig. 6 to describe the basic tenets of the New Keynesian DSGE model.



Source: Sbordone (2010)

Figure 6: The theoretical DSGE model

2.3.2 The demand block (IS curve)

The IS curve represents the intertemporal Euler consumption equation which results from household's desire to maximize its expected discounted lifetime utility subject to a budget constraint. Mathematically, households seek to maximize:

$$E_{t_0} \sum_{s=0}^{\infty} \beta^s \left\{ b_{t_0+s} [\log(C_{t_0+s} - \eta C_{t_0+s-1}) - \int_0^1 v(H_{t_0+s^{(i)}})^{di}] \right\} \tag{2.1}$$

subject to the sequence of budget constraints:

$$P_t C_t + \frac{B_t}{R_t} \leq B_{t-1} + \int_0^1 w_t((i) H_t(i) di] \tag{2.2}$$

for $t = t_0, t_{0+1}, ...\infty$, and given Bt_{0-1}. Households like consumption C_t hence it enters the utility function with a positive sign. Households dislike working denoted by number of hour H_t hence a negative sign. The level of dislike is represented by a convex function v. The flow of utility depends on current as well as past consumption defined by η (habit formation as in Smets and Wouters 2003). As a result of this, consumers are unhappy if their level of consumption falls below their recent past.

In order to consume, households work a certain amount of hours $H_t(i)$ in a number of i-firms where they earn nominal wage $W_t(i)$. Wages are taken as given when households decide how much to work. Using the income earned, households can purchase final goods at price P_t or save by accumulating one period discounted government bonds B_t which earns a return of R_t between t and $t+1$. From the perspective of time t, the household discounts utility in period $t+1$ by a time varying factor $\beta b_{t+1}/b$, where b_{t+1}/b_t is an exogenous random process. Changes to this process represent traditional demand shocks.

Finding the optimal paths of the solution requires forming a Lagrangian function of the form:

$$\begin{aligned} L \quad = \quad & E_{t_0} \sum_{s=0}^{\infty} \{ \beta^s \left[b_{t_0+s} [\log(C_{t_0+s} - \eta C_{t_0+s-1}) - \int_0^1 v(H_{t_0+s(i)})^{di}] \right] \\ & - \Lambda_{t_0+s} (P_{t_{0+s-1}} C_{t_{0+s}} + \frac{B_{t0+s}}{R_{t0+s}} - B_{t0+s-1} - \int_0^1 w_{t_{0+s}}((i) H_{t_{0+s}}(i) di] \} \end{aligned} \tag{2.3}$$

where Λ is the Lagrangian operator. The first order condition of L with respect to B_t, C_t and H_t are:

$$\frac{\partial l}{\partial B_t} : \beta E_t[\Lambda_t + 1] R_t = \Lambda_t \tag{2.4}$$

$$\frac{\partial L}{\partial Ct}:\frac{\Lambda_t}{b_t}p_t=\frac{1}{C_t-\eta C_{t-1}}-\eta E_t\left[\frac{\beta b_{t+1}/b_t}{C_{t+1}-\eta C_t}\right] \tag{2.5}$$

$$\frac{\partial L}{\partial H_t(i)}:\frac{v'(Ht(i))}{\Lambda_t/b_t}=W_t(i) \tag{2.6}$$

for $t=t_0,t_{0+1},.....\infty$ and $\forall i\epsilon[0,1]$. These conditions yield full state contingent household choices, namely how much to work, how much to consume and how much to invest in bonds. Although the household is uncertain at any point in time about the way in which the future will unfold, it is assumed that it is aware of the random shocks that can affect its decisions. Households also know the probability of occurrence of such shocks. Based on this, households can form expectations about future outcomes which have a feedback on current decisions. These expectations are assumed rational as they are based on the knowledge of the economy and the shocks that buffet it. $E_t(X_{t+s})$ is thus used to denote these expectations which are formed at time t of any future variable X_{t+s}.

Combining eqs.(2.5) and (2.6) after setting $\eta=0$, yields:

$$\frac{1}{C_t}=E_t\left[\frac{\beta b_{t+1}}{b_t}\frac{1}{Ct+1}\frac{R_t}{P_{t+1}/P_t}\right] \tag{2.7}$$

Eq.(2.7) is an Euler equation where consumption decreases when gross real interest rate $\left(\frac{Rt}{P_{t+1}/P_t}\right)$ increases, when expected future consumption decreases and when households become more patient (b_{t+1} goes up). Log-linearisation of the Euler consumption equation together with macroeconomic equilibrium condition which assumes that in this particular economy the only source of aggregate demand in consumption ,i.e $Y_t=C_t$, generates the demand block in Fig.6. This block determines real activity y_t as a negative function of the ex ante real interest rate $(i_t-E_t\pi_{t+1})$ and a positive function of expectations about future real activity y_{t+1}. Mathematically, this is captured as:

$$y_t = E_t y_{t+1} - (i_t - E_t \pi_{t+1}) + \epsilon_t \tag{2.8}$$

where $\pi_{t+1} = p_t/p_{t-1}$ is the rate of inflation and i_t is the nominal interest rate and ϵ_t is a demand shock. This theoretical version of the IS curve is forward looking. In practice, habit formation exists which implies that $\eta \neq 0$. When this happens, model dynamics are enriched and the IS curve features a backward looking element. This helps to match the lagged and persistent responses of inflation and output to monetary policy (see Rudebusch and Svensson 1999). With this, aggregate demand does not only depend on future income but also on lagged income resulting into what Goodhart and Hofman (2005) call a hybrid IS curve of the form:

$$y_t = ay_{t-1} + bE_t y_{t+1} - c(i_t - E_t \pi_{t+1}) + \epsilon_t, \tag{2.9}$$

where $a > 0$ captures output persistence, $b > 0$ measures the response of output to expected incomes while $c < 0$ is the interest rate sensitivity of aggregate demand. In recent years, the characterization of the IS curve has progressed with several extensions in addition to output gaps and real interest rate arguments which have traditionally characterized the IS curve. These extensions can be represented by Ω_t in eq. (2.10):

$$y_t = ay_{t-1} + bE_t y_{t+1} - c(i_t - E_t \pi_{t+1}) + d\Omega_t + \epsilon_t \tag{2.10}$$

The nature of arguments contained in Ω_t largely depends on assumptions and the functional form of the utility function as well as the nature of the specified budget constraint. In empirical works, Ω_t has contained the following: (i) the real exchange rate, such as in Wollmeshauser (2006) and Ball (1999). Typically, the exchange rate captures open economy effects and according to Sanchez (2008), output is allowed to be positively or negatively affected by the exchange rate depending on whether depreciations are contractionary or expansionary (ii) the monetary aggregates, such as in Benchimol and FourÇans (2012) and Canova and Menz (2011).

Monetary aggregates are irrelevant for IS dynamics only if money enters the utility function in separable form. Money may affect the marginal rate of substitution between consumption and leisure and hence the real wage. Furthermore, high risk aversion in an economy can lead to a significant role of money in output dynamics. The higher the level of money, the more economic activities implying a positive relationship between money and output dynamics iii) foreign output which affects domestic aggregate demand positively as in Liu and Zhang (2010) and Rasaki and Malikane (2014). If foreign incomes rise, the trade channel implies that there will be an increase in demand for domestic goods.

With reference to Fig. 6, when real interest rates are high, people and firms would rather save than consume. At the same time, people are willing to spend more when future prospects of income are promising, regardless of the level of interest rates. The line connecting the demand block to the supply one reflects the fact that the level of economic activity (y_t) is a key input in the determination of inflation. Unlike in a traditional IS relationship, though, this equation is dynamic and forward looking, as it involves current and future expected variables. In particular, it establishes a link between current output and the entire future expected path of real interest rates. At any point in time, aggregate demand can be disturbed through exogenous factors. These can also be micro-founded but for simplicity they are often assumed to follow a simple AR(1) process.

2.3.3 The supply block (Phillips curve)

The Phillips curve reflects intertemporal optimal price setting decisions by monopolistically competitive firms given the level of demand they face. In prosperous times, demand is high and firms must pay their workers higher wages. Similarly, if they are using domestic non-labour inputs, higher output will result in an increase in demand for non-labour inputs. As a result, the firms' costs of production tend to increase and hence the prices of their products. This generates a positive relationship between inflation and real activity.

To derive the supply block, it is assumed that the intermediate firm i hires units of labor $H_t(i)$ of type i on a competitive market to produce $Y_t(i)$ units of intermediate good i with the technology given as follows:

$$y_t(i) = A_t H_t(i), \tag{2.11}$$

where A_t represents the overall efficiency of the production process. It is further assumed that A_t follows an exogenous stochastic process, whose random fluctuations over time capture the unexpected changes in productivity. The market for intermediate goods is monopolistically competitive as in Dixit and Stigliz (1997) such that firm's price setting reflects the need to meet demand for their products which is characterized as:

$$y_t(i) = yt \left(\frac{p_t(i)}{p_t}\right)^{-\theta t} \tag{2.12}$$

where $p_t(i)$ is the price of good i and θ_t is the elasticity of demand. When the relative price of good i increases, its demand falls relative to aggregate demand by an amount that depends on θ_t. It is further assumed that firms change their prices only infrequently. This fact is modelled based on Calvo (1983) where a fraction of firms denoted by $(1 - \alpha)$ resets the prices each period while the rest maintain previous prices. This feature has important implications for overall price outturn. The higher the $(1-\alpha)$, the less persistent prices are and hence inflation will be. Those that reset the prices face a probability α that they may be unable to reset the price in future. The firms objective function therefore is to maximize:

$$Et \sum \alpha^s \frac{\beta^s \Lambda_{t+s}}{\Lambda_t} \left\{ P_t(i) Y_{t+s}(i) - W_{t+s}(i) H_{t+s}(i) \right\} \tag{2.13}$$

subject to eq. (2.11) and an additional constraint:

$$Y_{t+s}(i) = Y_{t+s} \left(\frac{P_t(i)}{P_{t+s}} \right)^{-\theta_{t+s}} \tag{2.14}$$

Eq. (2.14) entails that firms must satisfy the demand for their product at each point in time. In eq.(2.13), the first term in brackets $P_t(i)Y_{t+s}(i)$ is total firm revenue and the right term is an approximation of total costs $W_{t+s}(i)H_{t+s}(i)$. The difference between the two terms is discounted by $\frac{\beta^s \Lambda_{t+s}}{\Lambda_t}$ to translate it into the current value.

The aggregate price level is a function of newly set prices P_t^* and of the past prices p_{t-1} and is represented as:

$$p_t = \left[(1-\alpha) p_t^{*(1-\theta_t)} + \alpha p_{t-1}^{1-\theta_t} \right]^{\frac{1}{1-\theta_t}} \tag{2.15}$$

The first order conditions (FOCs) are obtained by maximizing eq. (2.13) subject to eqs. (2.11) and (2.14). Taylor approximation of the FOCs put together with the aggregate price dynamics in eq. (2.15) yields an approximate New Keynesian Phillips of the form:

$$\pi_t = \beta E_t \pi_{t+1} + \lambda rmc_t + \nu_t \tag{2.16}$$

where $\lambda = \frac{(1-\alpha)(1-\alpha\beta)}{\alpha(1+\omega\theta)}$ and $\omega = \frac{v''H}{v'}$ is the elasticity of the marginal disutility of work while θ is the elasticity of demand. in Fig. 6 and in many other models, such as Gali and Gertler (1999), output gap is assumed to be a sole proxy of real marginal costs. ν_t is a cost push shock which enable the model to generate variations in inflation that arise independently of movement in excess demand. In Fig. 6, ν_t is represented as Mark-up shocks.

Eq. (2.16) describes the relationship between inflation and real activity. The real marginal costs depend on aggregate economic activity. Higher economic activity leads to higher wages and hence a rise in marginal costs. Thus the firms increase their prices thereby boosting aggregate inflation. Another critical feature of eq. (2.16) is that it is forward looking just like the Euler equation. A quick iteration of eq. (2.16) forward shows that today's inflation depends on the entire future expected path of marginal costs, and hence on real activity. The model implies that, minus any pricing frictions, firms would set prices as a fixed markup over marginal cost; thus, inflationary pressures are generated by a high ratio of marginal cost to price.

Gali et al. (2001) argue that eq. (2.16) provides an adequate account of inflation while Rudd and Whelan (2007) argue that a backward looking Phillips curve better explain inflation dynamics. In recent years, Phillips curve analysis has progressed with several extensions. These have been driven by the (i) need to introduce inertia to match empirical data (Gali and Gertler 999) (ii) characterization of the firms cost function and hence real marginal costs where (a) real exchange rate has been deemed as a key positive driver of inflation in open economies (Wollmeshauser 2006) (b) input prices as in Malikane (2014) where input costs are positive drivers of real marginal costs (c) monetary aggregates as in Canova and Menz (2011) where real balances act as a forcing variable and enter as demand push factor.

2.3.4 Monetary policy conduct

When the economy is hit with cost push or demand shocks, it is the duty of monetary policy to stabilize it. The policy makers problem is composed of finding suitable monetary policy frameworks and instruments to perform this task thereby closing the model. In order to do this, monetary policy conduct can either be characterized by the traditional interest rate instrument which draws heavily from the New Keynesian economics or the money supply rules whose existence can be located in the literature on Quantity Theory of Money (QTM).

Interest rate rules: The theoretical underpinnings of the interest rate channel can be described using the Taylor (1993) rule. In this class of policy rules, when aggregate demand is high, represented by a positive output gap, interest rates are raised. When this happens, output gap closes creating a negative relationship between interest rates and output. Since output gap is a key determinant of inflation in the Phillips curve, when it goes down, inflation also goes down thereby creating a positive link between output gap and inflation. In this case, monetary policy stabilizes both inflation and output.

Money supply rules: Under money supply rules, authorities first set a forecast for real GDP growth and an inflation objective. Secondly, estimates of money velocity and the money multiplier are set. Then based on these four variables, authorities construct an annual forecast for broad money and they back out base money growth consistent with achieving the forecast GDP growth and inflation. The Broad money and base money are then typically divided into quarters, in part by incorporating additional information about government flows and seasonal patterns. These quarterly forecasts then become the policy targets. Monetary policy is either tightened or loosened depending on whether the projected aggregates are above or below the targets. For example, when the velocity of circulation and money multiplier are relatively constant a rise in inflation above target, triggers authorities to withdraw liquidity in order to meet the inflation target..

With some modifications, both rules can be derived by assuming that a central bank seeks to minimize the deviation of some variables in its objective function from the targets using the following loss function:

$$L_{t+j} = E_t \sum_{j=0}^{\infty} \beta^j \frac{1}{2} \theta_j (\sum_{j=1}^{n} K_{jt}^2), \tag{2.17}$$

where K includes the $j = 1, ...n$ central bank targets, such as the exchange rate, inflation, real GDP or nominal GDP. θ_j represents respective weights with which authorities penalize the deviation of the target variables from their trend. The monetary policy rules are generated by minimizing the loss function subject to the Phillips curve alone or together with the IS curve. Then one can solve for the values of m_t to get the monetary aggregate rule or i_t to get the interest rate rule. These rules can then be compared in terms of their performance on how they stabilize aggregate demand and aggregate supply.

Similarly, monetary policy frameworks are generated by changing the values of the weights in the loss function. For example, setting the weight on the exchange rate equal to zero describes an inflation targeting framework. Such frameworks can be compared in terms of their role in stabilizing output and inflation. A key feature of the described model is its stochastic nature. This means that it allows each block in Fig. (6) to be pertubed by stochastic processes thereby generating uncertainty in the evolution of the economy. Monetary policy frameworks and instruments are tasked to stabilize the economy after these disturbances.

The critical points of departure from the described theoretical model to the empirical model that we derive in Section 2.4 are threefold: (i) the characterization of the household's utility function where we assume money is non-separable in the utility function, (ii) the specification of a non-linear production function for firms, iii) the specification of central bank loss functions that enable us to 1) derive optimal interest as well as money supply rules, 2) examine the role of exchange rate smoothing, 3) derive alternative monetary policy regimes. The arguments that enter in the utility function, the budget constraint and the firms' production function together with their mathematical form have critical bearing on the distinctness of the IS curve, Phillips curve as well as the monetary policy conduct that characterize this research.

2.4 The model

2.4.1 Households

We specify a New Keynesian DSGE model inspired by Smets and Wouters (2003). However, in our model, we include real money balances. As argued by O'Connell (2011) and Berg et al. (2010), Africa is largely a cash continent with fiscal dominance and low financial market development such that 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 the real wage affect the Phillips curve via the marginal costs. Furthermore, Benchimol and FourÇans (2012) argue that higher risk aversion, a feature consistent with African economies, can lead to a significant role of money in output dynamics. Therefore, to capture the role of real balances, we specify a model similar to Castelnouvo (2012) and Andrés et al. (2009) where money is non-separable from consumption in the utility function.

Given the importance of imports in Africa, as observed by Senbeta (2011), we assume that a household consumes domestically produced goods C_t^d as well as imports C_t^m. Using a constant relative risk aversion utility function U_t , the representative household's preferences are given as follows:

$$U_t = E_t \sum_{j=0}^{\infty} \beta^j \left\{ \frac{1}{1-\sigma} \left[\left(C_t^d - hC_{t-1}^d \right)^{1-\sigma} + \left(C_t^m - hC_{t-1}^m \right)^{1-\sigma} \right] \left(\frac{M_t}{P_t} \right)^{\phi} - \frac{N_t^{1+\varphi}}{1+\varphi} \right\} \tag{2.18}$$

where E_t is an expectations operator, $\beta^j \in (0,1)$ is the intertemporal discount factor, $1/\sigma$ is the elasticity of intertemporal substitution, ϕ is the elasticity of money demand with respect to interest rate, h is a measure of habit formation as in Smets and Wouters (2003), while φ is the inverse of the Frisch labour supply elasticity with respect to real wage. We assume that $\sigma > 0$ and $0 \leq \phi \leq 1$. Utility positively depends on consumption of domestic C_t^d, imported goods C_t^m and real money balances $\frac{M_t}{P_t}$ but negatively on household labour supply N_t· While households enjoy consumption, they dislike working for it.

We also assume that households hold their current assets in three forms: money M_t, domestic bonds B_t and foreign bonds B_t^f. With this assumption, the household budget constraint is given as:

$$\frac{M_t}{P_t} + \frac{B_t}{P_t} + \frac{Z_t B_t^f}{P_t} = \frac{W_t N_t}{P_t} + \frac{M_{t-1}}{P_t} + \frac{(1+r_{t-1})B_{t-1}}{P_t} + \frac{Z_t(1+r_{t-1}^f)B_{t-1}^f}{P_t} - C_t^d - Q_t C_t^m, \tag{2.19}$$

where W_t is the nominal wage, Z_t is the nominal exchange rate measured as domestic currency per unit of foreign currency, Q_t stands for the real exchange rate, P_t is the overall domestic price level, P_t^f stands for the foreign price level. The budget constraint implies that households holding of current real balances, domestic and foreign bonds together with the current consumption of domestically produced and imported goods is financed by current real wages plus real balances, domestic and foreign bonds carried over from the previous period. Portfolio investors at any time t have the choice of holding assets denominated in domestic currency, and earning a return of own rate of interest r_t between times t and $t+1$. Alternatively, they can hold their assets in foreign currency, offering a rate of interest r_t^f .The variables r_t and r_t^f therefore denote returns on the domestic and foreign bonds, respectively. The household problem constitutes choosing intertemporal paths of C_t^d, C_t^m, B_t, B_t^f, M_t and N_t that maximize the expected utility in eq.(2.18) subject to the budget constraint in eq.(2.19). The resulting first order conditions are:

$$\left(C_t^d - hC_{t-1}^d\right)^{-\sigma}\left(\frac{M_t}{P_t}\right)^{\phi} = \lambda_t, \tag{2.20}$$

$$\left(C_t^m - hC_{t-1}^m\right)^{-\sigma}\left(\frac{M_t}{P_t}\right)^{\phi} = Q_t\lambda_t, \tag{2.21}$$

$$\beta E_t\lambda_{t+1}\left(\frac{1+r_t}{1+\pi_{t+1}}\right) = \lambda_t, \tag{2.22}$$

$$\beta E_t\lambda_{t+1}\left(\frac{1+r_t^f}{1+\pi_{t+1}}\right)\left(\frac{Z_{t+1}}{Z_t}\right) = \lambda_t, \tag{2.23}$$

$$\frac{\phi}{1-\sigma}\left(\frac{M_t}{P_t}\right)^{\phi-1} G_t = \lambda_t - \beta E_t\left\{\lambda_{t+1}\left(\frac{1}{1+\pi_{t+1}}\right)\right\}, \tag{2.24}$$

$$\frac{N_t^{\varphi}}{\lambda_t} = \frac{W_t}{P_t}, \tag{2.25}$$

where λ_t is the Lagrangian multiplier, and for ease of notation

$$G_t = \left[\left(C_t^d - hC_{t-1}^d\right)^{1-\sigma} + \left(C_t^m - hC_{t-1}^m\right)^{1-\sigma}\right]$$

Taylor approximation of eq.(2.20) to eq.(2.25) around the steady state yields the following:

$$\begin{aligned} \hat{c}_t^d \;=\; & \frac{1}{1+h}E_t\hat{c}_{t+1}^d + \frac{h}{1+h}\hat{c}_{t-1}^d - \frac{(1-h)}{\sigma(1+h)}(\hat{r}_t - E_t\hat{\pi}_{t+1}) \\ & + \frac{\phi(1-h)}{\sigma(1+h)}(\hat{m}_t - E_t\hat{m}_{t+1}) \end{aligned} \tag{2.26}$$

and

$$\begin{aligned} \hat{c}_t^m \;=\; & \frac{1}{1+h}E_t\hat{c}_{t+1}^m + \frac{h}{1+h}\hat{c}_{t-1}^m - \frac{(1-h)}{\sigma(1+h)}(\hat{r}_t - E_t\hat{\pi}_{t+1}) \\ & + \frac{\phi(1-h)}{\sigma(1+h)}(\hat{m}_t - E_t\hat{m}_{t+1}) - \frac{(1-h)}{\sigma(1+h)}(\hat{q}_t - E_t\hat{q}_{t+1}). \end{aligned} \tag{2.27}$$

Eq.(2.26) and eq.(2.27) are Euler equations for domestic and imported consumption. The small letters together with an accent above the variable stand for the deviation of the variable from its steady state. Specifically, $\hat{c}_t^m$,$\hat{c}_t^d$, $\hat{\pi}_t$, $\hat{m}_t$, $\hat{q}_t$ and $\hat{r}_t$ are defined as deviations of consumption of imported goods, consumption of domestic goods, inflation, real money balances, real exchange rate and nominal interest rates, respectively, from their steady state. Subscript $(t+1)$ stands for forward looking or model consistent expectations while $(t-1)$ stands for lagged value. The terms $\hat{c}_{t-1}^d$ and $\hat{c}_{t-1}^m$ stand for lagged deviation of domestic and imported consumption, respectively, from their steady state values.

Eq. (2.26) states that consumption of domestic goods positively depends on expected consumption and lagged consumption due to rational expectations and habit formation, but it is negatively related to real interest rate. Real money balances positively affect domestic consumption while exchange rate depreciation has negative impact on consumption of domestic goods. These relationship also holds for Euler equation for the consumption of imported goods depicted by eq. (2.27). To the extent that households consume foreign goods, a depreciation of the current exchange rate reduces aggregate consumption by raising costs of imports used in consumption as well as inputs. Through this channel, the depreciation may generate a contractionary effect on output as pointed out by Edwards and Ahamed (1986). In order to derive aggregate demand dynamics, we follow McCallum and Nelson (2000) and state the following open economy macro-balance equation in deviation from steady state.

$$\hat{y}_t = \tau_c \hat{c}_t^d + \tau_x \hat{x}_t - \tau_m \hat{c}_t^m, \tag{2.28}$$

Eq. (2.28) states that in equilibrium, output is portrayed as the sum of domestic consumption and exports less imports. $\hat{x}_t$ is the deviation of exports from their steady state and the rest of the variables are as defined above. The terms τ_c, τ_x and τ_m are steady state ratios of the adjacent variables to total output. Following Woodford (2000), we abstract from investment in the macro-balance equation. As in McCallum and Nelson (2000), we further specify the following export function:

$$\hat{x}_t = \gamma_q \hat{q}_t + \gamma_f \hat{y}_t^f, \tag{2.29}$$

where γ_q and γ_f are elasticities of exports with respect to the exchange rate and foreign income, respectively. $\hat{y}_t^f$ is the deviation of foreign output from steady state. This relationship states that when the exchange rate depreciates and foreign incomes rise, exports will rise. Substituting eq.(2.27) and eq.(2.29) into eq.(2.28) yields the following expression:

$$
\begin{aligned}
\hat{y}_t \;=\;& \kappa_1 E_t\hat{y}_{t+1} + \kappa_2\hat{y}_{t-1} - \kappa_3(\hat{r}_t - E_t\hat{\pi}_{t+1}) + \kappa_4\left(\hat{m}_t - E_t\hat{m}_{t+1}\right) \\
& +\kappa_5\left(\hat{q}_t - E_t\hat{q}_{t+1}\right) + \kappa_6 E_t\hat{q}_{t+1} + \kappa_7\hat{q}_t - \kappa_8\hat{q}_{t-1} + \kappa_9 E_t\hat{y}^f_{t+1} \\
& +\kappa_{10}\hat{y}^f_t - \kappa_{11}\hat{y}^f_{t-1} + \varepsilon_{yt},
\end{aligned} \tag{2.30}
$$

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.(2.30) is a hybrid open economy IS curve. It is similar to a traditional IS equation since it describes the negative relationship between aggregate demand and the ex ante real interest rate $\hat{r}_t - E_t\hat{\pi}_{t+1}$. However, unlike the traditional IS relationship, eq.(2.30) is dynamic and forward looking. It features current, lagged and expected variables. The term E_t is an expectations operator while the term $t+1$ stands for model consistent expectations.

Output gap $\hat{y}_t$ responds positively to the lead output gap $\hat{y}_{t+1}$ and lagged output gap $\hat{y}_{t-1}$. As argued by Smets and Wouters (2003), these variables affect output positively due to rational expectations and habit formation. With external habits, income depends on a weighted average of past and expected future income. Parameter κ_1 is thus expected to be positive. When economic agents expect higher incomes, their current expenditures tend to rise due to rational expectations. κ_1 also captures the percentage of consumers who are forward looking. Its value therefore ranges between 0 and 1. Parameter κ_2 is a measure of output gap persistence and it also measures the proportion of economic agents who are backward looking. Its value also ranges between 0 and 1. The closer to 1 the value of this parameter is, the more persistent the output gap. When output gap is persistent, it becomes more problematic to stabilize inflation.

Parameter κ_3 measures the interest rate sensitivity of aggregate demand. According to Keynes theory of aggregate demand, this parameter carries a negative sign. If $\kappa_3 \approx 0$, then aggregate demand will not respond to changes in interest rates. In that case, monetary policy is likely to be ineffective and vice-versa. The interest elasticity of output depends not only on the intertemporal elasticity of substitution, but also on the habit persistence parameter h. A high degree of habit persistence will tend to reduce the impact of the real interest rate on consumption for a given elasticity of substitution.

Similar to Ireland (2004) and Zanetti (2012), eq.(2.30) also features real money gap $\hat{m}_t - E_t\hat{m}_{t+1}$ whose effect on aggregate demand is captured by κ_4. This parameter determines whether money balances are important for system dynamics. McCallum (2001) shows that real balances become irrelevant for output determination if and only if the utility function is separable in consumption and real balances. In that case, there is good transmission such that interest rate and money can be substituted with each other (Fan et al. 2011). In African economies, the transmission may not be perfect, hence the inclusion of real balances. With higher real balances, economic agents reduce supply of labour which affects the real wage and aggregate demand. κ_4 is thus expected to be positive. The higher the value, the more significant the role of the monetary aggregates in driving system dynamics.

In order to capture the open economy effects, the IS curve also includes the real exchange $\hat{q}_t$. As shown by Senbeta (2011), Africa's consumption largely relies on imports, making the exchange rate a key variable in output dynamics. As in Wollmershäuser (2006) and Rasaki and Malikane (2014), the exchange rate affects output dynamics in levels and changes. When a currency depreciates, it is expected to boost foreign demand for exports while reducing imports. When this happens, aggregated demand goes up. This generates a positive link between exchange rate depreciation and output. But as argued by Sanchez (2008), this occurs when depreciations are expansionary. In some cases, depreciations tend to be contractionary . This would imply a negative relationship between the exchange rate and output.

Furthermore, to the extent that households consumption basket includes foreign goods, a depreciation of the exchange rate reduces household consumption, which reduces aggregate demand. Through this channel, the exchange rate may generate a contractionary effect on output as pointed out by Krugman and Taylor (1978). Thus, the effect of exchange rate on output, whether in levels or changes will depend on whether depreciations are expansionary or contractionary. Therefore, the sign of parameters κ_5, κ_6, κ_7 and κ_8 which capture the effect of exchange rate depreciation, exchange rate expectations, current exchange rate and lagged exchange rate on aggregate demand, respectively, will depend on whether the exchange rate affects output positively or negatively.

Another feature of the IS curve arising from the imposition of the macroeconomic resource balance is the presence of foreign output variables. Foreign output may affect domestic output through various channels, such as foreign direct investments, foreign aid and trade. Higher foreign incomes may induce high aid levels, high demand for Africas exports and also high foreign direct investment. Under all these circumstances, it would be expected that parameters κ_9, κ_{10} and κ_{11} which measure the response of domestic output to expected foreign incomes, current foreign incomes and expected foreign income to be positive. Just like the exchange rate variables, the foreign output variables serve to capture the open economy effects. This variable is key due to the perceived high dependence of African countries on aid, commodity trading and foreign direct investments.

The major difference between eq. (2.30) and the Convetional demand curves estimated for AEs and some EMEs is that eq. (2.30) features money, exchange rate and foreign output which are assumed to be critical in driving macroeconomic dynamics in Africa. As in Ireland (2004), we also include an aggregate demand shock ε_{yt} which captures exogenous influences on aggregate demand and is assumed to follow an AR(1) process.

2.4.2 Exchange rate determination

Since the economies being modelled are linked to the rest of the world, the determination of the exchange rate dynamics is critical. The exchange rate is key in ensuring that domestic and foreign entities transact. Our starting point is Gali (2008) who assumes that the economies have access to international markets. In this case, the evolution of the exchange rate follows the Uncovered Interest rate Parity (UIP) condition. The UIP states that the nominal exchange rate is determined by interest rate differentials between domestic interest rates $\hat{r}_t$ and foreign interest rates $\hat{r}_t^f$. The basic concept of the UIP recognizes the fact that portfolio investors at any time t have the choice of holding assets in domestic currency. In which case, they earn a return of own rate of interest r_t.

Alternatively, portfolio investors can hold their assets in foreign currency. In this case they will earn a rate of interest r_t^f . Whenever the return on one asset is higher than the return on the other asset, arbitrage conditions are created and depending on the spot exchange rate, investors tend to move their assets between the two investment options. These movements create demand and supply of foreign exchange which drive exchange rate movements. In order to generate the UIP condition similar to Gali (2008), we combine Taylor approximation around steady state of eq.(2.22) and eq.(2.23) which yields the following:

$$E_t \Delta \hat{z}_{t+1} = \hat{r}_t - \hat{r}_t^f. \tag{2.31}$$

Svensson (2000) argues that the typical UIP condition enters the open economy models in its real version. However, Thomas (2012) shows that the UIP condition does not hold in some African countries. These countries include South Africa, Ghana, Kenya, Tanzania, Uganda and Zambia. Instead he finds that the foreign exchange risk premium is a significant driver of exchange rate developments in these economies. We, therefore, augment the exchange rate equation with the term ε_{qt} . This term captures deviations from the UIP condition. We then transform eq. (2.31) to describe real exchange rate dynamics as follows:[4]

$$E_t \Delta \hat{q}_{t+1} = -\left[(\hat{r}_t - \hat{\pi}_{t+1}) - (\hat{r}_t^f - \hat{\pi}_{t+1}^f) \right] + \varepsilon_{qt}, \tag{2.32}$$

Eq. (2.32) states that real exchange rate dynamics are determined by interest rate differentials and the risk premium. The exchange rate channel is triggered by changes in the nominal interest rates. When domestic interest rates rise or inflation declines, the real exchange rate appreciate and viceversa. When foreign interest rates rise or foreign inflation declines, the real exchange rate depreciates. The effect of the exchange rate changes on aggregate demand can either be direct or indirect. The direct channel affects inflation via the pass-through of exchange rate to import prices and hence inflation. Indirectly, the real exchange rate affects the relative price

[4]See Appendix to Chapter II for the detailed derivation of the UIP condition

between domestic and foreign goods. This ignites expenditure switching between demand for domestic and foreign goods. In turn this affect aggregate demand.

The term ε_{qt} is typically referred to as the foreign exchange risk premium. The risk premium follows an AR(1) process such that $\varepsilon_{qt} = \rho_q \varepsilon_{qt-1} + \upsilon_{qt}$ where υ_{qt} is the risk premium shock and $\upsilon_{qt} \sim N(0, \sigma_q^2)$. The higher the risk premium the greater the exchange rate depreciation. A similar specification has been used in other open economy models for EMEs, such as Wollmershäuser (2006) and in AEs such as Svensson (2000).

2.4.3 Money market dynamics

We combine steady state forms of eq.(2.22) and eq.(2.24) and use the economy wide macro-balance described by eq.(2.28) to derive the following money market equilibrium condition:

$$\begin{aligned} \hat{m}_t \;=\; & \Psi_1 \hat{y}_t + \Psi_2 \hat{y}_{t-1} - \Psi_3(\hat{r}_t - E_t \hat{\pi}_{t+1}) - \Psi_4 E_t \hat{\pi}_{t+1} + \Psi_5 \hat{q}_t + \Psi_6 \hat{q}_{t-1} - \Psi_7 \hat{y}^f \\ & + \Psi_8 \hat{y}^f_{t-1} + \varepsilon_{mdt}. \end{aligned} \tag{2.33}$$

When the economy is faced with a money demand shock, real balances evolve according to eq. (2.33). As in Castelnouvo (2012), eq.(2.33) is of dynamic nature. It determines real money balances as a function of output, interest rates, expected inflation, the real exchange rate and foreign output. Parameter Ψ_1 is the income elasticity of money demand and its value lies between 0 and 1. According to Keynes theory, transactional motives compel economic agents to hold more real balances when their incomes rise. The presence of habits in the utility function generates a dynamic equation which makes demand for money to also depend on lagged income. Coefficient Ψ_2 which measures the impact of lagged income on money demand is thus expected to be positive.

Parameter Ψ_3 is the interest rate elasticity of money demand. It measures the contemporaneous opportunity cost of holding money. According to Keynes theory of money demand, this parameter is expected to be negative. Its value lies between 0 and 1. The closer to 0 the parameter is the less sensitive money demand is to changes in income. Under such circumstances, monetary policy will find it difficult to influence macroeconomic variables. Parameter Ψ_4 which measures the response of money demand to expected inflation is expected to be positive. Rational agents will increase their demand for money, particularly for transactional purposes if they anticipate inflation to rise.

Parameters Ψ_5 and Ψ_6 measure the response of money demand to current and lagged exchange rates, respectively. These parameters can take any real number depending on whether depreciations are contractionary or expansionary. If the depreciation is contractionary, it will reduce output which will eventually reduce demand for money thereby generating negative values for Ψ_5 and Ψ_6. When depreciations are expansionary, they will raise output and increase demand for money. Alternatively, when depreciations are inflationary, an increase in the exchange rate will tend to raise demand for money as economic agents take positions again loss of value. Due to the nature of the specified utility function and budget constraint, eq. (2.33) also features foreign output variables. Parameter Ψ_7 links money demand positively to changes in foreign incomes while Ψ_8 links money demand negatively to lagged foreign income. Equivalently, a corollary of eq.(2.33) can be specified with $\hat{r}_t$ as an endogenous variable as follows:

$$\hat{r}_t = \beta_1\hat{y}_t + \beta_2\hat{y}_{t-1} - \beta_3\hat{m}_t - \beta_4\hat{\pi}_{t+1} + \beta_5\hat{q}_t + \beta_6\hat{q}_{t-1} + \beta_7\hat{y}_t^f - \beta_8\hat{y}_{t-1}^f + \varepsilon_{rdt}, \quad (2.34)$$

Eq. (2.34) is similar to Rasaki and Malikane (2014) and Andrés et al. (2006). β_1 measures the positive relationship between market interest rates and changes in income. As incomes rise, demand for money rises and market rates must rise to cool off excess demand. Due to habit formation, β_2 which captures the response of market rate to lagged income is also expected to be greater than 0. Parameter β_3 measures the response of market rates to changes in money supply. The higher the money supply the lower the interest rate, hence a negative relationship. By extending the argument raised by Sanchez (2008), parameters β_5 and β_6 can take either positive or negative sign, depending on whether depreciations trigger an expansion or a contraction in output. Parameters β_7 and β_8 show that money market rates are increasing in foreign income through a positive link that foreign income is theoretically expected to have on domestic income. The terms ε_{rdt} and ε_{mdt} in eq. (2.33) and eq. (2.34), respectively, are money demand shocks which follow an AR(1) process[5]. The reduced form parameters in eq.(2.33) and eq.(2.34) are given as follows:

[5]This alternative description of money market dynamics which involves r_t is simply found by setting r_t as subject of the formula after estimation. We then use the calculated values for simulations.

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

2.4.4 Firms

Following Malikane (2014) and Batini et al. (2005), we assume that firms exhibit non-linear input demand. The rationale for this type of production function is that in the short-run, firms may be unable to substitute between labour and material inputs. Furthermore, if firms use capital equipment whose efficiency varies with output, at the margin as output rises, less efficient capital is called to duty. These machines demand relatively large amounts of material inputs to produce a unit of output. The non-labour input demand therefore takes the following form: $X_{jt} = Y_t^{\eta_j}$, where X_{jt} stands for inputs other than labour and η_j is the elasticity of input j in the production process. We assume that one of the major non-labour inputs in the production process is imported. Thus, this general specification helps to account for the impact of changes in costs of imported raw material prices and also serves to capture the fact that African economies largely rely on imported inputs for production.

Firms are assumed to seek profit maximization but operate in a monopolistically competitive environment and face staggered price setting as in Calvo

(1983). Following Baldini et al. (2015) and Batini et al. (2005), we normalize the capital stock to unity. The production function is Cobb-Douglas in nature and is specified as follows:

$$Y_t = A_t N_t^{\alpha} \left[\prod_{j=1}^{m} Y_t^{\theta_j \eta_j} \right]. \tag{2.35}$$

The term Y_t stands for total output which is produced by firms and is equal to the real GDP. Similar to Andrés et al. (2006), A_t is an AR (1) technological process. N_t is the amount of labour used in production. Parameter $0 < \alpha < 1$ therefore measures the labour share in income, and θ_j is the elasticity of output with respect to input j. Π is an $m - array$ product function and serves to capture the firm's non-linear requirement of the non-labour input. m is the number of non-labour inputs required by the firm. The majority of countries we are investigating do not have labour statistics which can be used to estimate eq. (2.35). We therefore present it in its reduced form as follows:

$$Y_t = \acute{A}_t N_t^{\Upsilon}, \tag{2.36}$$

where $\Upsilon = \frac{\alpha}{1-\Psi}$, $\Psi = \sum_{j=1}^{m} \theta_j \eta_j$ and $\acute{A}_t = A_t^{\frac{1}{1-\Psi}}$. The firm's real total costs TC_t can thus be expressed as:

$$TC_t = \frac{W_t Y_t^{\frac{1}{\Upsilon}}}{P_t \acute{A}^{\frac{1}{\Upsilon}}} + \sum_{j=1}^{m} \frac{P_{jt} Y_t^{\eta_j}}{P_t}, \tag{2.37}$$

where the real wage and real non-labour costs are denotes as $\frac{W_t Y_t^{\frac{1}{\Upsilon}}}{P_t \acute{A}^{\frac{1}{\Upsilon}}}$ and $\frac{P_{jt} Y_t^{\eta_j}}{P_t}$, respectively. The term P_t is the domestic price level which is used to deflate nominal wages and nominal non-labour input costs. Eq. (2.37) states that total costs for the firms are a sum of real wage and real non-labour input costs. Combining eq.(2.25) and eq.(2.36) yields the following real wage ($\frac{W_t}{P_t}$), expression:

$$\frac{W_t}{P_t} = \left(\frac{Y_t}{\acute{A}_t}\right)^{\frac{\varphi}{\Upsilon}} \frac{1}{\lambda_t}. \tag{2.38}$$

Combining eq.(2.37) and eq.(2.38), and letting p_{it} denote the real price of non-labour input yields the following real marginal cost, rmc_t, expression:

$$rmc_t = \beta_1 \frac{Y_t^{\beta_2}}{A_t^{\beta_3}} \frac{1}{\lambda_t} + \sum_{j=1}^{m} \eta_j p_{it} Y_t^{\eta_i - 1}, \tag{2.39}$$

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 term λ_t is the Lagrangian function as defined in eqs. (2.20-2.25). The Taylor approximation of eq.(2.39) yields:

$$r\hat{m}c_t = \phi_1 \hat{y}_t - \phi_2 \hat{a}_t - \phi_3 \hat{\lambda}_t + \sum_{j=1}^{m} \phi_4 \hat{p}_{it}, \tag{2.40}$$

In eq. (2.40) real marginal costs increase with a rise in output gap $\phi_1 > 0$, decrease with a rise in technology $\phi_2 < 0$ and increase with a rise in prices of imported inputs $\phi_4 > 0$.

$$\begin{aligned}
\phi_1 &= \frac{1}{MC_0}\left[\frac{\beta_2 Y_0^{\beta_2 - 1}}{\Upsilon A_0^{\beta_3} \lambda_0} + \sum_{j=1}^{m} (\eta_j - 1)\eta_j p_{j0} Y_0^{\eta j - 1}\right], \ \phi_2 = \frac{1}{MC_0}\left[\frac{\beta_3 Y_0^{\beta_2}}{\Upsilon A_0^{\beta_3} \lambda_0}\right], \\
\phi_3 &= \frac{1}{MC_0}\left[\frac{1}{\Upsilon \lambda_0} \frac{Y_0^{\beta_2}}{A_0^{\beta_3}}\right], \ \phi_4 = \frac{1}{MC_0}\left[\sum_{j=1}^{m} \eta_j Y^{\eta j - 1} P_{i0}\right].
\end{aligned}$$

Next, we combine the steady state forms of eq.(2.21), eqs.(2.28) and (2.29) and substitute the result in eq.(2.40) to get the following expression:

$$\begin{aligned}
r\hat{m}c_t &= \phi_1\hat{y}_t + \left(\frac{\phi_3 + \sigma\tau_m\Lambda}{1-h}\right)E_t\hat{y}_{t+1} - \left(\frac{\phi_3 + \sigma h\tau_m\Lambda}{1-h}\right)\hat{y}_{t-1} + \phi_3\hat{q}_t \\
&+ \frac{\phi_3\gamma_q\sigma\tau_x\tau_m}{1-h}E_t\hat{q}_{t+1} - \frac{\phi_3\gamma_q\sigma h\tau_x\tau_m}{1-h}\hat{q}_{t-1} - \phi_3\phi\hat{m}_t \\
&+ \frac{\phi_3\gamma_f\sigma\tau_x\tau_m}{1-h}\ E_t\hat{y}^f_{t+1} - \frac{\phi_3\gamma_f\sigma h\tau_x\tau_m}{1-h}\ \hat{y}^f_{t-1} + \phi_4\hat{p}_{it}\ - \phi_2\hat{a}_t
\end{aligned} \tag{2.41}$$

Eq.(2.41) states that the firm's real marginal costs $r\hat{m}c_t$ positively depend on current output gap $\hat{y}_t$ and expected output gap $E_t\hat{y}_{t+1}$, negatively depend on lagged output gap $\hat{y}_{t-1}$, positively depend on current real exchange rate $\hat{q}_t$, positively depend on expected real exchange rate $E_t\hat{q}_{t+1}$, negatively depend on lagged real exchange rate $\hat{q}_{t-1}$, negatively depend on real money balances, positively depend on expected foreign incomes, negatively depend on lagged foreign income, positively depend on real input prices and negatively depend on technology. The novelty in eq. (2.41) is that it expands on the traditional assumption of output gap as the sole proxy of real marginal costs as in Gali and Gertler (1999). This specification is more elaborate and is also in line with Malikane (2014) and Petrella and Sontoro (2012).

Therefore substituting the more elaborate real marginal cost function represented by eq.(2.41) into the baseline hybrid new-Keynesian Phillips curve proposed by Gali and Gertler (1999) yields the following:

$$\begin{aligned}
\hat{\pi}_t &= \chi_f E_t\hat{\pi}_{t+1} + \chi_b\hat{\pi}_{t-1} + \delta_1\hat{y}_t + \delta_2 E_t\hat{y}_{t+1} + \delta_3\hat{y}_{t-1} + \delta_4\hat{q}_t \\
&+ \delta_5 E_t\hat{q}_{t+1} - \delta_6\hat{q}_{t-1} + \delta_7\hat{m}_t + \delta_8 E_t\hat{y}^f_{t+1} - \delta_9\hat{y}^f_{t-1} \\
&+ \delta_{10}\hat{p}_{it} + \varepsilon_{\pi t},
\end{aligned} \tag{2.42}$$

where

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

Eq. (2.42) is a hybrid Phillips curve. As in Gali and Gertler (1999), parameters $0 < \psi_f < 1$ and $0 < \psi_b < 1$ capture the degree of forward and backward looking price setting, respectively. The closer to 1 ψ_b is the higher the degree of inflation indexation and the more persistent inflation is. Monetary policy faces a difficult task of bring inflation down if price setting is mostly backward looking. Parameters δ_1 captures the impact of output gap on inflation and is expected to be greater than 0. Higher output comes from higher production. An increase in firms production raises demand for raw materials which tends to push up real marginal costs. Since output gap depends on interest rates, this parameter also shows how expectations about monetary policy affects inflation.

Parameter $\delta_2 > 0$ captures the impact of income expectations on price setting. With anticipated increase in income, firms project higher demand for their goods and services and tend to produce more in order to meet the anticipated demand. Again higher production calls for increase in resource deployment which bids up resource prices thereby raising real marginal costs. This process has the tendency of pushing up prices. Parameter δ_3 captures the response of inflation to lagged output gap which as suggested by Berg et al. (2010) is expected to be greater than zero.

As argued by Senbeta (2011), firms in Africa are assumed to import the bulk part of their raw materials. This makes the exchange rate a key driver of the firms real marginal costs. A depreciated currency raises real marginal. This generates a positive link between inflation and exchange rate such that $\delta_4 > 0$. When firms anticipate the exchange rate to depreciate, they also tend to adjust current prices of their products in order finance the purchase of raw materials under a depreciated currency. This suggests that δ_5 which measures the response of current inflation to exchange rate expectations takes a positive sign. However, as shown by Sanchez (2008), since depreciations can either be contractionary or expansionary. Therefore parameters δ_4, δ_5 and δ_6 might be ambiguous.

The presence of real money balances $\hat{m}_t$ may reduce firms' costs associated with searching for alternative financing to procure inputs. In this case δ_7 can be expected to be negative. But Castelnouvo (2012) argues that real balances may also act as a forcing variable capturing demand push on prices. Furthermore, money may also affect household labour supply decisions and hence the real wage due to the non-separability assumption. When agents have high real money balances, they may decide to reduce their supply of labour. Firms must then offer higher wages in order to induce economic agents to work. When this happens, real marginal costs can increase generating a positive link between real money balances and inflation.

Inflation is also influenced positively by foreign output through trade and aid which act as demand push factors.The impact of expectation about foreign income and lagged foreign income on domestic inflation development are captured by parameters δ_8 and δ_9. The Phillips curve also exhibits the response of inflation to changes in input prices, δ_{10}. Recent studies, such as Malikane (2014) show that including input prices generates a theoretically consistent response of inflation to the output gap. Parameter δ_{10} is thus expected to carry a positive sign. Higher input prices raise real marginal costs which manifest in an increase in prices.

Finally, following Ireland (2004), the Phillips curve also exhibits an aggregate supply shock $\varepsilon_{\pi t}$. This shock may capture technology or cost push factors and is assumed to follow an AR(1) process $\varepsilon_{\pi t} = \rho_{\pi}\varepsilon_{\pi t-1} + \upsilon_{\pi t}$, where $\upsilon_{\pi t}$ $\sim N(0, \sigma_{\pi}^{2})\upsilon_{\pi t}$. According to Clarida et al. (2001), this shock may also arise from stochastic wage mark-up in imperfect labour markets. Similar specification has also been used by Rasaki and Malikane (2014).

2.4.5 Monetary policy reaction function

Consistent with the 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 Henderson and McKibbin (1993), the central bank can optimize monetary policy instead of following an adhoc approach. Optimization also helps in the objective comparison of the monetary policy rules. In order to derive optimal monetary policy rules, we follow Svensson (1999) and Woodford (2003) and specify the following central bank loss function:

$$L_t = E_t \sum_{j=0}^{\infty} \beta^j \frac{1}{2} (\hat{\pi}_{t+j}^2 + \Theta \hat{y}_{t+j}^2), \tag{2.43}$$

where $0 < \beta < 1$ is the policymaker's discount factor similar to the private sector discount factor in eq.(2.18). The parameter $\Theta > 0$ signifies that authorities place some weight on output stabilisation. The central bank seeks to minimize eq.(2.43) subject to eqs. (2.30) and (2.42) where it can either control $\hat{r}_t$ or $\hat{m}_t$ at any point. We follow Svensson (1999) who argues that in order to increase efficiency, monetary policy must respond to drivers of target variables as described by eqs.(2.30) and (2.42). We therefore minimize eq.(2.43) subject to these equations and get the first order conditions for $\hat{\pi}_t$, $\hat{y}_t$, $\hat{q}_t$, $\hat{r}_t$ as follows:

$$\begin{aligned}
\hat{\pi}_t + \beta\chi_b\lambda_{1t+1} - \lambda_{1t} &= 0, &(2.44)\\
\theta_y\hat{y}_t + \beta\kappa_2\lambda_{2t+1} - \lambda_{2t} + \delta_1\lambda_{1t} + \beta\delta_3\lambda_{1t+1} &= 0, &(2.45)\\
-\lambda_{2t}\kappa_5 - \kappa_7\lambda_{2t} + \beta\kappa_8\lambda_{2t+1} - \delta_4\lambda_{1t} - \beta\delta_6\lambda_{1t+1} &= 0, &(2.46)\\
\lambda_{2t}\kappa_3 &= 0, &(2.47)
\end{aligned}$$

where λ_{1t} and λ_{2t} are Lagrangian multipliers. Eqs. 2.44 to 2.47 represent period t optimal discretionary policy conditions which yield the following reduced form optimal relationship between inflation and output:

$$\hat{y}_t = -\frac{1}{\theta_y}\left[\gamma_1\hat{\pi}_t + \gamma_2\hat{\pi}_{t-1}\right], \qquad (2.48)$$

where $\gamma_1 = \frac{\delta_4\delta_3}{(\delta_6-\delta_4\chi_b)}$ and $\gamma_2 = \frac{\delta_4\delta_1}{\beta(\delta_6-\delta_4\chi_b)}$. The optimal condition in eq. (2.48) can be interpreted as follows: if inflation is above target, contract demand below the natural output by increasing the interest rate. If inflation is below its target expand demand above capacity by decreasing interest rates. The coefficients of proportionality γ_1 and γ_2 depend positively on coefficients of output gap and exchange rate in the Phillips curve and inversely on the weight θ_y attached to output stabilization in the objective function. The smaller the value of θ_y the stronger is the demand contraction initiated by the central bank if inflation deviates from the target and vice versa. Following Evans and Honkapohja (2003), we combine the real sector equilibrium dynamics described by eq.(2.30) with the optimal condition (2.48) to derive the central bank's optimal interest rate reaction function as follows:

$$\begin{aligned}\hat{r}_t &= \delta_{1y}\hat{y}_{t+1} + \delta_{2y}\hat{y}_{t-1} + \delta_{1\pi}\hat{\pi}_t + \delta_{2\pi}\hat{\pi}_{t-1} + \delta_{3\pi}\hat{\pi}_{t+1} + \delta_m(\hat{m}_t - \hat{m}_{t+1}) \\ &\quad +\delta_{1q}(\hat{q}_t - \hat{q}_{t+1}) + \delta_{2q}\hat{q}_{t+1} + \delta_{3q}\hat{q}_t - \delta_{4q}\hat{q}_{t-1} + \delta_{1f}\hat{y}^f_{t+1} \\ &\quad +\delta_{2f}\hat{y}^f_t - \delta_{3f}\hat{y}^f_{t-1} + \varepsilon_{rt}, \qquad (2.49)\end{aligned}$$

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. (2.49) is a reduced form optimal Taylor-type interest rate reaction function (IRR). Some studies such as Gali and Gertler (1999) set monetary policy to react to current inflation and output gaps only. However, following Svensson (1999), who argues that to increase monetary policy efficiency, authorities must react to drivers of target variables rather than target variables themselves, eq. (2.49) also features factors that drive both the IS and the Phillips curve. The structure of the policy rule also reflects habit formation in the utility function.

Parameters δ_{1y} and δ_{2y} measure the reaction of monetary policy to expected output gap and lagged output gap. If authorities expect an increase in output gap, they will preemptively tighten monetary policy. Furthermore, if output gap has been positive and it is persistent, authorities will also maintain tight monetary policy stance. Therefore, the expectation is that $\delta_{1y} > 0$ and $\delta_{2y} > 0$. Parameters δ_{2y} is expected to be higher for countries that have high inflation persistence. Parameters $\delta_{1\pi}, \delta_{2\pi}$ and $\delta_{3\pi}$ capture the reaction of monetary policy to current inflation, lagged and expected inflation. Similarly, if current inflation is positive, inflation is persistent and inflation expectations are high, monetary authorities will maintain tight policy stance to deal with inflation pressures. It is therefore expected that $\delta_{1\pi} > 0, \delta_{2\pi} > 0$ and $\delta_{3\pi} > 0$.

Similar to Benchimol and FourÇans (2012), the non-separability assumption leads to the appearance of the real balances in the Taylor rule. Monetary policy responds positively to a rise in real money gap $\delta_m > 0$. Parameters δ_{1q}, δ_{2q}, δ_{3q} and δ_{4q} measure the reaction of monetary policy to real exchange rate depreciation, exchange rate expectations, current exchange rate and lagged exchange rate, respectively. Similar to Wollmeashäuser (2006), monetary policy is concerned with exchange rate in level and changes. As argued by Mohanty and Klau (2004), exchange rate depreciations can be inflationary. Furthermore, Garcia et al. (2011) also show that exchange rate depreciations can have negative balance sheet effects. It is therefore expected that monetary policy will be tightened following threats from exchange rate depreciations, such that $\delta_{1q} > 0$, $\delta_{2q} > 0$ $\delta_{3q} > 0$ and $\delta_{4q} > 0$.

Just like in Rasaki and Malikane (2014), monetary policy also responds to expected and current foreign income through parameters $\delta_{1f} > 0$ and $\delta_{2f} > 0$, respectively. A rise in foreign income is likely to trigger a rise in foreign interest rates. Depending on the strength of the UIP, domestic monetary policy may respond accordingly in order to guard against exchange rate depreciation. Through derivations, δ_{3f} which measures the impact of lagged foreign income on domestic monetary policy conduct is negative. The term ε_{rt} is a shock to monetary policy and it follows an AR(1) process.

Alternatively, McCallum (2000) states that the central bank's reaction function can be described in terms of the monetary aggregate rule. We combine the optimal dynamics in eq.(2.48) with the Phillips curve described by eq.(2.42) to get the following:

$$\begin{aligned}\hat{m}_t &= -\sigma_{3y}\hat{y}_{t-1} - \sigma_{1y}\hat{y}_t - \sigma_{2y}\hat{y}_{t+1} - \sigma_b\hat{\pi}_{t-1} - \sigma_f\hat{\pi}_{t+1} - \sigma_{3q}\hat{q}_{t-1} \\ &\quad -\sigma_{1q}\hat{q}_t - \sigma_{2q}\hat{q}_{t+1} + \sigma_{2ff}\hat{y}^f_{t-1} - \sigma_{1ff}\hat{y}^f_{t+1} - \sigma_o\widehat{oilp_t} + \varepsilon_{mt}, \quad (2.50)\end{aligned}$$

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. (2.50) is an optimal Taylor-type money aggregate rule (MAR). It is consistent with Taylor (1979) proposal that the optimal money supply can be set as a function of inflation and the output gap. As pointed out by Svensson (1999), eq.(2.50) represents pragmatic monetary rule . In this rule, additional information beyond output and inflation which characterize the basic QTM is considered when undertaking policy decisions. Similar to Fan et al. (2011), the rule incorporates the role of the exchange rate, foreign output and crude oil prices on monetary policy conduct. When output gap increases, authorities contract money supply. This is denoted by negative signs on coefficients of lagged output gap σ_{3y}, current output gap σ_{1y} and expected output gap σ_{2y}. Similarly, authorities contract money supply when there is high inflation persistence and inflation expectations. This is captured by parameters $\sigma_b < 0$ and $\sigma_f < 0$.

Parameters σ_{3q}, σ_{1q}, and σ_{2q} measure the reaction of monetary policy to lagged, current and expected exchange rate. Exchange rate depreciations are assumed to be inflationary, and hence monetary policy reacts by reducing money supply. As a result, these coefficients carry negative signs. If we assume that exchange rate depreciations are expansionary, monetary policy will respond by withdrawing liquidity as well. However, if exchange rate depreciations are contractionary, they will reduce output thereby generating a contrary policy reaction. Therefore, the sign of these parameters will ultimately depend on whether output responds positively or negatively to exchange rate changes. These will be buttressed by the positively pass-through of the exchange rate depreciation.

Parameters σ_{2ff} and σ_{1ff} capture the influence of foreign income on domestic monetary policy conduct. To the extend that foreign incomes push up domestic income, monetary policy reacts by contracting money supply. Therefore, the expectation is that $\sigma_{2ff} < 0$ and $\sigma_{1ff} < 0$. Finally, similar to Fan et al. (2011), monetary policy responds to input prices. If input prices are high, they filter into the real marginal costs. The real marginal costs show up in inflation. Monetary policy therefore responds by contracting money supply, such that $\sigma_o < 0$.

Eqs.(2.49) and (2.50) 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 stabilization in Africa. Within the context of the rules versus discretion debate, our rules feature some degree of flexibility and considerable scope for policy adjustment. This is premised on their robustness as they respond to several variables a part from inflation and output gaps. They also differ from those of the AEs such as in Smets and Wouters (2003) and Ireland (2004). The rules are in line with Africa's macroeconomic landscape as they include the exchange rate, foreign input prices and foreign output. Uncertainty in monetary policy lags, a feature more prominent in African countries is taken care of by responding to different lags of variables.

2.4.6 Estimable System

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 reproduce below the derived reduced form New Keynesian model together with the way these equations have been numbered in the text. The equations describing money market dynamics and those describing monetary policy conduct enter the system interchangeably.

IS Curve

$$\begin{aligned} \hat{y}_t &= \kappa_1 E_t \hat{y}_{t+1} + \kappa_2 \hat{y}_{t-1} - \kappa_3(\hat{r}_t - E_t\hat{\pi}_{t+1}) + \kappa_4 (\hat{m}_t - E_t\hat{m}_{t+1}) \\ &\quad + \kappa_5 (\hat{q}_t - E_t\hat{q}_{t+1}) + \kappa_6 E_t\hat{q}_{t+1} + \kappa_7\hat{q}_t - \kappa_8\hat{q}_{t-1} + \kappa_9 E_t\hat{y}^f_{t+1} \\ &\quad + \kappa_{10}\hat{y}^f_t - \kappa_{11}\hat{y}^f_{t-1} + \varepsilon_{yt} \end{aligned} \tag{2.30}$$

Exchange rate dynamics

$$E_t\Delta\hat{q}_{t+1} = -\left[(\hat{r}_t - \hat{\pi}_{t+1}) - (\hat{r}^f_t - \hat{\pi}^f_{t+1})\right] + \varepsilon_{qt} \tag{2.32}$$

Money market dynamics

$$\begin{aligned} \hat{m}_t &= \Psi_1\hat{y}_t + \Psi_2\hat{y}_{t-1} - \Psi_3(\hat{r}_t - E_t\hat{\pi}_{t+1}) - \Psi_4 E_t\hat{\pi}_{t+1} + \Psi_5\hat{q}_t + \Psi_6\hat{q}_{t-1} - \Psi_7\hat{y}^f \\ &\quad + \Psi_8\hat{y}^f_{t-1} + \varepsilon_{mdt} \end{aligned} \tag{2.33}$$

$$\begin{aligned} \hat{r}_t &= \beta_1\hat{y}_t + \beta_2\hat{y}_{t-1} - \beta_3\hat{m}_t - \beta_4\hat{\pi}_{t+1} + \beta_5\hat{q}_t + \beta_6\hat{q}_{t-1} + \beta_7\hat{y}^f_t \\ &\quad - \beta_8\hat{y}^f_{t-1} + \varepsilon_{rdt} \end{aligned} \tag{2,34}$$

Phillips curve

$$\begin{aligned}
\hat{\pi}_t &= \chi_f E_t \hat{\pi}_{t+1} + \chi_b \hat{\pi}_{t-1} + \delta_1 \hat{y}_t + \delta_2 E_t \hat{y}_{t+1} + \delta_3 \hat{y}_{t-1} + \delta_4 \hat{q}_t \\
&\quad + \delta_5 E_t \hat{q}_{t+1} - \delta_6 \hat{q}_{t-1} + \delta_7 \hat{m}_t + \delta_8 E_t \hat{y}^f_{t+1} - \delta_9 \hat{y}^f_{t-1} \\
&\quad + \delta_{10} \hat{p}_{it} + \varepsilon_{\pi t} \qquad (2.42)
\end{aligned}$$

Interest rate policy rule

$$\begin{aligned}
\hat{r}_t &= \delta_{1y} \hat{y}_{t+1} + \delta_{2y} \hat{y}_{t-1} + \delta_{1\pi} \hat{\pi}_t + \delta_{2\pi} \hat{\pi}_{t-1} + \delta_{3\pi} \hat{\pi}_{t+1} + \delta_m (\hat{m}_t - \hat{m}_{t+1}) \\
&\quad + \delta_{1q} (\hat{q}_t - \hat{q}_{t+1}) + \delta_{2q} \hat{q}_{t+1} + \delta_{3q} \hat{q}_t - \delta_{4q} \hat{q}_{t-1} + \delta_{1f} \hat{y}^f_{t+1} \\
&\quad + \delta_{2f} \hat{y}^f_t - \delta_{3f} \hat{y}^f_{t-1} + \varepsilon_{rt}, \qquad (2.49)
\end{aligned}$$

Money supply rule

$$\begin{aligned}
\hat{m}_t &= -\sigma_{3y} \hat{y}_{t-1} - \sigma_{1y} \hat{y}_t - \sigma_{2y} \hat{y}_{t+1} - \sigma_b \hat{\pi}_{t-1} - \sigma_f \hat{\pi}_{t+1} - \sigma_{3q} \hat{q}_{t-1} \\
&\quad - \sigma_{1q} \hat{q}_t - \sigma_{2q} \hat{q}_{t+1} + \sigma_{2ff} \hat{y}^f_{t-1} - \sigma_{1ff} \hat{y}^f_{t+1} - \sigma_o \widehat{oilp_t} + \varepsilon_{mt} \quad (2.50)
\end{aligned}$$

Following Woodford (2003), we seek to identify which of the policy rules between eqs. (2.49) and (2.50) generates lower macroeconomic loss as measured by eq. (2.43) and also restores the economy back to the steady state in a relatively shorter period. We analyze impulse responses which represent the expected path of the endogenous variables conditional on a one standard deviation contractionary shock in period one. In estimating the model, we assume that exogenous variables are driven by the following stochastic processes: $\varsigma_t = \rho_\varsigma \varsigma_{t-1} + \upsilon_{\varsigma t}$ 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, $\upsilon_{\varsigma t} \sim N(0, \sigma_\varsigma^2)$ and $\mu_{\vartheta t} \sim N(0, \sigma_\vartheta^2)$.

2.5 Data, parameterization and estimation

2.5.1 Data

We estimate the model using nine macroeconomic variables described as follows: i) inflation is calculated as a log difference of the Consumer Price Index (CPI) between one quarter and the same quarter of the previous year, ii) real balances are calculated as the log difference between money supply and the CPI, iii) output gap is calculated as the difference between the log of real GDP and its trend. In countries where quarterly GDP statistics are not available, e.g. Malawi, Tanzania, Morocco, Zambia and Nigeria we interpolate the data, iv) real exchange rate is calculated as the sum of the logs of the nominal bilateral US dollar exchange rate and the US CPI less the log of the domestic CPI, v) foreign output is proxied by the US real GDP, vi) we use the US inflation to proxy foreign inflation, vii) Brent crude oil price is used as a proxy for the price of imported raw material.

Similar to Baldini et al. (2015) who use interest rate on government bonds as policy instrument, we also use (viii) Treasury bill rate as proxy for official policy rates, ix) foreign interest rate is proxied by the three months London Interbank Offer Rate (LIBOR). We use the LIBOR because it represents a benchmark rate that leading global banks charge each other for short-term loans. Unlike the federal funds rate, the LIBOR is determined by the equilibrium between supply and demand on the funds market, and it is calculated for five currencies. The LIBOR is an important rate used worldwide by financial institutions to determine the interest rate to be charged on various loans. Although there are several maturities, we choose the three month LIBOR because it is the most popular and is in line with quarterly data that we use in this study. Similar studies like Rasaki and Malikane (2014) also use the same rate.

Data is de-trended using the Hodrick-Prescott (1997) filter (HP filter) as part of the estimation procedure. The HP filter decomposes the data into a cyclical component and a growth component and removes the latter. As argued by Canova (2007), the HP filter has been and is still one of the preferred methods for extracting cycles from economic series. Del Negro and Schorfheide (2003) explains that the rationale behind filtering is that the model is designed to explain business cycles as opposed to very short-run or long-run movements in data. The variables are thus in deviation from steady state.

The model is estimated using quarterly data on 10 African countries. The countries are chosen to reflect various stages of economic development as well as different stages and aspirations in monetary policy conduct. A common feature across them is that they are either actively using the interest rate instrument, e.g. South Africa, Ghana, Kenya and Uganda or contemplating migration, e.g. Malawi, Egypt, Zambia, Morocco, Nigeria and Tanzania. Some countries, such as, South Africa, Egypt and Morocco are categorized as EMEs while the rest are categorized as Low Income Countries. Furthermore some countries, such as South Africa, Uganda, Kenya, Egypt are considered as frontier economies in Africa. It is therefore important to understand their monetary policy processes if they have to effectively act as benchmarks for other African countries. The diverse choice of countries also serves to highlight differences and compare monetary policy performance across African countries. Consistent with data availability, estimation is done using different sample periods as shown in Table 5. Data is obtained from the International Financial Statistics of the International Monetary Fund.

Table 5: The sample periods for each country

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

2.5.2 Model parameterization

The coefficients used for simulation in the study are estimated using actual data. However, in calibrating exogenous processes, we follow Svensson (1999) where all exogenous variables are assumed to follow AR(1) processes. The AR(1) persistence parameters are obtained by regressing equilibrium values of the variables proxied by the HP filter on their one period lag (see Table 27 in the Appendix to Chapter 3 and 4). Liu and Zhang (2010) use a similar approach and estimate the persistence of foreign output, foreign inflation and foreign interest rates at 0.96, respectively. Rasaki and Malikane (2014) estimate foreign output and foreign interest rate persistence at 1.0 while persistence in commodity prices is estimated at 0.92. Therefore our persistence estimates are largely in line with those from literature. These parameters are held constant across the models for all countries.

2.5.3 Estimation

There are several techniques to estimate DSGE models. Ruge-Murcia (2007) provides a succinct summary of them. The Bayesian technique, the Generalized Method of Moments (GMM) and the 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 in addressing identification issues. The generation of the priors, however, remains contentious in literature.

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 minimize 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 shortcomings. The system GMM may suffer from the 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 as applied by Ireland (2004) and Andrés et al. (2006). Hansen and Sargent (2007) show that this estimator is consistent and asymptotically efficient in DSGE models. This study, therefore, uses the MLE method and applies the Kalman (1960) filtering technique. This allows us to deal with unobserved or poorly measured predetermined variables. It yields the optimal solution to the problem of predicting and updating the state-space which 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 drawback 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 et al. (2005). Secondly, is to extend the model to permit additional structural shocks as in Leeper and Sims (1994). However, as observed 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 the 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:

$$E_t\hat{X}_{t+1} = \Gamma_1\hat{X}_t + \Gamma_2\varepsilon_{t,} \tag{2.51}$$

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 error terms.

Using the Blanchard-Kahn (1980) solution, we can solve for the elements in matrices Γ_1 and Γ_2 in each iteration of the optimization process of the Log-likelihood 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 have been characterized by linearizing 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. Based on guidelines in

Pfeifer (2014), we use the output gap, inflation, real exchange and real balances as our observables.

2.6 Results

The key results of our study are based on analysis of macroeconomic loss and impulse responses. However, before discussing these, we first discuss the parameter estimates which are subsequently used for model simulations.

2.6.1 Parameter estimates

Estimates for the IS curve: Parameter estimates for the IS curve are presented in Table 6. κ_1 which measures the response of output to expected income is statistically significant and ranges from 0.37 in Kenya to 0.78 in Uganda. These estimates suggest that when economic agents expect more income, they increase their current spending regardless of the level of interest rates. As suggested by Smets and Wouters (2003) this estimate reflects economic agents rational expectations. Optimistic view of expected real GDP growth will increase current spending thereby raising current incomes. The response of output to lagged income measured by κ_2 is statistically significant. It ranges from 0.33 in Uganda to 0.87 in Kenya. In all the countries, except in Uganda, the estimates of this parameter are in line with Berg et al. (2006) who suggest that it should typically lie between 0.5 and 0.9. These estimates show relatively high output gap persistence except in Uganda and South Africa where this parameter is estimated at 0.33 and 049, respectively.

On average $\kappa_2 > \kappa_1$.This suggests that there are more backward than forward looking agents in Africa. Expectations of future income play a relatively small role in output dynamics compared to previous output. The hysteresis in output gap implies that booms are likely to be followed by booms while slumps will be followed by slumps. As shown by Batini and Yates (2003), this makes inflation difficult to control as the persistence tends to impair the output gap channel leading to higher inflation variability. Since output gap is a key determinant of inflation, its persistence also contributes to inflation persistence. This is one of the reasons why authorities in Africa find it difficult to break the inflation cycles. As argued by Andrle et al. (2015), the structural features of the majority of African countries compel economic agents to mostly rely on previous outcomes to make decisions hence larger backward looking coefficients.

The estimates for κ_3 are theoretically consistent but insignificant in 3 countries, namely Malawi, Morocco and Tanzania. In Egypt and Zambia, this estimate is quite low but also carries a contrary sign. This parameter is statistically significant, theoretically consistent but is also estimated at relatively small values in Ghana, Kenya, South Africa and Uganda. In Nigeria, it is statistically significant but Counterintuitively carries a contrary sign. Nelson (2002) terms the relatively low estimates of this parameter as an IS puzzle. Fuhrer and Rudebusch (2004) also find conflicting signs and relatively low estimates for this parameter. Similarly, Goodhart and Hofman (2005) find that aggregate demand is less sensitive to interest rate changes.

The insignificance and relatively small size of this parameter suggests that there is weak interest rate transmission in African economies. In the traditional New Keynesian models, the interest rate transmission channel is key in stabilizing inflation and output. However, for effective transmission of interest rate signals, there is need for efficient financial system. With this, the interest rate channel is unlikely to play a significant role in Low Income Countries (Mishra et al. (2012). The relatively low estimates together with the insignificance of this parameter therefore reflects the underdeveloped nature of the financial system in Africa. This finding poses unique challenges in monetary policy management as interest rates can not be used effectively to control aggregate demand. To use interest rates, policy makers would have to change them with relatively large magnitudes in order to bring about desired impact on inflation and aggregate demand. This approach might however be inconsistent with other goals, such as financial and fiscal stability.

As shown by Zanetti (2012) and Ireland (2004), κ_4 is critical in evaluating the importance of monetary aggregates in output dynamics. In all countries, except Tanzania and Zambia, real balances significantly drive output dynamics. The estimated coefficients range from 0.001 for Zambia to 0.63 for Uganda. The absolute average sensitivity of aggregate demand to changes in monetary aggregates is calculated at 0.16. Zanetti (2012) estimates this parameter at 0.12 for the US. This suggests that real balances play an important role in output dynamics in Africa compared to AEs. In absolute terms, the average sensitivity of aggregate demand to changes in monetary aggregates is higher than that for interest rates. This suggests that monetary aggregates play a more prominent role in aggregate demand dynamics than interest rates in Africa. This finding also reflects the underdeveloped nature of financial markets. The interest rates are not market clearing. In which case, output dynamics can not only be explained by interest rates alone but also money balances.

Parameter κ_5 which measures the impact of exchange rate depreciations on output is significant in Egypt, Ghana, Kenya, Morocco and Nigeria. In the rest of the countries, κ_5 is not significant. Although in Ghana and Kenya κ_5 is significant, it carries a negative sign. κ_6 which measures the response of output to exchange rate expectations is significant in 7 countries, namely Egypt, Ghana, Kenya, Malawi, Nigeria, Tanzania and Uganda. However in 2 countries, namely Malawi and Nigeria, it affects output negatively. In Morocco, South Africa and Zambia κ_6 is not significant. Similarly, κ_7 which measures the response of output to current exchange rate is significant in 8 countries, namely Ghana, Kenya, Malawi, Morocco, Nigeria, South Africa, Tanzania and Uganda. This estimate is not significant in Egypt and Zambia. κ_8 which captures the response of output to lagged exchange rate is significant in 7 countries countries, namely Kenya, Malawi, Morocco, Nigeria, South Africa, Tanzania and Uganda. This parameter however carries a negative sign in Kenya, Nigeria and South Africa. In the other 3 countries, namely Egypt, Ghana and Zambia this estimates is not significant.

The estimates for exchange rate coefficients can be summarized as follows. First, depreciations have significant impact on output in 5 countries. However, it exerts contractionary effect in 2 of these countries. Second, exchange rate expectations have significant effect in 7 countries but exert contractionary force in 3 of these countries. Third, the current level of the exchange rate has significant impact in 8 countries but exerts contractionary effect in 4 of these countries. Fourth, the lagged exchange rate is significant in 7 countries but exerts contractionary effects in 4 of these countries. On aggregate therefore, exchange rate terms are significant in driving output dynamics in Africa. These findings are similar to Andrle et al. (2015) and they suggest a relatively important role of the exchange rate channel in Africa. African counties rely on imports for both production and consumption. They also rely on commodity exports. Changes in the exchange rate therefore directly transmit to changes in demand.

However, the finding that in some countries exchange rate terms are either contractionary or have no effect on output is also of significant importance. This finding is consistent with Bahmani-Oskooee and Gelan (2013) who show that in 14 of the 23 African countries they examined, the exchange rate depreciations are contractionary. When exchange rate depreciations are contractionary, they reduce output. One of the channels through which the exchange rate may be contractionary or have no effect on output is when import and export demands are inelastic. The majority of African countries have inelastic demand for products they do not produce, such as fuel and pharmaceuticals. Exchange rate depreciation ends up hurting the countries" balance sheets and growth prospects. Under these circumstances, exchange rate depreciations will either have no or negative effect on output. This process is worsened by the high pass-through of the exchange rate to inflation.

κ_9 which measures the response of output to expected foreign income is significant and positive only in 2 countries, namely Zambia and Uganda. Similarly, κ_{10} which measures the response of output to current foreign income is only significant in Zambia, Uganda and Tanzania. κ_{11} which captures the response of output to lagged foreign income is significant in 6 countries, namely Egypt, Kenya, Morocco, Nigeria, South Africa and Zambia. In Kenya, lagged foreign income carries a negative sign. The significance of the lagged foreign income could be due to lags of transmission from foreign incomes to domestic incomes. It also supports the operability of trade, aid and foreign direct investment channels in these countries.

Estimates for the Phillips Curve: The Phillips curve estimates are presented in Table 7. The estimates for χ_f are theoretically consistent and statistically significant, ranging from 0.35 for South Africa to 1 for Ghana. Estimates for parameter χ_b which measures inflation persistence (inertia) or inflation indexation ranges from 0.19 for Ghana to 0.58 for Malawi. In 7 countries, namely Ghana, Egypt, Kenya, Morocco, Uganda, Tanzania and Zambia, $\chi_f > \chi_b$, suggesting that in these economies agents are mostly forward looking in forming inflation expectations. When agents are forward looking, it is less difficult to manage inflation. On the contrary, South Africa, Nigeria and Malawi display higher backward looking behavior in forming inflation expectations as $\chi_b > \chi_f$. Authorities faced with high inflation hysteresis, find it relatively difficult to break an inflation cycle. The relatively large values of χ_b also shed light on why inflation is persistent in many African countries.

Estimates for δ_1 which capture the impact of output gap on inflation rate are positive and statistically significant in all countries, except in Nigeria. It ranges from 0.02 for South Africa to 1.96 in Ghana. Similarly, δ_2 which captures the impact of expected output gap on inflation is statistically significant and theoretically consistent in all countries. It is mostly estimated between 0.12 (Egypt) and 0.73 (Zambia), except in Uganda where it is estimated at 1.39. The impact of lagged income on inflation, measured by parameter δ_3 is statistically significant and carries a correct sign in all countries except in Kenya where it is significant but carries a negative sign.

Overall, these coefficients suggest that the output gap is critical in determining inflation dynamics in Africa. This finding is similar to Rudd and Whelan (2005). The measure of output used in this study encompasses agriculture GDP. Similarly, inflation includes food items. As observed earlier, agriculture significantly contributes to inflation and GDP dynamics in Africa. Changes in output gap therefore may reflect swings in production of agricultural products, such as food. When food production goes down, output gap rises. Inflation also rises due to the relatively large weight of food in the inflation basket. This is one of the channels through which output gap is found to have positive impact on inflation in African economies. One of the policy implications of this finding is that if authorities succeed in stabilizing the output gap, they will also be successful in stabilizing inflation. Put differently, demand management policies are key in stabilizing inflation in Africa. However, authorities must be careful in recognizing sources of demand pressure.

Parameter δ_4 captures the impact of the current exchange rate on inflation. It is significant in all countries except in Egypt. It ranges from 0.25 in Egypt to 0.80 in Malawi. This estimate however carries a negative sign in 2 countries, namely Morocco and Uganda. This result reflects the estimates under the IS curve where current exchange rate is found to exert contractionary effect in Morocco and Uganda. Parameter δ_5 which captures the impact of exchange rate expectations on inflation is significant in all countries and it ranges from 0.10 for Uganda to 0.55 for Nigeria and Kenya. This parameter is statistically significant in all countries but carries negative sign in 5 countries, namely Egypt, Kenya, Morocco, Nigeria and South Africa. Parameter δ_6 captures the impact of lagged exchange rate on inflation. It is statistically significant in all countries, except in Uganda. It ranges from 0.01 for Uganda to 0.79 for Uganda. This estimate is negative in Egypt, Kenya, Nigeria and Uganda.

The coefficients of the exchange rates can be summarized as follows: Firstly, in 9 of the 10 countries, the current exchange rate is a significant driver of inflation dynamics. However, in 2 of these countries, the exchange rate has negative impact on inflation. Secondly, exchange rate expectations are key drivers of inflation in all the countries. However, in 5 of these countries expectations exert negative impact on inflation. Thirdly, the lagged exchange rate is significant driver of inflation in 9 of the 10 countries. In 3 of these countries, the lagged exchange rate generates depressing effects on inflation. These results suggest that the exchange rate is key in driving inflation dynamics in Africa.

Razafimahefa (2012) similarly finds a relatively large average exchange rate pass-through to inflation of 0.4 in Sub-saharan Africa. This pass-through is found to be higher under depreciations. It is found to be lower in countries with relatively more flexible exchange rate systems. To the effect that African countries are characterized by frequent depreciations and frequent interventions in the foreign exchange market to manage exchange rate fluctuations, it would be expected that the impact of the exchange rate on inflation will be relatively large. In some countries such as Egypt, Kenya, Nigeria and Uganda, the majority of exchange rate parameters carry a negative sign.

This could reflect IS curve estimates where some exchange rate terms affect output negatively.

One of the key parameters of interest is δ_7 which captures how inflation reacts to monetary aggregates. This parameter is statistically significant in all countries and it ranges from 0.02 in South Africa to 0.50 in Zambia. However, in 3 countries, namely Kenya, Nigeria and Tanzania, real balances are found to be deflationary. In some cases, money acts as a demand push factor as suggested by Castelnouvo (2012) hence generating a positive sign while in other cases its availability can reduce the costs associated with searching for alternative financing hence generating negative effect on real marginal costs. The overall significance of this parameter suggests that policy makers in Africa can not dispel the role of real balances in inflation dynamics as this would be inconsistent with macroeconomic stabilisation.

Parameter δ_8 measures the impact of foreign income expectations on domestic inflation. This parameter is significant in 4 countries, namely Kenya, South Africa, Uganda and Zambia. Its estimate ranges from 0.14 in Egypt to 0.81 in Zambia, except in Uganda where it is estimated at 1.02. Parameter δ_9 measures the impact of lagged foreign income on domestic inflation and it is significant in Kenya, Morocco, Uganda and Zambia. These findings suggest that imported inflation which may arise from higher foreign incomes is not a major threat to inflation in the majority of African economies. However in those countries which display relative large level of openness, such as Kenya, South Africa, Uganda and Zambia, the pass-through of foreign inflation to domestic prices is relatively high. Parameter, δ_{10}, which measures the impact of imported inputs on inflation is significant only in 3 countries, namely South Africa, Uganda and Zambia. This suggests that imported inputs are not a significant determinant of the firms' real marginal costs in the majority of African economies.

Estimates for Money Demand[6] Parameter estimates for money demand are presented in Table 8. Ψ_1 which measures the income elasticity of money demand is statistically significant and theoretically consistent. It ranges from 0.53 in Egypt to 1.83 Ghana. In 2 countries, name Ghana and South Africa, money demand displays overreaction to changes in income with estimates of greater than unity. Near unity estimates are also obtained for Kenya, Nigeria and Zambia. Parameter Ψ_2 captures the impact of lagged income on money demand. Similarly, this parameter is statistically significant in all countries except in Zambia. It ranges from 0.22 in Malawi to 2.55 in South Africa.

These findings are in line with the unity value found by Chari et al. (2000) and Jonsson (1999) and also the long-run calibrated values in the literature. Africa is still characterized by high and volatile inflation environment. Under these conditions, findings of high income elasticity of demand are not farfetched. If ones income rises and is faced with a threat of inflation, their demand for money should be high. Similarly, Africa is characterized by lower financial market development. This implies that access to facilities like credit cards and online banking remains limited. Under such circumstances, the income elasticity of money demand is expected to be high. Thus as shown by Knell and Six (2005), the development of financial system has considerable impact on the structure of money demand. High income elasticities of money demand is also associated with demand for luxury goods and services. Luxuries are typically priced higher that normal goods. A high estimate for South Africa, for example, may reflect the fact when economic agents in South Africa face a rise in income the demand for luxuries significantly jumps raising the demand for money. This might also reflect growth of the middle class in South Africa.

Ψ_3 which measures the interest rate elasticity of money demand is significant

[6] The alternative description of money market dynamics which involves r_t is found by setting r_t as subject of the formula after estimation and using the calculated values for simulations.

in 8 countries. In 2 of these countries, namely Uganda and Tanzania, the estimates shows an overreaction of money demand to interest rate changes. Counterintuitively, in 2 countries, Ghana and Zambia, money demand rises in response to an interest rate hike, a feature akin to liquidity puzzle. On average, all estimates of Ψ_3 are significant, except in South Africa and Uganda. Parameter estimates for Ψ_4 which captures the impact of inflation expectations on demand for money is significant in all countries except in Malawi. Furthermore, except in Ghana and Zambia, inflation expectations are positive drivers of demand for money. When economic agents expect a rise in inflation, transactional demand for money rises.

Parameter Ψ_5 which captures the impact of exchange rate on demand for money is statistically significant in all countries. However, in 2 countries, namely Ghana and Tanzania, these estimates are negative implying that a depreciation in the exchange rate reduces demand for Money. This may occur if a depreciation reduces output and hence demand for money. We noted from the anlaysis on IS curve estimates that the current exchange rate exerts negative effect on output in Tanzania while exchange rate depreciation is contractionary in Ghana. Parameter Ψ_7 captures the effect of foreign income on domestic money demand and is significant in 6 countries, namely Kenya, Malawi, Morocco, South Africa, Uganda and Zambia. Similarly, lagged foreign income measured by Ψ_8 is significant in Kenya, Malawi, Morocco, Nigeria, South Africa and Zambia. When foreign incomes rise, they contribute to a rise in domestic income. Through this channel, foreign income positively affects domestic money demand.

Estimates for the interest rate rule: Following Zanetti (2012), we directly estimate parameters of the policy rule. This approach is consistent with a black box search for an appropriate policy rule. The estimated parameters are presented in Table 9. Parameter δ_{1y} captures the response of monetary policy to income expectations. This parameter is statistically significant across all countries and ranges from 0.18 as smallest reaction for South Africa to 1.19 as the highest reaction for Malawi. In Malawi, Tanzania, Zambia and Morocco this estimate is above unity implying an expected increase of 1 percent in output gap triggers a more than 1 percent increase in interest rates. Mohanty and Klau (2004) estimate this parameter at 2.00 for South Africa. Parameter δ_{2y} measures how monetary policy responds to lagged output gap and is also statistically significant across all countries with reactions of more than unity estimated for Malawi, Morocco, South Africa and Tanzania.

Overall, it can be observed that monetary policy strongly penalizes deviations of actual output from trend. Output gap has been identified as one of the key drivers of inflation. It is therefore not surprising that authorities also strongly react to it. If inflationary pressures are motivated by demand factors as found under the Phillips curve, then these findings are consistent with stabilizing inflation and output, simultaneously. It is however critical to understand whether output gap fluctuations arise from supply or demand factors and ensure that monetary policy does not excessively react to output gap fluctuations that arise from supply factors. For example, fiscal policy in Africa tends to accentuate rather than attenuate demand shocks. Central banks therefore are left to respond to demand fluctuations that have origins in the fiscal sector (see Sidaoui 2003). This is even more problematic when the rise in aggregate demand follows deficit driven fiscal expansion.

Parameter $\delta_{1\pi}$ captures the reaction of monetary policy to inflation. Its estimates range from 0.17 for Zambia to 1.97 for South Africa. Parameter $\delta_{2\pi}$ captures the influence of lagged inflation on monetary policy conduct. The estimate is significant but carries a contrary sign in Ghana and Tanzania. $\delta_{3\pi}$ which measures policy reaction to inflation expectations is also significant in all countries. In 4 countries, namely Kenya, Morocco, Nigeria and South

Africa, $\delta_{3\pi}$ obeys the Taylor principle. Mohanty and Klau (2004) and Houssa et al. (2010) find similar results. Despite, the presence of non-monetary price pressures, estimates for $\delta_{1\pi}, \delta_{2\pi}$ and $\delta_{3\pi}$, suggests that monetary policy strongly reacts to inflation variables. This shows that authorities do not accommodate inflationary pressures regardless of the source.

δ_m captures how monetary policy responds to the deviation of real balances from the trend. In 9 countries, authorities significantly react to excessive money growth. In South Africa, authorities do not pay attention to monetary aggregates when setting policy rates. Overall, our findings suggest that authorities still consider the monetary aggregate as relevant to macroeconomic dynamics. In Africa, money still contains information about future output and prices that can not be observed via the interest rate. Movements in money balances therefore reflect information on multiple observable and unobservable yields that directly affect aggregate demand. It is therefore not surprising that in the majority of African economies, authorities tend to strongly react to movements in monetary aggregates. These findings are also consistent with Nelson (2003).

Parameter δ_{1q} measures the reaction of monetary policy to exchange rate depreciations. This parameter is statistically significant in all countries, except in Uganda, and it ranges from 0.23 in South Africa to 1.70 in Morocco. Similarly, parameter δ_{2q} which measures authorities' reaction to exchange rate expectations is statistically significant across all countries with estimates ranging from 0.09 in South Africa to 1.69 in Morocco. Coefficient δ_{3q} which captures how authorities react to current exchange rate is also significant across countries but carries a negative sign in Tanzania and Uganda. The estimates for δ_{4q} which measures the response of authorities to lagged exchange rate are equally significant in all countries and they range from 0.01 in South Africa to 1.75 in Morocco. The extreme reaction of Morocco to exchange rate movements is consistent with the authorities desire of pursuing fixed exchange rate.

Overall, the estimated exchange rate parameters suggest that central banks strongly react to exchange rate movements in Africa. The positive and significant coefficients suggest mean reversion. Due to the UIP condition, central banks would eventually reverse their interest rate actions. This feature is in line with Mohanty and Klau (2004) who show that exchange rate dynamics significantly influence output and inflation fluctuations. These findings also reflect earlier results where the exchange rate is found to be critical in inflation and aggregate demand dynamics in Africa. They further capture the tendency of African authorities to announce flexible exchange rate systems and pursue monetary policies that constrain exchange rate pass-through to inflation.

The majority of central banks do not react to changes in foreign income. This is shown by the insignificance of parameters δ_{1f}, δ_{2f} and δ_{3f} In all countries, except Uganda, Zambia and Kenya, these parameters are not significant. These parameters also reflect the fact that in the majority of African countries foreign incomes do not significantly influence inflation and output. This reduces the need for authorities to directly react to them. In summary, the analyzed results rule are in line with Svensson (1999) who argues that monetary authorities must react to drivers of target variables. The Output gap, exchange rate and money are key drivers of inflation and aggregate demand. Authorities in Africa therefore strongly reacts to these variables in order to constrain the behaviour of inflation and output to be in line with the authorities' macroeconomic trajectory.

Estimates for the money supply rule: Estimates for the money supply rule are presented in Table 25. The response of money supply to lagged output gap is significant in Ghana, South Africa, Uganda and Zambia. It carries a negative sign in Ghana and Zambia. The response of money supply to current output gap is not significant in 7 countries, except in Kenya, Malawi and Zambia. In Kenya and Malawi the coefficient carries a positive sign suggesting that instead of contracting money supply authorities increase money supply to support demand pressures (Muhanji et al. 2013). Similarly, in 5 countries, namely Morocco, Nigeria, Tanzania, Uganda and Zambia authorities increase money supply in response to an increase in income expectations. In Morocco and Tanzania, authorities react by contracting money supply.

Consistent with a priori expectations, liquidity is withdrawn in response to lagged inflation in all countries except in Morocco where σ_b is statistically insignificant. The estimates range from 0.12 for South Africa to 1.13 for Nigeria. σ_f which measures the response of monetary policy to expected inflation is significant in 5 countries, namely Egypt, Morocco, Nigeria, Tanzania, Zambia and Uganda. Similar to Muhanji et al. (2013), these estimates carry conflicting signs with money supply responding positively to expected inflation in Morocco, Nigeria, South Africa and Tanzania.

Coefficients σ_{3q}, σ_{1q} and σ_{2q} capture the reaction of monetary policy to lagged, current and expected exchange rates. In 7 countries, authorities react to exchange rate expectations while authorities in 5 countries react to current exchange rate and in 4 countries, authorities react to lagged exchange rates. On aggregate, except in Egypt and Nigeria, monetary policy tends to withdraw liquidity in the economy in light of exchange rate depreciations. This suggests that authorities stand ready to smooth exchange rate fluctuations. This finding is premised on the significance of the exchange rate is driving output and inflation dynamics. Authorities therefore tend to limit the pass-through of exchange rate change to inflation. Morocco contracts money supply more than other countries to deal with exchange rate rate movements.

Table 6: Parameter estimates for the IS curve

	Egypt	Ghana	Kenya	Malawi	Morocco	Nigeria	S. Africa	Tanzania	Uganda	Zambia
κ_1	0.73***	0.39***	0.37***	0.58***	0.67***	0.44***	0.49***	0.40***	0.78***	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***	0.87***	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	-0.001	0.13***	-0.02**	-0.06	-0.07**	0.01
	[0.00]	[0.00]	[0.00]	[0.06]	[0.00]	[0.00]	[0.01]	[0.08]	[0.03]	[0.00]
κ_4	-0.10***	0.02**	-0.12***	0.05**	-0.09***	0.28***	0.17**	-0.05	-0.63***	-0.001
	[0.02]	[0.01]	[0.00]	[0.02]	[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]	[0.03]	[0.05]	[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	0.10	0.21	0.37**	0.08**
	[69.21]	[20.22]	[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]

Note: [ ] Denote standard errors. *,**, *** denote significance at 10%, 5%, 1%, otherwise not significant

Table 7: Parameter estimates for the Phillips curve

	Egypt	Ghana	Kenya	Mal	Mor.	Nig.	S. Afr	Tanz	Uganda	Zam
χ_f	0.79***	1.01***	0.61***	0.53***	0.61***	0.40***	0.35***	0.71***	0.53***	0.66**
	[0.00]	[0.02]	[0.00]	[0.00]	[0.00]	[0.01]	[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]	[0.02]	[0.00]	[0.00]	[0.00]	[0.01]	[0.00]	[0.00]	[0.00]	[0.03]
δ_1	0.79***	1.96***	1.04***	0.89***	0.85***	0.01	0.26***	0.62***	0.96***	0.88***
	[0.00]	[0.23]	[0.00]	[0.00]	[0.15]	[0.00]	[0.01]	[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]	[0.20]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.30]	[0.00]
δ_3	0.66**	0.92***	-0.26***	0.41**	0.71**	-0.13***	0.15***	0.69***	0.81***	0.55***
	[0.30]	[0.00]	[0.00]	[0.00]	[0.20]	[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***
	[35.1]	[109.2]	[0.00]	[5.50]	[0.18]	[92.9]	[0.00]	[52.51]	[0.50]	[0.03]
δ_9	0.194	0.17	0.67***	0.01	0.18***	0.85	0.22	0.18	0.85***	1.09***
	[26.9]	[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 errors. *,**,*** denote significance at 10%, 5%, 1%, otherwise not significant

Table 8: Parameter estimates for the money demand

	Egypt	Ghana	Kenya	Mal.	Mor.	Nig.	S. Afr	Tanz.	Ugan	Zam.
Ψ_1	0.53**	1.83***	0.87***	0.67***	0.54***	0.73**	1.58**	0.54***	0.39***	0.81***
	[0.20]	[0.00]	[0.01]	[0.00]	[0.00]	[0.31]	[0.50]	[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
	[0.30]	[0.00]	[0.40]	[0.00]	[0.00]	[0.40]	[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]	[0.01]	[0.01]	[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**
	[0.10]	[0.00]	[0.20]	[0.00]	[0.00]	[0.00]	[0.10]	[0.00]	[0.00]	[0.10]
Ψ_6	0.012	-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	0.91	3.16	2.00***	1.33***	2.90***	0.83	0.82***	0.90	1.29***	0.49**
	[2.80]	[81.6]	[0.00]	[0.25]	[0.00]	[54.2]	[0.00]	[45.22]	[0.00]	[0.14]
Ψ_8	0.91***	2.42	0.48***	1.40***	3.29***	0.48**v	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. *, **,*** denote significance at 10%, 5%, 1%, otherwise not significant

Table 9: Parameter estimates for the interest rate policy rule

	Egypt	Ghana	Kenya	Mal.	Mor.	Nig.	S. Afr.	Tanz	Ugan	Zam
δ_{1y}	0.90***	0.89***	0.78***	1.19***	1.10***	0.80***	0.18***	1.11***	0.99***	1.14***
	[0.00]	[0.00]	[0.00]	[0.60]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.70]
δ_{2y}	0.91***	0.97***	0.70***	1.39***	1.89***	0.68***	1.16***	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***	1.02***	0.83***	1.34***	-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***	1.60***	3.99***	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**	1.70***	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***	1.69***	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***	1.75***	-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	1.10	4.48	4.50	0.90	0.92***	0.15***
	[31.32]	[24.98]	[71.34]	[54.11]	[13.48]	[154.6]	[38.64]	[45.20]	[0.00]	[0.02]
δ_{2f}	0.93	0.86	1.27***	1.29	2.30	0.62	0.60	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**	0.89	2.50	1.96	2.01	0.89	0.98***	0.79***
	[98.56]	[65.87]	[0.00]	[2.15]	[5.10]	[27.61]	[4.35]	[19.91]	[0.00]	[0.02]

Note: [ ] Denote standard errors, **Significant at 5 percent, otherwise not significant

Captured by σ_0, in 7 countries, money supply responds negatively to a rise in foreign input prices. The estimate ranges from -0.003 in Morocco to -0.18 in Ghana. When prices of inputs rise, firms' real marginal costs go up. Firms pass this cost onto prices of their products which is reflected in overall inflation. Therefore, by contracting money supply monetary policy works in two ways: First, by contracting credit expansion which reduces demand for foreign exchange to purchase foreign inputs. This helps to stabilize the exchange rate and limit the pass-through to inflation. Secondly, contracting money supply constrains demand for firms' final products. Both of these channels lead to a decline in inflation.

2.6.2 Impulse responses and variance analysis

In this section, we analyse impulse responses and variances of inflation and output following one standard deviation contractionary shocks applied to the interest rate and money supply rules. As in McCandless (2008), the economy begins in a stationary state, with all shocks to stochastic processes set to zero since variables are log differences from the stationary state. Results presented in Figs. 7 and 8, and Table 10 show that the monetary aggregate rule (MAR) performs better in macroeconomic stabilization of 5 countries, namely Nigeria, Tanzania, Malawi, Zambia and Morocco. In the other 5 countries, namely South Africa, Egypt, Ghana, Uganda and Kenya, it is the IRR which is optimal.

Figs. 7 and 8 show that in South Africa, both rules lead to output and inflation stability after 22 quarters. However, the IRR yields lower volatility for both inflation and output leading to an absolute loss of 0.00022 compared to 0.00048 under the MAR. In Malawi, output stabilizes after 16 quarters under the MAR compared to 20 quarters under the IRR. However, under both rules, inflation reverts to steady state after 21 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 stabilizes 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 the steady state under the MAR and 28 quarters under the IRR. 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 stabilizes 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 stabilize 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 the 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 the 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

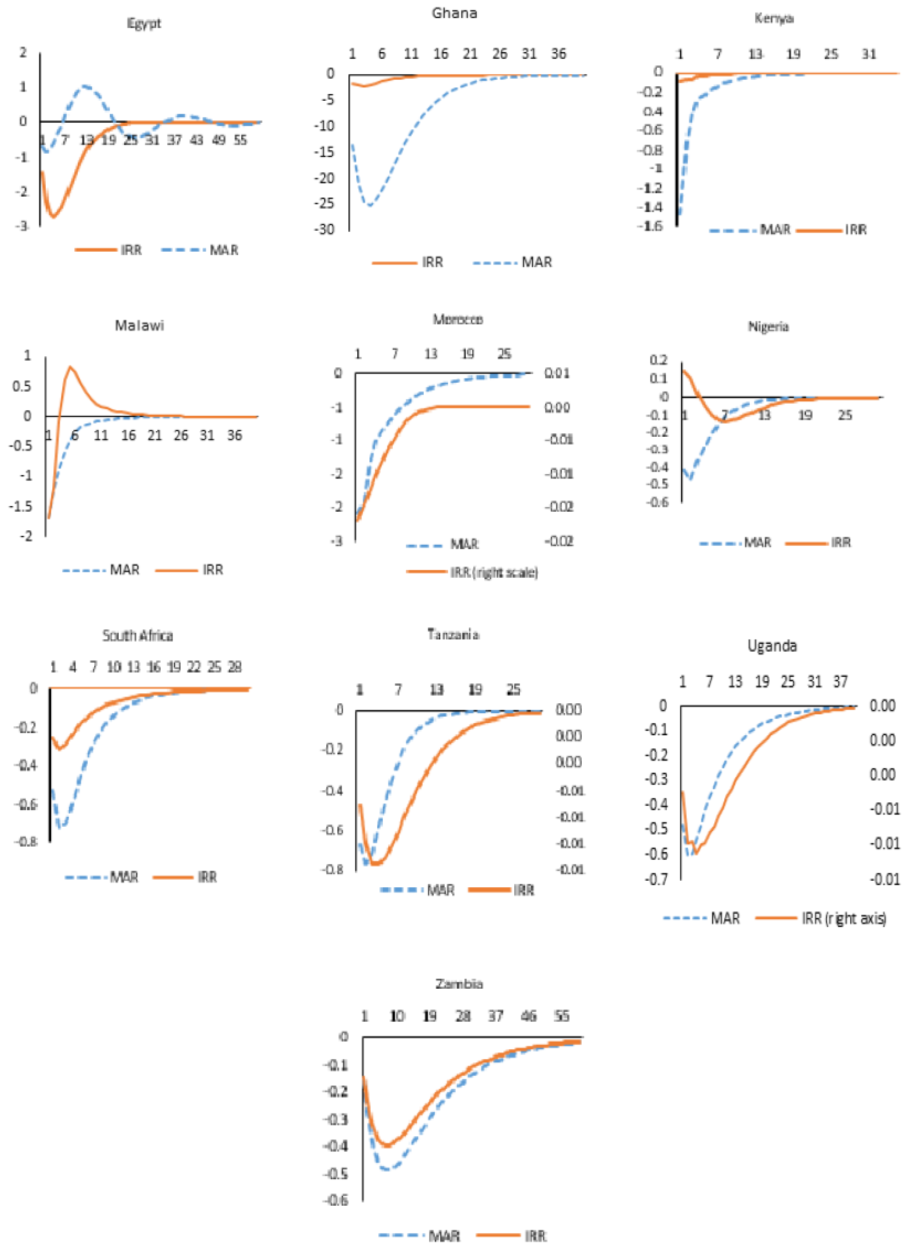
under MAR implying that the IRR performs better. Results for Kenya show that the MAR yields lower output fluctuations and higher inflation fluctuations while the IRR yields lower inflation fluctuations and higher output fluctuations. Output reverts to steady state after 16 quarters under the MAR compared to 22 quarters 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.

On aggregate, the results show that in 5 countries, namely South Africa, Egypt, Kenya, Uganda and Ghana, it is the interest rate rule that performs better while in the other 5 countries, name Malawi, Tanzania, Zambia, Nigeria and Morocco it is the monetary aggregate rule which performs better. These results reflect several factors: First, is the difference in the level of financial development. South Africa and Egypt compete favorably with Advanced Economies in terms of their level of financial development. Uganda and Kenya are also relatively above the rest of the countries in our sample in terms of financial development. According to Mishra et al. (2012), a developed financial system is critical for the transmission of interest rates signals.

Secondly, countries where the interest rate instrument is found to be optimal are characterized by comparatively large interest rate sensitivity of aggregate demand. This implies that authorities in these countries can use the interest rates to stabilize output and inflation. Thirdly, the size of food in the overall CPI is relatively less in these countries. This leaves a bigger segment of the CPI to be influenced by the interest rates. Fourth, in the countries where interest rate instruments is found to be optimal, the authorities have already adopted (South Africa, Ghana and Uganda) inflation targeting which actively uses interest rate instruments. In Kenya, authorities have for sometime been laying solid foundation for the adoption of the IT regime. IMF (2015) argues that the effectiveness of the interest rate instrument is not divorced from the monetary policy framework within which they are implemented.

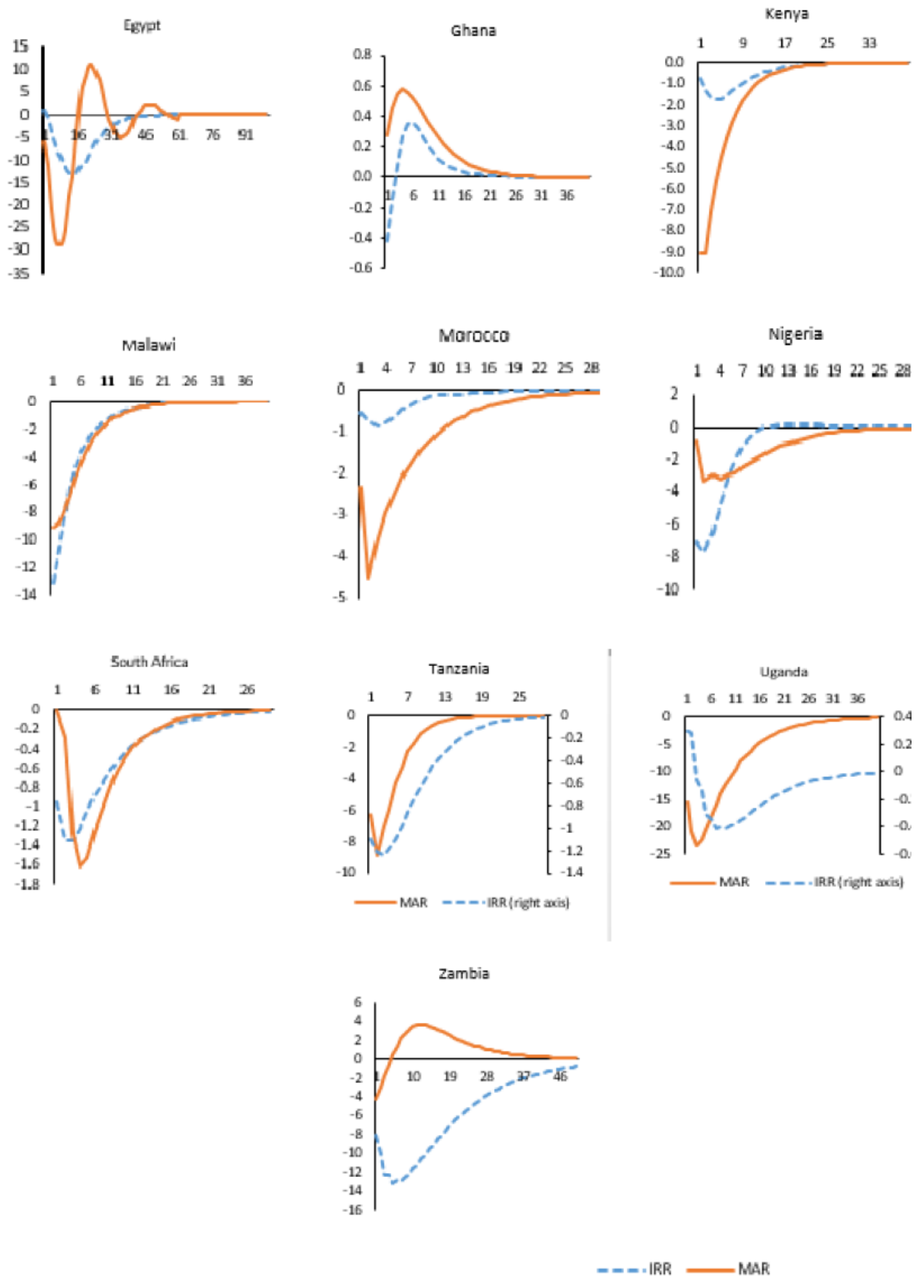
Fifth, non-monetary GDP which can be approximated by the share of agriculture in the GDP is relatively small in countries where the interest rate rule performs better. The small size of non-monetary GDP implies that interest rate signals are capable of reaching a wider portion of the economy. These factors which explain why the interest rate instrument performs better in the South Africa, Ghana, Uganda, Egypt and Kenya are mostly absent in the other economies making the monetary aggregate instrument to have an upper hand.

With respect to the estimated parameters, it can be observed that the average absolute sensitivity of inflation to monetary aggregates is 0.31 in the 5 countries where monetary aggregate targeting is optimal. This is comparatively larger than the average of 0.18 for countries where the interest rate performs better. Since inflation responds more to the monetary aggregate than the interest rate in the former, it follows that the monetary aggregate instrument performs better in handling inflation fluctuations. Similarly, in the other 5 countries where the interest rate is optimal, the absolute average interest rate sensitivity of aggregate demand is estimated at 0.07. This estimate is relatively large than an average of 0.4 in the other 5 countries. Therefore, the optimality of the monetary policy instruments also reflects the role of money and interest rates in driving macroeconomic dynamics in respective countries.



Note: Scale in percentage deviations from steady state (x10^3)

Figure 7: Impulse responses of output gap to monetary policy shocks



Note: Scale in percentage deviations from steady state (x10^3)

Figure 8: Impulse responses of inflation to monetary policy shocks

Table 10: Variance of inflation and output

	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	0.0002	0.00043	0.3453	0.31892	0.0020	0.09007	0.0304	0.01370
(var y)	0.00026	0.00005	0.00004	0.0001	0.00001	0.00003	0.00030	0.00006	0.0028	0.00080
Loss	0.00963	0.00257	0.00022	0.00048	0.34531	0.31894	0.00215	0.0901	0.0318	0.0141
Rank	2	1	1	2	2	1	1	2	2	1

2.7 Conclusion

This study compares the performance of the monetary aggregate and the interest rate as policy instruments for macroeconomic stabilization 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 model also features 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.

We find several results. In 5 countries, namely Nigeria, Malawi, Tanzania, Morocco and Zambia, it is the monetary aggregate instrument that performs better in stabilizing the economies. In the other 5 countries, namely South Africa, Egypt, Ghana, Uganda and Kenya, it is the interest rate that performs better. These results can be attributed to several factors. Firstly, differences in the level of financial development amongst these countries. The relatively low level of financial market development together with a GDP which is mostly dominated by agriculture implies that the interest rate signals are not effectively transmitted in the first group of countries. Secondly, the estimated coefficients suggest that inflation is more sensitive to the monetary aggregate in the first 5 countries than the latter. Similarly, aggregate demand is more sensitive to interest rate changes in the last 5 countries than in the former.

These findings imply that the current monetary policy modernization process in Kenya and Egypt is consistent with macroeconomic stabilisation. Kenya is formally embracing active use of interest rate instruments. With assistance from the IMF, Egypt is equally taking necessary step to enhance the use of interest rate instruments. We also find the use of interest rates in South Africa, Ghana and Uganda to be consistent with the predictions of our model.

Similarly, our model's predictions are consistent with the monetary policy conduct in Nigeria, Malawi, Tanzania, Morocco and Zambia. However, the overall weak role of the interest rate is reminiscent of challenges in using the interest rate as a policy instrument to influence macroeconomic dynamics in Africa. On the contrary, the larger role of the real balances suggests that dispelling the use of monetary aggregates in monetary policy conduct may be inconsistent with macroeconomic stabilization goals in Africa.

In terms of monetary policy response, the interest rate reaction to inflation exceeds or is quite close to unity suggesting a non-accommodating stance of monetary policy towards price shocks. This evidence is also in line with Mohanty and Klau (2004). This finding, however, poses particular policy challenges in some countries due to the dominance of non-monetary GDP. Non-monetary GDP is beyond the reach of monetary policy impulses. It is therefore important for authorities in countries with huge agriculture GDP to take analyze the sources of demand pressures before responding with monetary policy. Where output gap fluctuations are driven by fiscal and agricultural activities, it would probably be important to limit policy response. We thus underscore the importance of understanding sources of output gap pressure to avoid excessively responding to supply factors.

Exchange rate depreciations are found to either have contractionary or no effect on output. However, they are found to be inflationary in all countries. In line with this, authorities strongly react to exchange rate movements. Given the diversity in results, we caution policymakers against a generalized adoption of the interest rate instrument in Africa. The finding that the interest rate instrument performs better in countries with relatively large non-monetary GDP and improved financial markets suggests that countries that aspire to improve monetary policy conduct by adopting interest rates must develop their financial markets and enhance the industrial sectors first in order to broaden the demand base.

2.8 Appendix to Chapter 2: Derivation of the UIP Condition

Households seek to maximize utility U_t given by:

$$U_t = E_t \sum_{j=0}^{\infty} \beta^j \left\{ \frac{1}{1-\sigma} \left[\left(C_t^d - hC_{t-1}^d\right)^{1-\sigma} + \left(C_t^m - hC_{t-1}^m\right)^{1-\sigma} \right] \left(\frac{M_t}{P_t}\right)^{\phi} - \frac{N_t^{1+\varphi}}{1+\varphi} \right\} \tag{A2.01}$$

Subject to budget constraint BC_t given by:

$$BC_t = \frac{M_t}{P_t} + \frac{B_t}{P_t} + \frac{Z_t B_t^f}{P_t} - \left[\begin{array}{c} \frac{W_t N_t}{P_t} + \frac{M_{t-1}}{P_t} + \frac{(1+r_{t-1})B_{t-1}}{P_t} + \frac{Z_t(1+r_{t-1}^f)B_{t-1}^f}{P_t} \\ -C_t^d - Q_t C_t^m \end{array} \right] = 0 \tag{A2.02}$$

Combining A2.01 and A2.02 yields the following Lagrangian function:

$$L_t = U_t + \lambda_t [BC_t] \tag{A2.03}$$

First Order Condition for domestic bonds B_t is given as follows:

$$\frac{\delta L_t}{\delta Bt} = \beta E_t \lambda_{t+1} \left(\frac{1+r_t}{1+\pi_{t+1}} \right) = \lambda_t \tag{A2.04}$$

First Order Condition for foreign bonds B_t^f is given as follows:

$$\frac{\delta L_t}{\delta B^f t} = \beta E_t \lambda_{t+1} \left(\frac{1+r_t^f}{1+\pi_{t+1}} \right) \left(\frac{Z_{t+1}}{Z_t} \right) = \lambda_t, \tag{A2.05}$$

Taylor approximation (or log linearization) of A2.04 yields:

$$\hat{r}_t - \hat{\pi}_{t+1} + \hat{\lambda}_{t+1} = \hat{\lambda}_t \tag{A2.06}$$

Taylor approximation (or log linearization) of A2.05 yields:

$$\hat{r}_t^f - \hat{\pi}_{t+1} + \hat{z}_{t+1} - \hat{z}_t + \hat{\lambda}_{t+1} = \hat{\lambda}t \quad \text{(A2.07)}$$

It follows from A2.06 and A2.07 that:

$$\hat{r}_t - \hat{\pi}_{t+1} = \hat{r}_t^f - \hat{\pi}_{t+1} + \hat{z}_{t+1} - \hat{z}_t \quad \text{(A2.08)}$$

$$\therefore \;\; \hat{z}_t - \hat{z}_{t+1} = -(\hat{r}_t - \hat{\pi}_{t+1}) + \hat{r}_t^f - \hat{\pi}_{t+1} \quad \text{(A2.09)}$$

$$\text{Hence } E_t \Delta \hat{z}_{t+1} = -(\hat{r}_t - \hat{\pi}_{t+1}) + \hat{r}_t^f - \hat{\pi}_{t+1} \quad \text{(A2.10)}$$

Transforming the left side of A2.10 into the real exchange requires adding the term $(\hat{\pi}_{t+1}^f - \hat{\pi}_{t+1})$ which represents inflation differentials between domestic and foreign economy to both sides of the equation. This yields:

$$E_t \Delta \hat{z}_{t+1} + \hat{\pi}_{t+1}^f - \hat{\pi}_{t+1} = -(\hat{r}_t - \hat{\pi}_{t+1}) + \hat{r}_t^f - \hat{\pi}_{t+1} + \hat{\pi}_{t+1}^f - \hat{\pi}_{t+1} \quad \text{(A2.11)}$$

$$\therefore E_t \Delta \hat{q}_{t+1} = -(\hat{r}_t - \hat{\pi}_{t+1}) - (\hat{r}_t^f - \hat{\pi}_{t+1}^f) \quad \text{(A2.12)}$$

3 Should central banks smooth exchange rate fluctuations in Africa?

3.1 Introduction

This paper investigates the effects of exchange rate smoothing on macroeconomic performance in 10 selected African economies. African economies are characterized by frequent shocks. As argued by Lubik and Schorfheide (2007), these shocks alter business cycles and lead to persistent exchange rate fluctuations. Sanchez (2008) observes that exchange rate fluctuations tend to create unstable balance sheets which are associated with volatile macroeconomic performance. Furthermore, exchange rate developments in small open economies can have a substantial influence on prices and output, which makes it a potentially important indirect channel of the transmission mechanism. An important research questions therefore arises. Should African central banks smooth exchange rate fluctuations?

Some studies, such as Taylor (2001) and Bernanke and Gertler (2001), argue that responding to exchange rate movements either leaves macroeconomic performance unchanged or worsens it. However, Calvo (2001) and Eichengreen (2006) argue that there is high exchange rate pass-through to inflation in emerging economies. The high pass-through of the exchange rate also applies to Africa. Apart from high pass-through, the situation in Africa is complicated by thin foreign exchange markets and high levels of external debt denominated in foreign currencies. The thinness of foreign exchange markets implies that trading on the foreign market does not only depend on demand and supply. Furthermore, high debt denominated in foreign currency implies that exchange rate depreciations tend to worsen countries' balance sheets. Based on these factors, other scholars, such as Sekkat and Varoudakis (2000), argue that exchange rate management matters for macroeconomic stability.

The significance of this study is that it will shed light on the relative performance of the monetary aggregate and the interest rate instruments, when exchange rate smoothing is explicitly specified as a monetary policy objective. As argued by Sanchez (2008), exchange rate smoothing must be guided by whether depreciations are contractionary or expansionary. Monetary policy tightening in response to a contractionary depreciation is likely to worsen macroeconomic performance. This observation is particularly relevant for African economies because, as Bahmani-Oskooee and Gelan (2013) show, depreciations are mostly contractionary. Given the challenge posed by contractionary depreciations, balance sheet effects and pass-through to inflation, understanding the effect of monetary policy reaction to exchange rate fluctuations is critical for macroeconomic stability in Africa.

The gap that is filled by this paper is twofold. First, studies like Hufner (2004) only estimate simple policy rules for emerging market economies and find that the authorities react to the exchange rate variable. However, these studies do not examine the implication of this reaction on macroeconomic stability. Those that examine the implication on macroeconomic stability in general also tend to produce divergent results. For example, Wollmershäuser (2006) and Ball (1999) find some reduction in inflation volatility when authorities engage in exchange rate smoothing while Garcia et al. (2011) do not. Thus in this study, we combine both elements. We examine whether central banks react to the exchange rate by including the exchange rate variable in the policy rules. We then proceed to analyze the implication of exchange rate smoothing on macroeconomic performance. This is done by explicitly including exchange rate smoothing as a central bank objective. Secondly, studies on exchange rate smoothing, such as Mohanty and Klau (2004) and Wollmershäuser (2006), are mostly on emerging market economies but remain scanty for African economies.

The contribution of this paper is threefold. First, similar studies to ours, such as Alpanda et al. (2010), Wollmershäuser (2006) and Leitemo and Söderström (2005), examine the role of the exchange rate under Taylor-type rules only. We build on this literature by responding to the question raised by Taylor (2001): "how should the instruments of monetary policy (interest rate or a monetary aggregate) react to the exchange rate"? We therefore extend the literature by including a comparison of the performance of interest rate and money supply rules, when exchange rate smoothing is explicitly specified as a policy objective. Secondly, we examine whether changing the weight placed on exchange rate smoothing influences the choice between policy instruments. For example, a mild response of the interest rate rule may be the most efficient while a more aggressive response may be the least efficient, even compared to some monetary aggregate rules. Thirdly, we approach the research question by simulating an estimated New Keynesian model where money is non-separable from consumption. We use optimal policy rules for each of the selected African economies.

The rest of the chapter is structured as follows: Section 3.2 consists of literature review. Section 3.3 lays out the model. Section 3.4 describes data and the estimation technique. Section 3.5 discusses the results. Section 3.6 concludes with some policy recommendations.

3.2 Literature review

There are two major approaches used by central banks to smooth exchange rate fluctuations. The first approach is through foreign exchange market interventions. According to Ghosh et al. (2015), this approach is appealing when monetary policy changes fail to direct capital flows due to high risk premium. The second approach is through the interest rate rule. Monacelli (2004) and Calvo and Reinhart (2002) observe that interest rate policy rules which respond to exchange rate volatility are increasingly replacing foreign exchange interventions as devices for smoothing exchange rate fluctuations. However, Mishkin and Savastano (2001) observe that responding heavily, frequently and not transparently to exchange rate changes whether by interventions or interest rate policy raises the risk of making the exchange rate a de-facto anchor for monetary policy over an inflation target.

The literature on policy rules with exchange rate feedback takes two strands. First, there are those studies which examine whether the exchange rate is significant in estimated policy rules. Furlani et al. (2010), Ades et al. (2002) and Brischetto and Voss (1999) follow this approach. Their results show that monetary policy responds to exchange rate movements. The second strand of literature seeks to examine whether responding to exchange rate movements enhances macroeconomic stability. The literature under this strand, e.g. Wollmershäuser (2006), Ball (1999) and Batini et al. (2003), compares the performance of models which feature exchange rate smoothing vis-à-vis those that do not. These studies also tend to find that when a policy rule responds to exchange rate fluctuations, macroeconomic performance is somewhat enhanced.

According to Taylor (2000), the omission of the exchange rate in policy rules has been empirically validated for advanced economies. In terms of emerging economies, Mohanty and Klau (2004) argue that exchange rate stability appears to be a key policy concern. The reasons for this are partly articulated by Ho and McCauley (2003). They show that most emerging market economies miss their inflation targets due to sharp exchange rate volatility. This suggests that central banks stand alert to change monetary policy in light of large swings in exchange rates. However, empirical evidence for emerging markets is still divided. Moura and Carvalho (2009) find that, except for Mexico, the other six Latin American Countries do not react to exchange rate fluctuations. Similarly, Furlani et al. (2010) find that Brazil does not react to the exchange rate.

Unlike the vast literature on advanced and emerging economies, the evidence on the subject in Africa is little but also divided. For example, Alpanda et al. (2010) find no evidence of weight on the exchange rate in monetary policy setting in South Africa. On the contrary, Gupta and Jooste (2014) and Ades et al. (2002) provide this evidence. In a different view, Sanchez (2008) advocates reacting to the exchange rate only when depreciations are temporal but not structural or expansionary. A study by Bahmani-Oskooee and Gelan (2013) shows that depreciations are mostly contractionary in 14 out of the 22 African countries examined. This finding partly provides the justification for some central banks in Africa to engage in exchange rate smoothing. Central banks are further cautious about movements in the exchange rate since the nominal exchange rate has an important influence on inflation. Similarly, the real exchange rate matters for the competitiveness of traded goods.

As observed by the IMF (2008), risks arising from exchange rate smoothing abound. Firstly, a failed attempt to smooth exchange rate fluctuations may weaken policy credibility. Secondly, central banks may lack capacity to identify episodes that require smoothing. Pavasuthipaisit (2010) refers to this as the inability to observe the true exchange rate. He advocates not reacting to the exchange rate if it is already reflected in the state of the economy. This is corroborated by Taylor (2001) who does not see the need to react directly to exchange rate changes. Rather, he argues that inertia and rational expectations ignite an indirect exchange rate channel to policy rules. This channel reduces interest rate fluctuations. Mishkin and Savastano (2001) further argue that smoothing of the exchange rate may confuse the public into believing that the central bank's objective is to achieve some exchange rate target and not the inflation target.

A further risk is highlighted by Wollmershäuser (2006), who argues that the link between exchange rate and monetary policy remains uncertain, especially because of the controversy surrounding the empirical strength of the

UIP. There is therefore a likelihood that policy rules with feedback from the exchange rate may fail to successfully stabilize economies. This likelihood is more pronounced in Africa where the validity of the UIP condition is more uncertain. Furthermore, monetary policy transmission is still weak. In addition, many central banks in the region are still faced with challenges to model the true state of the economy. Given these factors, the implication of exchange rate smoothing on macroeconomic performance in Africa remains a fertile area of research.

3.3 The Model

Similar to Canova and Menz (2011) and Castelnouvo (2012), we use a New Keynesian DSGE model where money features as non-separable from consumption in the utility function. Benchimol and FourÇans (2012) argue that higher risk aversion which is prevalent in the majority of African economies can lead to a significant role of money in output and inflation dynamics. All model derivations except the monetary policy rules are presented in Appendix to Chapters 3 and 4. Detailed explanation of the model is provided in Chapter 2. For brevity, we therefore only extract and present the estimable system in Table 11. The system is composed of aggregate demand, aggregate supply, money market dynamics and exchange rate equations. These equations are *briefly* explained from subsection 3.3.1 to subsection 3.3.4. Consistent with the objectives of this chapter, the optimal monetary policy reaction functions which distinquish this chapter are derived in detail in subsection 3.3.5.

Table 11: The reduced form DSGE model

$$\begin{aligned}
\hat{y}_t &= \varphi_1 E_t\hat{y}_{t+1} + \varphi_2\hat{y}_{t-1} - \varphi_3(\hat{r}_t - E_t\hat{\pi}_{t+1}) + \varphi_4\left(\hat{m}_t - E_t\hat{m}_{t+1}\right) \\
&\quad + \varphi_5\left(\hat{q}_t - E_t\hat{q}_{t+1}\right) + \varphi_6\hat{q}_{t+1} + \varphi_7\hat{q}_t - \varphi_8\hat{q}_{t-1} + \varphi_9 E_t\hat{y}^f_{t+1} \\
&\quad + \varphi_{10}\hat{y}^f_t - \varphi_{11}\hat{y}^f_{t-1} + \varepsilon_{yt,} \qquad (3.01) \\
\hat{\pi}_t &= \psi_f E_t\hat{\pi}_{t+1} + \psi_b\hat{\pi}_{t-1} + \psi_1\hat{y}_t + \psi_2 E_t\hat{y}_{t+1} + \psi_3\hat{y}_{t-1} + \psi_4\hat{q}_t \\
&\quad + \psi_5 E_t\hat{q}_{t+1} - \psi_6\hat{q}_{t-1} + \psi_7\hat{m}_t + \psi_8 E_t\hat{y}^f_{t+1} - \psi_9\hat{y}^f_{t-1} \\
&\quad + \psi_{10}\hat{p}_{it} + \varepsilon_{\pi t}, \qquad (3.02) \\
\hat{m}_t &= \varpi_1\hat{y}_t + \varpi_2\hat{y}_{t-1} - \varpi_3(\hat{r}_t - \hat{\pi}_{t+1}) + \varpi_4\hat{\pi}_{t+1} + \varpi_5\hat{q}_t + \varpi_6\hat{q}_{t-1} \\
&\quad + \varpi_7\hat{y}^f_t - \varpi_8\hat{y}^f_{t-1} + \varepsilon_{mdt} \text{ or} \qquad (3.03) \\
\hat{r}_t &= \beta_1\hat{y}_t + \beta_2\hat{y}_{t-1} - \beta_3\hat{m}_t - \beta_4\hat{\pi}_{t+1} + \beta_5\hat{q}_t + \beta_6\hat{q}_{t-1} + \beta_7\hat{y}^f_t \\
&\quad - \beta_8\hat{y}^f_{t-1} + \varepsilon_{rdt}, \qquad (3.04) \\
E_t\Delta\hat{q}_{t+1} &= -\left[(\hat{r}_t - \hat{\pi}_{t+1}) - (\hat{r}^f_t - \hat{\pi}^f_{t+1})\right] + \varepsilon_{qt}. \qquad (3.05)
\end{aligned}$$

$\hat{y}_t$ = output gap, $\hat{r}_t$ = Three months treasury bill rate, $\hat{\pi}_t$ = domestic inflation, $\hat{\pi}^f_t$ = US inflation, $\hat{p}_{it}$ = crude oil price, $\hat{q}_t$ =real exchange rate, $\hat{y}^f_t$ = foreign output, $\hat{r}^f_t$ = LIBOR rate. $\varsigma_t = \rho_\varsigma\varsigma_{t-1} + \upsilon_{\varsigma t}$ and $\vartheta_t = \rho_{\vartheta t}\vartheta_{t-1} + \mu_t$, where $\varsigma_t = \left(\hat{y}^f_t, \hat{r}^f_t, \hat{\pi}^f_t, p\hat{i}t\right)$, and $\vartheta_t = (\varepsilon_{yt}, \varepsilon_{\pi t}, \varepsilon_{mdt},\ \varepsilon_{rdt}, \varepsilon_{qt}, \varepsilon_{rt}, \varepsilon_{mt},)$.
Furthermore, $\upsilon_{\varsigma t} \sim N(0, \sigma^2_\varsigma)$ and $\mu_{\vartheta t} \sim N(0, \sigma^2_\vartheta)$.

All variables are deviation from steady state, represented by a hat on top of a variable. The focus of our paper is on policy analysis rather than recovering the underlying parameters. We, therefore follow Zanetti (2012) and Fujiwara (2007) and use a reduced form New Keynesian model.

3.3.1 Aggregate demand

The aggregate demand (IS) dynamics described by eq.(3.01) in Table 11 arise from households' desire to maximize utility subject to a constrained budget. It features the lead $\hat{y}_{t+1}$ and lagged $\hat{y}_{t-1}$ output variables. As argued by Smets and Wouters (2003), these variables affect output positively due to rational expectations and habit formation. Output is negatively related to the real interest rate $(\hat{r}_t - E_t\hat{\pi}_{t+1})$. The terms π_{t+1} stands for model consistent inflation expectations. Similar to Ireland (2004) and Zanetti (2012), eq.(3.01) also features real money balances $\hat{m}_t$ which positively drive output dynamics. According to Canova and Menz (2011), this could result from the impact of money on the marginal rate of substitution between consumption and leisure and hence the real wage.

The IS curve also includes the real exchange $\hat{q}_t$. As shown by Senbeta (2011), Africa's consumption largely relies on imports, making the exchange rate a key variable in output dynamics. As in Wollmershäuser (2006), the exchange affects the output dynamics in levels and changes. Another feature arising from the imposition of the macroeconomic resource balance is the presence of foreign output variable $\hat{y}_t^f$. Foreign output may affect domestic output through various channels, such as foreign direct investments, foreign aid and trade. The exchange rate and foreign output variables serve to capture the open economy effects. As in Ireland (2004), we include the aggregate demand shock ε_{yt} which is assumed to follow an AR(1) process.

3.3.2 Aggregate supply

Eq.(3.02) is a hybrid Phillips curve. As in Gali and Gertler (1999), parameters ψ_f and ψ_b capture the degree of forward and backward looking price setting, respectively. Inflation is also positively affected by the output gap at various lags. Consistent with Senbeta (2011), supply dynamics are also driven by the real exchange rate $\hat{q}_t$ since most inputs are imported. The presence of real money balances $\hat{m}_t$ may reduce firms' costs associated with searching for alternative financing to procure inputs. Castelnouvo (2012) argues that real balances may also act as a forcing variable capturing demand push on prices. Money may also affect household labour supply decisions and hence the real wage due to the non-separability assumption, generating a positive link with inflation. Eq.(3.02) also exhibits input prices $\hat{p}_{it}$. Recent studies, e.g. Malikane (2014), show that including input prices generates a theoretically consistent response of inflation to the output gap. Inflation is also influenced by foreign output $\hat{y}_t^f$ through trade and aid which act as demand push factors. We also include an aggregate supply shock $\varepsilon_{\pi t}$ which follows an AR(1) process.

3.3.3 Money market dynamics

Eq.(3.03) describes money demand. Money demand is positively influenced by current income $\hat{y}_t$ and lagged income $\hat{y}_{t-1}$. The presence of habits in the utility function makes money demand depend on lagged and expected incomes. It also features the contemporaneous opportunity cost of holding money $(\hat{r}_t - \hat{\pi}_{t+1})$. The real exchange rate $\hat{q}_t$ and $\hat{q}_{t-1}$, positively affect demand for money through several channels, e.g. domestic consumption of imported goods. The foreign output $\hat{y}_t^f$ affects demand for money positively through its impact on domestic income. The equation also exhibits a money demand shock ε_{mdt}. Eq.(3.04) is a corollary of eq.(3.03).

3.3.4 Exchange rate determination

In eq.(3.05), the real exchange rate dynamics are described as a function of the real interest rate differentials also known as the Uncovered Interest Parity condition (UIP). We however augment it with the term ε_{qt} which serves to capture the deviations from the parity condition. Studies similar to ours e.g. Wollmershäuser (2006) typically refer to ε_{qt} as the foreign exchange risk premium. This specification is consistent with African economies, where the UIP condition remains contentious due to higher risk premiums. This equation underpins the majority of the recent open economy models and has been used by Coenen and Wieland (2003) and Svensson (2000), among others.

3.3.5 Monetary policy conduct

Monetary policy is described by two alternative rules, the monetary aggregate and the interest rate. According to Liu and Zhang (2010), the monetary aggregate may fail to capture policy dynamics in an environment where the interest rate plays a significant role in driving macroeconomic dynamics and vice versa. To derive these policy rules, we specify a central bank intertemporal loss function similar to De Paoli (2009):

$$L_{t+j} = E_t \sum_{j=0}^{\infty} \beta^j \frac{1}{2}(\hat{\pi}_t^2 + \theta_y \hat{y}_t^2 + \theta_q \hat{q}_t^2), \tag{3.06}$$

where $\hat{q}_t^2$ measures the exchange rate volatility. Its presence in the loss function captures the policy makers inclination to penalize exchange rate deviations from the trend. According to Ghosh et al. (2015), this could reflect the need for authorities to protect competitiveness and deal with balance sheet concerns. $\theta_q \geqslant 0$ is the weight placed on stabilization of the real exchange rate by authorities. $\theta_y > 0$ is the weight placed by the central bank on output stabilization. We follow Evans and Honkapojha (2003) and Walsh (2001) to derive the first order conditions for $[\hat{\pi}_t, \hat{y}_t, \hat{q}_t]$ by minimizing eq.(3.06) subject to eq.(3.02). We get the following first order conditions:

$$
\begin{aligned}
\hat{\pi}_t + \psi_b \beta \phi_{t+1} - \phi_t &= 0, & (3.07)\\
\theta_y \hat{y}_t + \psi_3 \beta \phi_{t+1} + \phi_t \psi_1 &= 0, & (3.08)\\
\theta_q \hat{q}_t + \phi_t \psi_4 - \phi_{t+1} \psi_6 \beta &= 0, & (3.09)
\end{aligned}
$$

where ϕ_t is the Lagrangian multiplier. Substituting eq. (3.07) into (3.09) and combining the result with eq.(3.08) yields the following optimal relationship:

$$
\hat{y}_t = -\frac{1}{\theta_y} \left[\vartheta_1 \hat{\pi}_t + \vartheta_2 \hat{\pi}_{t-1} + \vartheta_3 \hat{q}_t + \vartheta_4 \hat{q}_{t-1} \right], \tag{3.10}
$$

where

$$
\begin{aligned}
\vartheta_1 &= \frac{\psi_3 \psi_4}{(\psi_6 - \psi_b \psi_4)}, \ \vartheta_2 = \frac{\psi_1 \psi_4}{(\psi_6 - \psi_b \psi_4)} \\
\vartheta_3 &= \frac{\psi_3 \theta_q}{\beta (\psi_6 - \psi_b \psi_4)}, \ \vartheta_4 = \frac{\psi_1 \theta_q}{\beta (\psi_6 - \psi_b \psi_4)}.
\end{aligned}
$$

The optimal dynamics in eq.(3.10) feature the current and lagged real exchange rate terms which are activated only when authorities engage in exchange smoothing i.e $\theta_q > 0$. Eq. (3.10) states that if inflation is above target, contract demand below the natural output by increasing the interest rate. This is captured by the negative relationship between output gap and inflation, both current and lagged. Similarly, authorities can increase the interest rate in order to appreciate the exchange rate and knock off excess demand. This feature is again captured by the negative relationship between output gap and exchange rate terms, namely $\hat{q}_t$ and $\hat{q}_{t-1}$. The coefficients of proportionality ϑ_1 up to ϑ_4 depend positively on coefficients of output gap and exchange rate in the Phillips curve and inversely on the weight θ_y attached to output stabilization in the objective function. Furthermore, ϑ_3 and ϑ_4 positively depend on exchange rate smoothing parameter θ_q. The higher the value of θ_q,the less the pass-through to inflation and higher the output. The smaller the value of θ_y the stronger is the demand contraction initiated by the central bank if inflation deviates from the target and vice versa.

Combining eq.(3.01) and eq.(3.10) leads to the following interest rate rule:

$$\begin{aligned}\hat{r}_t &= \varkappa_1 \hat{y}_{t-1} + \varkappa_2 \hat{y}_{t+1} + \varkappa_3 \hat{\pi}_t + \varkappa_4 \hat{\pi}_{t-1} + \varkappa_5 \hat{\pi}_{t+1} + \varkappa_6 (\hat{m}_t - \hat{m}_{t+1}) \\ &\quad + \varkappa_7 (\hat{q}_t - \hat{q}_{t+1}) + \varkappa_8 \hat{q}_{t+1} + \varkappa_9 \hat{q}_t - \varkappa_{10} \hat{q}_{t-1} + \varkappa_{11} \hat{y}^f_{t+1} \\ &\quad + \varkappa_{12} \hat{y}^f_t - \varkappa_{13} \hat{y}^f_{t-1} + \varepsilon_{rt}, \end{aligned} \tag{3.11}$$

Where

$$\begin{aligned}\varkappa_1 &= \frac{\varphi_2}{\varphi_3}, \varkappa_2 = \frac{\varphi_1}{\varphi_3}, \varkappa_3 = \frac{\vartheta_2}{\varphi_3},\ \varkappa_4 = \frac{\vartheta_2}{\varphi_3},\ \varkappa_5 = 1, \\ \varkappa_6 &= \frac{\varphi_4}{\varphi_3}, \varkappa_7 = \frac{\varphi_5}{\varphi_3}, \varkappa_8 = \frac{\varphi_6}{\varphi_3}, \varkappa_9 = \frac{\varphi_7 + \vartheta_3}{\varphi_3}, \varkappa_{10} = \frac{\varphi_{8+}\vartheta_4}{\varphi_3}, \\ \varkappa_{11} &= \frac{\varphi_9}{\varphi_3}, \varkappa_{12} = \frac{\varphi_{10}}{\varphi_3},\ \varkappa_{13} = \frac{\varphi_{11}}{\varphi_3}.\end{aligned}$$

Eq.(3.11) shares the same dynamics with eq. (2.49). The difference is that in eq. (3.11) authorities must pay additional attention to current and lagged exchange rates by adjusting the interest rate with additional magnitudes of ϑ_3 and ϑ_4, respectively, in order to address real exchange rate volatility. The values of ϑ_3 and ϑ_4 depend on the exchange rate smoothing factor θ_q. When $\theta_q = 0$, these magnitudes collapse to zero, giving rise to a comparable case in which authorities use the interest rate instrument without smoothing exchange rate fluctuations. Alternatively, we can combine eq.(3.02) and eq.(3.10) to get the following money supply rule:

$$\begin{aligned}\hat{m}_t &= -\beta_1\hat{y}_{t-1} - \beta_2\hat{y}_t - \beta_3\hat{y}_{t+1} - \beta_4\hat{\pi}_{t-1} - \beta_5\hat{\pi}_{t+1} \\ &\quad -\beta_6\hat{q}_{t-1} - \beta_7\hat{q}_t - \beta_8\hat{q}_{t+1} - \beta_9\hat{y}^f_{t-1} \\ &\quad -\beta_{10}\hat{y}^f_{t+1} - \beta_{11}\hat{p}_{jt} + \varepsilon_{mt},\end{aligned} \tag{3.12}$$

where

$$\begin{aligned}\beta_1 &= \frac{\psi_3}{\psi_7},\ \beta_2 = \frac{\theta_y + \psi_1}{\vartheta_1\psi_7},\ \beta_3 = \frac{\psi_2}{\psi_7},\ \beta_4 = \frac{\psi_b + \vartheta_2}{\psi_7}, \\ \beta_5 &= \frac{\psi_f}{\psi_7},\ \beta_6 = \frac{\psi_6 + \vartheta_4}{\psi_7},\ \beta_7 = \frac{\psi_4 + \vartheta_3}{\vartheta_1\psi_7},\ \beta_8 = \frac{\psi_5}{\psi_7},\ \beta_9 = \frac{\psi_9}{\psi_7}, \\ \beta_{10} &= \frac{\psi_8}{\psi_7},\ \beta_{11} = \frac{\psi_{10}}{\psi_7}.\end{aligned}$$

Eq. (3.12) shares same dynamics with eq. (2.50). However, the novelty in eq.(3.12) is that authorities adjust the monetary aggregate instrument by further magnitudes of ϑ_3 and ϑ_4 to respond to the current and lagged real exchange rates, respectively. Again, the values of ϑ_3 and ϑ_4 depend on θ_q. When $\theta_q = 0$, these terms collapse to zero, giving rise to a comparable case where authorities use the monetary aggregate instrument but do not respond to exchange rate fluctuations. When $\theta_q = 0$, the response of the interest rate and the monetary aggregate instruments to the real exchange rate is only triggered by the implication of exchange rate developments on aggregate demand and supply dynamics, a feature akin to what Taylor (2001) terms indirect exchange rate effect.

Table 12: Data description

Inflation	Calculated as a log difference of the CPI between one quarter and the same quarter of the previous year
Real balances	Calculated as the log difference between of the money supply and the CPI
Output gap	Calculated as the difference between the log of real GDP and its trend
Real exchange rate	Calculated as the sum of the logs of the nominal bilateral US dollar exchange rate and the US CPI less the log of the domestic CPI
Foreign interest rate	Proxied by the three months London Interbank Offer Rate,
Foreign output	Proxied by the US real GDP
Foreign inflation	Proxied by US inflation
Raw material price	Proxied by Brent crude oil price
Policy rate	Proxied by three months Treasury bill rate

3.4 Data, calibration and simulation

3.4.1 Data

Data used is obtained from the International Financial Statistics of the International Monetary Fund and is described in Table 12. Due to differences in data availability from different countries, the sample periods considered vary from country to country as follows: For South Africa, Ghana, Uganda, Malawi and Egypt we use quarterly data from 1990-2014. For Tanzania and Zambia, we estimate our models with quarterly data from 1993-2014. For Morocco, we use quarterly data from 1995 to 2014. For Nigeria, we use 1995-2014 while for Kenya we use quarterly data from 1993-2014. Where quarterly GDP is not available, e.g. Malawi and Tanzania, we interpolate. All variables are in deviation from steady state.

3.4.2 Calibration

We pay particular attention to the choice of parameters characterizing the loss function described by eq.(3.06), namely θ_q, θ_π and θ_y. The parameters represent the weights with which authorities penalize the deviations of exchange rate, inflation and output from their targets, respectively. Similar to Ghosh et al. (2015) on emerging market economies, we set $\theta_\pi = 1$. There are diverse calibrations for θ_q in literature. For emerging economies, Nordstrom et al. (2009) set $\theta_q = 0.3$ and find this value to be consistent with dampening inflation volatility while slightly increasing output variability in the presence of demand and risk premium shocks. They also find that welfare is compromised when a smoothing parameter of more than 0.6 is used. Ghosh et al. (2015) set $\theta_q = 0.1$. Garcia et al. (2011) compare smoothing parameters of between 0.25 and 0.7. They also consider cases where weights are applied on levels and changes of the exchange rate. They find that beyond a smoothing parameter of 0.75, inflation and output variability tend to go up significantly.

In line with the Taylor's (1993) proposal and other studies, e.g. Leitemo and Söderström (2005), we calibrate the output smoothing parameter at $\theta_y = 0.5$. Following an approach similar to Garcia et al. (2011), we set the minimum weight for the exchange rate smoothing parameter $\theta_q = 0$ and adjust this by margins of 0.1 up to $\theta_q = 0.5$. Varying the values of θ_q enables us to examine two cases: i) whether the effect of exchange rate smoothing on macroeconomic performance is invariant to the level of aggressiveness of the central bank towards exchange rate fluctuations, ii) whether there is a change in the choice of the monetary policy instrument when authorities smooth the exchange rate using the interest rate or money supply rules. The rest of the parameters used for simulations in this Chapter are estimated in Chapter 2 and are presented in Appendix to Chapter 3 and 4 as Tables 22-26.

3.4.3 Simulation

We simulate the model using the Maximum Likelihood (ML) technique. Hansen and Sargent (2007) show that this estimator is consistent and asymptotically efficient in DSGE models. In order to deal with a probable problem of singularity, we follow Ireland (2004) and add error terms to the observation equations of the state-space representation. This limits the effects of misspecification and helps to deal with identification issues. This representation also captures the limitations of the DSGE models to exhaustively capture macroeconomic dynamics in African context. We use output, inflation, real exchange and real money balances as observables.

According to Taylor (2000), a good policy rule is the one that minimizes fluctuations of the goal variables. We therefore simulate the estimated model by applying a 0.01 standard deviation contractionary shock to the monetary aggregate and the interest rate rules. We follow Wollmershäuser (2006) and seek to identify a model that yields lowest macroeconomic loss and restores the economy back to the steady state in a relatively short period. The macroeconomic loss is defined by eq.(3.06). The paper is for monetary policy analysis rather than recovering the underlying parameters. We therefore follow Zanetti (2012) and Fujiwara (2007) and use the reduced form model. The system to be simulated is presented in Table 13.

Table 13: The estimable system

Model	θ_q	Included equations				
Models with interest rate rule						
1	0.0	3.01	3.02	3.03	3.05	3.11
2	0.1	3.01	3.02	3.03	3.05	3.11
3	0.2	3.01	3.02	3.03	3.05	3.11
4	0.3	3.01	3.02	3.03	3.05	3.11
5	0.4	3.01	3.02	3.03	3.05	3.11
6	0.5	3.01	3.02	3.03	3.05	3.11
Models with money supply rule						
Model	θ_q	Included equations				
7	0.0	3.01	3.02	3.03	3.05	3.12
8	0.1	3.01	3.02	3.03	3.05	3.12
9	0.2	3.01	3.02	3.03	3.05	3.12
10	0.3	3.01	3.02	3.03	3.05	3.12
11	0.4	3.01	3.02	3.03	3.05	3.12
12	0.5	3.01	3.02	3.03	3.05	3.12

3.5 Results

3.5.1 Variance of output and inflation

The key results addressing the questions raised in this chapter arise from analysis of variance and impulse responses. The variances are presented in Table 14 while impulse responses are presented in Figs. 9 and 10. When exchange rate smoothing is excluded from the central bank's objective, i.e. $\theta_q = 0$, macroeconomic loss is minimized when authorities use the interest rate instrument in Egypt, Ghana, Kenya, South Africa and Uganda. However, in Malawi, Morocco, Nigeria, Tanzania and Zambia it is the monetary aggregate instrument which minimizes macroeconomic loss[7]. This result is replicated in Table 14 by comparing Model 1 and model 7.

[7] These results are similar to what we obtained in Chapter 2

When exchange rate smoothing is explicitly included as a central bank objective, i.e $\theta_q > 0$, several other results appear. Firstly, exchange rate smoothing improves macroeconomic performance in Ghana, Kenya, Malawi and Tanzania. These results reflect estimates from the Phillips curve which show that the response of inflation to the exchange rate variables is relatively large in these countries compared to others. Similarly, the impact of the exchange rate on aggregate demand is on average higher in these countries compared to others. Therefore, the significance of exchange rate smoothing in these countries reflects the authorities' desire to deal with high pass-through of the exchange rate to inflation, an observation also made by Pavasuthipaisit (2010).

In addition, ToTs are either more volatile or declining in these countries. The behaviour of the ToTs together with the significance of the exchange rate in driving inflation and output dynamics compel authorities to engage in exchange rate smoothing. Fig. 4 suggests that in the 2000s, these countries should have experienced significant depreciations of the currencies because they were faced with declining ToTs. Declining ToTs imply that a country imports relatively more than it exports. Typically, this should translate into significant depreciation of the exchange rate. However, during this period, the exchange rates for these countries marginally moved suggesting that authorities implemented policies to buoy the currencies (also see Fig. 19 in the Appendix to Chapter 3 and 4). This buoyed stability constitutes exchange rate smoothing which helped to improve macroeconomic performance in these countries.

Our results further suggest that the weight with which authorities smooth exchange rate fluctuations has implications for macroeconomic stabilization. Below certain thresholds, exchange rate smoothing is not sufficient such that the pass-through of the exchange rate to inflation and aggregate demand remains high which generates inflation and output volatility. Beyond certain thresholds, the situation is akin to running a near fixed exchange rate regime which as argued by Baldini et al. (2015) leads to higher macroeconomic volatility. Indeed, as we find in this study, exchange rate smoothing in Morocco, Nigeria and Egypt which pursue conventional peg, stabilization arrangement and other managed float worsens macroeconomic performance.

We also find that exchange rate smoothing worsens macroeconomic performance South Africa, Uganda and Zambia. With relatively more open financial accounts and independent monetary policies, managing exchange rate fluctuations through active monetary policy in these countries generates more volatile interest rates. As argued by Calvo, Reinhart and Végh (1995) this leads to volatile output and inflation. Therefore in 6 of the 10 countries, exchange rate smoothing worsens macroeconomic performance. These findings are also consistent with other empirical studies, such as IMF (2008), Taylor (2001) and Calvo, Reinhart and Végh (1995). Despite the fact that exchange rate smoothing worsens macroeconomic performance in the majority of countries, authorities still react to exchange rate changes. This is evidenced by the significance of the exchange rate parameters in the policy rule. One possible reason is the "fear of floating" syndrome. The fear of floating arises from the observed significance of the exchange rate in driving inflation and output dynamics in Africa.

However, as suggested by Ghosh et al. (2015), authorities in these countries should consider relying more on sterilized foreign exchange interventions rather than monetary policy instruments to smooth exchange rates. Sterilized foreign exchange interventions would also be applicable to countries which find gains from exchange rate smoothing but cannot adjust monetary policy to deal with exchange rate fluctuations, for instance, due to financial or fiscal stability concerns. This approach would be critical in ensuring that fundamental exchange rate level is not affected while also maintaining suitable interest rate and money supply levels to meet other domestic objectives.

Sterilized interventions can be effective in influencing the exchange rate because capital mobility is not perfect due to high risk premium and also the small size of domestic financial markets in Africa.

The use of foreign exchange interventions allows authorities to address two policy objectives, namely inflation and exchange rate stability by using two policy instruments, namely interest rates or money supply and foreign exchange interventions. This is different from loading a single interest rate or money supply instrument with achieving inflation and exchange rate stability. According to Timbergen (1952), pursuing multiple objectives with one instrument can be recipe for policy ineffectiveness. Sterilized interventions should however be motivated by the need to dampen short term exchange rate volatility rather than averting structural misalignment. Under structural misalignment, repeated interventions would contribute to the accumulation or drainage of liquidity thereby increasing risks to inflation targets. This appears to have been the case in Malawi and Nigeria in periods leading to 2012 and 2016, respectively. While trying to achieve exchange rate stability, the liquidity that ensued due to interventions threatened inflation stability. Just like Open Market Operations, foreign exchange interventions are costly and therefore require the central banks to have relatively strong balance sheets. A feature that African authorities must leave with if they opt for an independent monetary policy.

Our findings also suggest that in Tanzania there is a switch in the optimal rule. When exchange rate fluctuations become a concern for the authorities, macroeconomic loss is minimized at 0.1723 using the interest rate instrument with a smoothing parameter of 0.5 instead of the monetary aggregate. In the other 9 countries, there is no trade-off in policy instruments. However, we observe that the interest rate instruments only performs better in Tanzania at very high level of smoothing, i.e $\theta_q = 0\ .5$. This suggests that if an overly tight policy stance on account of exchange rate fluctuations is not feasible due to other domestic objectives, such as financial stability, the monetary aggregate instrument may still be preferred.

3.5.2 Impulse responses

We present impulse responses of output and inflation in Figs. 9 and 10. In the baseline case (where monetary policy does not respond to exchange rate fluctuations), it would be expected that a monetary policy tightening represented by an increase in interest rate or a withdraw of liquidity would result in a decline in aggregate demand and induce a decline in inflation. In the alternative case, where authorities smooth exchange rates, it would be expected that impulse responses will behave in similar way to the baseline case but that the economy should revert to steady state earlier and the level of deviation after a shock should be relatively smaller compared to the baseline case.

Fig. 9 shows that the response of inflation to policy tightening is theoretically consistent in Egypt. Without interest rate smoothing, the interest rate rule generates less volatility although it is the money rule which stabilizes inflation earlier. In Ghana and Kenya, the interest rate rule with an exchange rate smoothing parameter of 0.1 brings the economy back to steady state earlier than that without exchange rate smoothing. In Uganda, it is the interest rate rule without exchange rate smoothing that stabilizes the economy earlier.

Fig. 9 also shows the impulse responses of output. In Egypt, output stabilizes at around 55 quarters under monetary aggregate rule with an exchange rate smoothing parameter of 0.3, similar to the interest rate rule without exchange rate smoothing. In Ghana and Uganda, reacting to exchange rate volatility generates a contrary response of output to monetary policy shock. In Ghana, output reverts to steady state after 11 quarters under the interest rate rule without exchange rate smoothing compared to 19 quarters under exchange rate smoothing. In Uganda, output gap stabilizes after 19 quarters without exchange rate smoothing compared to 80 quarters under exchange rate smoothing.

In Fig. 10, we present impulse responses of inflation to the monetary aggregate shock. In Nigeria, Malawi, Morocco, Zambia, Tanzania and South Africa, monetary policy tightening represented by a contraction in money supply generates theoretically consistent impulse responses. Exchange rate smoothing results in earlier reversion of output to steady state in Nigeria and Tanzania. For example, in Nigeria, Inflation reverts to steady state after 13 quarters under exchange rate smoothing with a value of 0.1 compared to 10 quarters without exchange rate smoothing.

Overall, the findings from the analysis of variance and impulse responses are rather mixed. On one hand, engaging in exchange rate smoothing enhances macroeconomic performance in 4 countries, namely Ghana, Kenya, Malawi and Tanzania. The gains in macroeconomic performance mostly arise from lower inflation and exchange rate volatility. Exchange rate smoothing lowers the pass-through of the exchange rate to inflation and minimizes the volatility of the exchange rate itself. This finding is supported in literature by studies such as Wollmershäuser (2006), Batini et al. (2001) and Ball (1999). In practice, caution must be exercised such that exchange rate smoothing is exclusively used to smooth exchange rate fluctuations and not achieve an inflation objective. The interest rate or the monetary aggregate should remain a primary instrument for monetary policy. Their level of adjustment should however be adjusted only when there are eminent threats of excessive exchange rate fluctuations. One clear risk is that economic agents might believe that authorities have changed policy objectives such that inflation and exchange rate stability are both primary goals of monetary policy. To avoid this, clear communication about why authorities are smoothing the exchange rate would be key.

On the other hand, there seems to be no additional benefit in responding to the exchange rate fluctuations in the other 6 countries, namely Egypt, South Africa, Morocco, Uganda, Zambia and Nigeria. As argued by Wollmershäuser (2006), the economic rationale behind this result can also be directly derived from the exchange rate model underlying the open economy models. According to the UIP the real exchange rate moves in response to real interest rate differentials as well as disturbances to the UIP. Low level of openness and thinness of foreign exchange markets mean that reaction to foreign interest rate changes is limited. At the same time, subscription to international programmes, such as those from the IMF and World Bank together with improved governance structures suggest that the risk premium might somewhat be decreasing. In this case, real exchange rate is mostly determined by the domestic real interest rate, which can be controlled by authorities. From this, it directly follows that the contemporaneous movement of the exchange rate contains no extra information for the decision making process of the central bank. As a result, if the exchange rate is not an independent source of disturbances, there is no additional information to be had from responding to the exchange rate itself. The exchange rate is endogenous such that responding to it will not deal with the fluctuations but nevertheless will influence interest rate volatility which as argued by Calvo et al. (1995) will contribute to more macroeconomic volatility.

Table 14: The variance estimates

Model	θ_q	Egypt	Ghana	Kenya	Mal.	Moroc.	Nigeria	S. Africa	Tanz.	Uganda	Zambia
Loss function values for models with interest rate rule											
1	0.0	0.010	0.112	0.0013	1.184	1.4754	0.0096	0.00022	0.9056	0.0022	0.0318
2	0.1	0.042	0.081	0.0012	1.106	5.1025	0.0062	0.00024	0.5307	0.0046	0.3969
3	0.2	6.404	0.146	0.0014	0.195	2.7785	0.0114	0.00027	0.3218	0.0095	0.3609
4	0.3	0.569	0.175	0.0016	0.222	2.1970	0.0178	0.00027	0.3473	0.0056	0.1866
5	0.4	25.64	0.141	0.0013	0.306	3.5101	0.0219	0.00047	0.1723	0.0065	0.6469
6	0.5	5.760	0.097	0.0017	0.669	2.6572	0.0277	0.00246	0.2220	0.0054	0.6427
Loss function values for models with money supply rule											
7	0.0	0.029	1.413	0.0079	0.257	0.00078	0.0026	0.00480	0.3189	0.0901	0.0140
8	0.1	0.027	1.415	0.0178	0.274	0.00079	0.1315	0.00568	0.5883	0.1070	6.1018
9	0.2	0.034	1.239	0.0414	0.059	0.00088	0.2632	0.00571	0.4606	0.0982	2.3486
10	0.3	0.03	0.678	0.0374	0.061	0.00095	0.2962	0.00579	0.3105	0.0996	0.4061
11	0.4	0.039	1.264	0.0469	0.063	0.00099	0.1227	0.00891	0.3515	0.1057	0.4624
12	0.5	0.039	1.406	0.0569	0.064	0.0013	0.4530	0.02944	0.3119	0.1107	9.2175
Rankings based on loss function											
Models with interest rate rule											
1	0.0	1	3	2	12	7	3	1	12	1	2
2	0.1	8	1	1	11	12	2	2	10	2	5
3	0.2	11	5	4	5	10	4	3	6	6	4
4	0.3	9	6	5	6	8	5	4	7	4	3
5	0.4	12	4	3	9	11	6	5	1	5	9
6	0.5	10	2	6	10	9	7	11	2	3	8
Models with money supply rule											
7	0.0	2	11	7	7	1	1	6	5	7	1
8	0.1	3	12	8	8	2	9	7	11	11	11
9	0.2	7	8	10	1	3	10	8	9	8	10
10	0.3	4	7	9	2	4	11	9	3	9	6
11	0.4	5	9	11	3	5	8	10	8	10	7
12	0.5	6	10	12	4	6	12	12	4	12	12

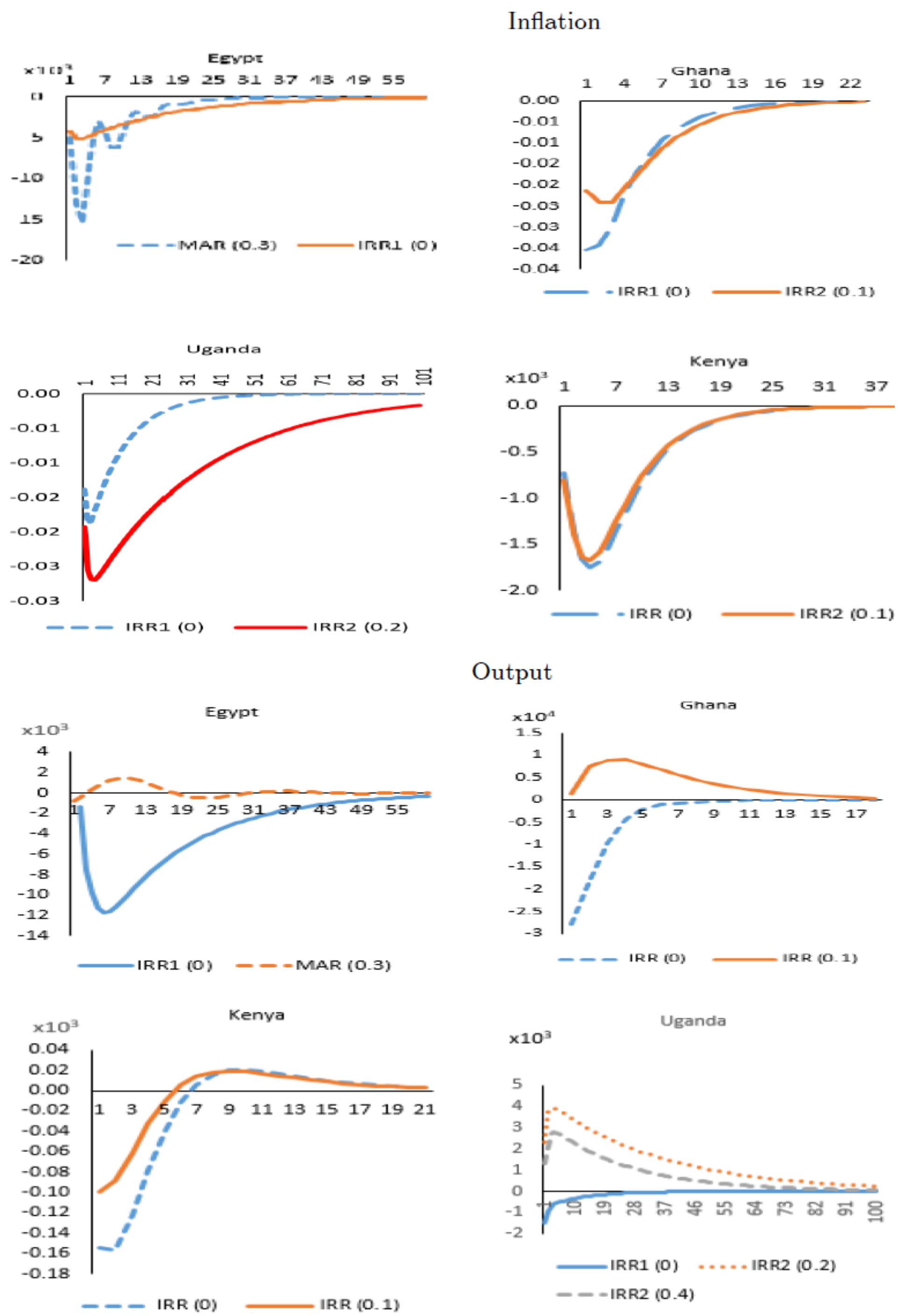


Figure 9: Impulse responses of inflation and output to the interest rate shock

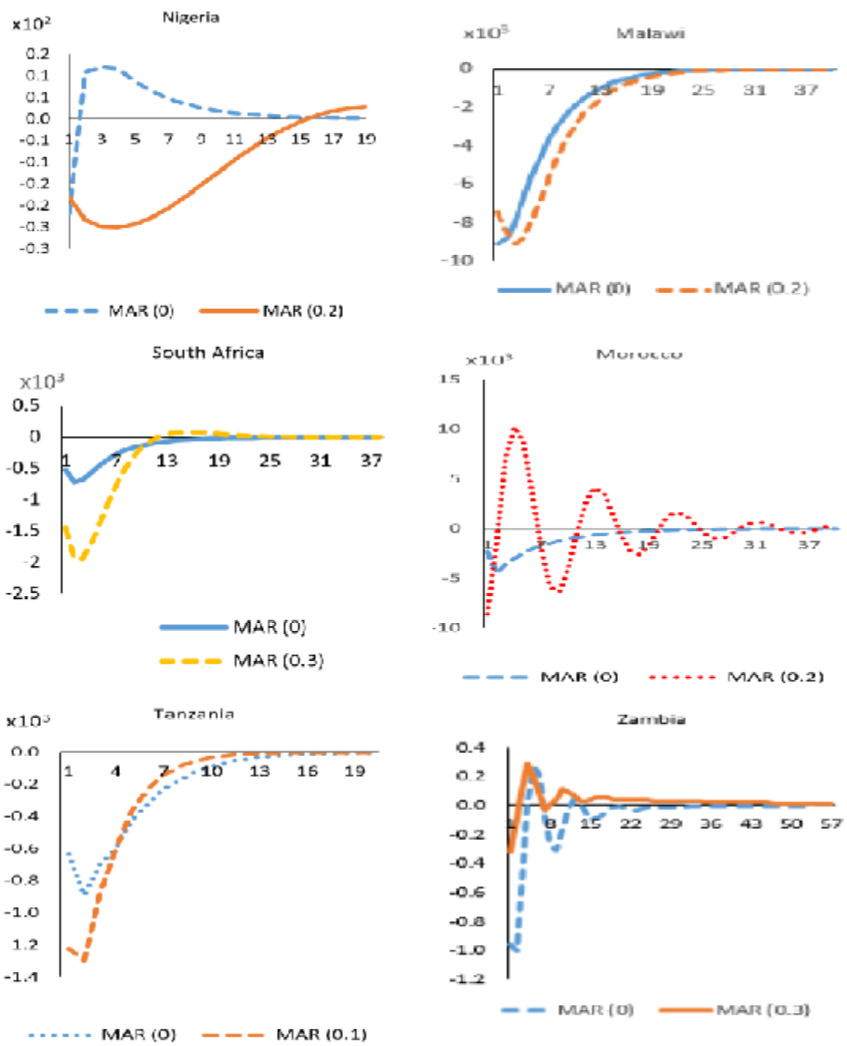


Figure 10: Impulse responses of output to the monetary aggregate shock

3.6 Conclusion

African economies are faced with frequent and diverse shocks. Lubik and Schorfheide (2007) show that these shocks generate persistent exchange rate fluctuations which as shown by Sanchez (2008) create unstable balance sheets and volatile macroeconomic performance. Observed data attests to these. Given these observations, in this paper we examine whether exchange rate smoothing can yield dividends in form of enhancing macroeconomic performance in African countries. We use the New-Keynesian framework estimated using the Maximum Likelihood method. The loss function is specified as a quadratic expression of output, inflation and the real exchange rate. Apart from output and inflation stability, the authorities are therefore also concerned with exchange rate volatility and hence engage in exchange rate smoothing. The implication of exchange rate smoothing on macroeconomic performance is examined by varying the level of aggressiveness by the monetary authorities towards exchange rate volatility.

The results show that in 4 countries, namely Ghana, Kenya, Malawi and Tanzania there is strong evidence for authorities to engage in exchange rate smoothing as it enhances macroeconomic performance. These countries are faced with more volatile and declining terms of trade which compel authorities to engage in exchange rate smoothing. This is also reflected in the behaviour of the exchange rates which does not fully reflect developments in terms of trade. This suggests that indeed authorities smooth fluctuations. In these countries, the exchange rate also exerts a relatively large influence on macroeconomic variables. Exchange rate smoothing therefore limits the pass-through of the exchange rate to inflation which results in improved macroeconomic performance (see Pavasuthipaisit 2010). Put differently, in the absence of inflation risks warranting policy adjustments, threats from exchange rate fluctuations are a justifiable reason for authorities to adjust monetary policy.

Secondly, in the other 6 countries, namely Egypt, South Africa, Morocco, Nigeria, Uganda and Zambia engaging in exchange rate smoothing worsens macroeconomic performance. This result is also consistent with some studies, such as Batini et.al (2003) and Ball (1999), which find no or small macroeconomic improvement when the exchange rate is included in policy rules. The findings are also supported by Taylor (2001) who argues that policy rules which react to the exchange rate movements may perform worse than their counterparts. As of 2014, Nigeria and Morocco had relatively fixed exchange rate systems. Exchange rate smoothing in an environment where authorities already pursue fixed exchange rate system generates more macroeconomic volatility. Fixed exchange rates contain little information about the economy. Responding to an exchange rate when it does not contain any new information tends to increase interest rates volatility resulting into policy induced instability.

Thirdly, we find evidence that the level of aggressiveness towards exchange rate fluctuations has implications for macroeconomic performance. Below some threshold, the smoothing is not sufficient to contain the pass-through to inflation. Above certain levels, there is too much smoothing which is tantamount to implementing near fixed exchange rate regimes. According to Baldini et al. (2015), fixed exchange rate regimes generate more macroeconomic volatility. The threshold of smoothing is however found to be country specific.

Fourth, our results suggest that exchange rate smoothing succeeds in reducing macroeconomic instability by mostly reducing the volatility of inflation. The exchange rate is characterized by two transmission channels, direct and indirect channels. Under the direct channel, a depreciation of the exchange rate immediately translates into a rise in imported goods which translates into higher domestic prices. This is the case in Africa since the production and consumption patterns are largely based on imports (see Senbeta

2011). Exchange rate smoothing therefore works by directly leveraging the pass-through under the direct channel.

Overall, our results are rather mixed. On one hand, they suggest that exchange rate smoothing is beneficial in 4 countries. On the other hand, they do not support smoothing in 6 countries. We can thus conclude that exchange rate smoothing using monetary policy rules is harmful in Africa. The results further suggest that where smoothing delivers gains, authorities must carefully determine appropriate thresholds to minimize policy induced macroeconomic instability. Under circumstances where adjusting monetary policy to deal with exchange rate fluctuations does not seem feasible, but nevertheless authorities are concerned with exchange rate fluctuations, authorities should consider alternatives such as sterilized foreign exchange intervention (Gosh et al. 2015). Using sterilized interventions would allow authorities to pursue inflation and exchange rate stability objectives using two different instruments, namely the interest rates or money supply and exchange rate interventions (see Timbergen 1952).

4 Inflation targeting versus nominal income targeting in selected African economies: An empirical assessment

4.1 Introduction

This study compares the performance of inflation targeting and nominal GDP targeting as alternative monetary policy regimes for macroeconomic stabilization in 10 African economies. The spike in commodity prices between 2006 and 2008, their subsequent reversal and the dislocation of trade that followed the global financial crisis brought a long period of relatively benign macroeconomic conditions to an abrupt halt (IMF 2015). There is mounting evidence that price volatility has increased thereafter and it is likely that policy challenges will continue. Authorities around the world are thus forced to reassess the reach and limits of their macroeconomic management tools. Africa is not spared. One of the critical tools for macroeconomic management is monetary policy. IMF (2015) observes that despite the success in reducing inflation to single digits, most central banks in LICs including those from Africa do not have effective monetary policy frameworks for formulating and implementing monetary policy to deal with shocks. The absence of clear policy frameworks, numerous macroeconomic challenges and the authorities' dissatisfaction with current monetary policy regimes has created a search for alternatives.

According to the 2011 IMF World Economic Outlook, the number of inflation targeters increased by 25 percent, globally, between 2003 and 2011. Although there is evident shift in research and practice towards inflation targeting by several countries, recent studies, such as Woodford (2014) and Bill (2013), argue that the IT regime has been unable to sufficiently resuscitate aggregate demand in AEs after the 2008 financial crisis. Some studies, such as Sumner (2012), show that the severity of the 2008 crisis would have been limited if countries pursued NGDP targeting instead of inflation targeting. Several recent studies, such as Belongia and Ireland (2015), Frankel (2014) and McCallum (2011), also propose NGDP targeting as a potential framework for macroeconomic stabilization in the presence of huge supply shocks.

As argued by Frankel (2014), the IT framework is gaining more popularity among AEs and EMEs because it is robust to aggregate demand shocks which are dominant in these economies. However, this framework could be ill-suited to deal with supply and terms of trade shocks as it leads to excessively tight monetary policy. In Africa, the choice of appropriate monetary policy regimes is blemished by these features. Other studies such as IMF (2008) emphasize responding to second round effects other than first round effects under supply shocks. However, the distinction between first and second round effects is a useful construct but fraught with uncertainty as it is difficult to tell where first round effect stop and where second round effects kick in. It also requires an understanding of the structural features of the economy, the state of the economy, and a thorough assessment of available data which the majority of African economies still lack. Not surprising, the frequency of these shocks have seen the enthusiasm for inflation targeting that was widespread in the early 2000s being replaced by a i) more sober assessment of how such regime might best be modified for the conditions of Africa, ii) search for alternative regimes that are robust to prevailing shocks.

In Africa, several studies, like Heintz and Ndikumana (2011), Loening et al. (2009) and Nell (2004), show that inflation is mostly driven by supply shocks. Kose and Riezman (2001) show that roughly 50 percent of the economic fluctuations in Africa are driven by trade shocks. Rasaki and Malikane (2015) find external debt, exchange rate and commodity price shocks as significant drivers of output fluctuations in Africa. Nguyen et al. (2017) find that

45 percent of inflation fluctuations in Africa arise from supply shocks. IMF (2011) further shows that the probability of terms of trade and disaster shocks are higher in Africa compared to AEs and EMEs.

Despite this evidence, there are no studies on Africa that examine the relative macroeconomic performance of the NGDP targeting as alternative to the IT regime under these conditions. The focus on the IT regime alone contradicts the features characterizing African economies and also stands in contrast to some studies, such as Sumner (2015) and Frankel (2014) who argue that the effectiveness of this regime is dwarfed when supply or terms of trade shocks dominate. Unfortunately, the majority of the studies on monetary policy frameworks are on AEs which makes choices on the subject difficult for Africa. These studies are also lopsided in favour of the IT frameworks.

This study contributes to literature in several ways. Firstly, similar studies like ours, such as Frankel (2014), Bill (2013), Houssa et al. (2010) and Garin et al. (2015), focus their analysis on two regimes, namely flexible versions of nominal GDP targeting and inflation targeting. In this study, we extend the analysis by defining the strict versions of these frameworks thereby generating additional comparable monetary policy regimes. Secondly, different from these studies, we address our research question by simulating a reduced form New Keynesian model where money is non-separable from consumption in the utility function. Furthermore, our study uses optimized policy rules thereby enhancing objective comparison of the policy regimes. By examining the NGDP regime, this study provides an alternative potential framework against which the conventional IT framework can be evaluated in Africa.

The rest of the chapter is organized as follows: Section 4.2 consists of literature review. Section 4.3 lays out the model. Section 4.4 describes data and the estimation technique. Section 4.5 discusses the results. Section 4.6 concludes with some policy options.

4.2 Literature review

There are various monetary policy regimes. The popular ones are Exchange Rate Targeting (ERT), Monetary Aggregate Targeting (MAT), Inflation Targeting (IT) and Nominal GDP Targeting (NGDP). As explained by Mishkin (1999), ERT involves either fixing the value of a domestic currency to a low inflation currency or use of policies that do not allow the exchange rate to move beyond some prescribed values. Under the MAT, authorities use the central bank balance sheet items, typically reserves, to programme monetary developments to be consistent with the inflation target. The IT involves an announcement of a medium term inflation target. Interest rates are then moved to steer the inflation projection towards the inflation target. Under the NGDP targeting, authorities change monetary policy to ensure that the growth of nominal income is consistent with the sum of targeted real GDP growth and inflation.

As observed by Frankel (2014), the ERT is quite successful in anchoring expectations in small open economies. As argued by IMF (2015), some LICs have and will continue to choose fixed exchange rate regimes. These regimes, which include currency unions, currency boards, and hard pegs in which an explicit exchange rate commitment represents the main nominal anchor, have advantages and represent a viable choice for many countries. Indeed for some of these countries, strengthening their fixed exchange rate regime may be the preferred direction of policy reform. However, by definition, the exchange rate target would not allow the exchange rate to move in line with macroeconomic fundamentals.

In Africa, weak balance of payments positions, poor terms of trade and dominance of supply shocks make the ERT regime not suitable. Indeed a comparison of the exchange rate peg against inflation targeting in Mozambique by Peiris and Saxegaard (2010) shows that inflation targeting is superior in stabilizing the economy due to higher interest rate volatility. In terms of the MAT, Mishkin (1999), observes that its effectiveness relies on the stability of the velocity and money multiplier. Some studies, e.g. Sichei and Kamau (2010) document instability of the velocity and the money multiplier in Kenya while in Uganda they find that the money multiplier is unstable in the short run. Similarly, Adam and Kessy (2010) show that the money multiplier is unstable in Tanzania. These challenges are rendering the MAT framework ineffective and have generated the quest for alternative regimes in Africa.

The IT framework has been the preferred alternative over the MAT regime. Under IT, authorities can either follow strict inflation targeting (SIT) or flexible inflation targeting (FIT). In the former, real sector developments are not considered when setting interest rates while in the latter, authorities pay some attention to output developments when setting interest rates. Rudebusch and Svensson (1999) argue that the SIT framework is suboptimal and leads to higher macroeconomic loss compared to the FIT. However, Frankel (2014) argues that under both cases, sticking with the announced regime in the aftermath of an adverse trade shock would likely yield an excessively tight monetary policy. A further caveat of the IT is highlighted by Mishkin (1999) who argues that inflation targets are just hard to hit, a process which is complicated by long lags of monetary policy effects.

A contending regime to the IT is the NGDP targeting. Originally proposed by Meade (1978) and Tobin (1980), a nominal GDP target accommodates the adverse supply shocks by automatically dividing it between real output and inflation. Belongia and Ireland (2015) show that the nominal GDP targeting implemented using the monetary base instrument is transparent, convenient to implement and monitor in real time and therefore easy to communicate to the public. Their proposal is therefore appealing to the majority of African economies who still use the MAT framework. In terms of AEs, Frankel (2014) argues that NGDP targeting can help them to achieve credible monetary expansion and raise inflation expectations. This, for example would help AEs deal with economic weaknesses that ensued following the severe negative demand shock in 2008.

Empirical evidence on the performance of IT and NGDP targeting remains divided. Bill (2013) finds that for a standard calibration, the IT under discretion generates a deflationary trap while the NGDP level targeting does not. Frankel (2014) finds that a NGDP rule performs better than the IT rule except when the Phillips curve is steep or when the weight placed on price stability is quite high. Frisch and Staudinger (2003) find that the IT regime generates a trade off between inflation and output under a supply shock. This trade off depends on the relative weights in the loss function. Under NGDP targeting, authorities face a constant trade off between inflation and output. According to Garin et al. (2015), the NGDP targeting produces a smaller welfare loss than an estimated Taylor rule and significantly outperforms the IT. This is the case particularly when wages are sticky and supply shocks dominate. Kim and Henderson (2004) argue that SIT and NGDP targeting are suboptimal under full or partial information but NGDP targeting dominates FIT for some reasonable parameters.

According to Jensen (2002), when the economy is subject to shocks that do not involve monetary policy trade-offs, the IT is preferable. In the absence of this, NGDP targeting may be superior because it induces inertial policy making which improves the inflation-output trade-off. He argues that the IT may be relatively less favorable, the more society dislikes inflation and the more persistent are the shocks. To the contrary, Rudebusch and Svensson (2002) show that the NGDP targeting is inefficient compared to the IT in the Euro area. In a different approach, Aoki (2001) and Kamps and Pierdzioch (2002) argue that instead of targeting overall inflation under IT, countries must use indices, such as the core inflation to prevent policy mistakes of responding to noisy shocks. This should improve the performance of the IT regime. However, the relatively small size of the core inflation component in many countries in Africa means that authorities still analyze the overall inflation and would therefore fail to circumvent this problem.

Frisch and Staudinger (2001) put forward two other arguments that justify the need for further examination of the NGDP regime vis-à-vis the IT regime. First, despite historical academic discussions, NGDP targeting has received little practical application compared to the IT. Secondly, some central banks e.g. the European Central Bank still use reference values which largely incorporate an inflation target as well as a real GDP target adjusted by the decline in the velocity of money. Besides these observations, McCallum (1997), Orphanides (1999) and Rudebusch (1999) argue that there is a tendency for economies to wrongly predict real GDP growth and inflation. This leads to unreliable forecasts which may affect policy effectiveness under the IT regime which relies more on an inflation forecast. The unreliability of output gap estimates is also underscored by Orphanides and van Norden (2002). The challenge to precisely measure these variables is more pronounced in African countries than in advanced economies.

Clearly, there is little consensus in literature on the performance of the IT and NGDP targeting regimes. The performance of each regime seems to depend on a lot of factors. These factors include the level of inflation aversion by authorities, prevailing shocks and the level of their persistence, the definition of the inflation target and also whether monetary policy is implemented under discretion or commitment. Since countries face different shocks with different intensities and have different levels of inflation aversion, it follows that the choice of a particular monetary policy regime requires country-specific analysis. Furthermore, the majority of the studies are on AEs. The IMF AREAER (2016) places three of the countries in our sample, namely Zambia, Egypt and Kenya as pursuing "Other" policy frameworks. They have been described as putting in place necessary steps for the adoption of Inflation targeting. Together with South Africa, Ghana and Uganda, this brings "IT" countries to 6 in our sample. This trend raises a compelling case for this study.

4.3 The model

We specify a DSGE model which features real money balances as non-separable from consumption in the utility function. Canova and Menz (2011) argue that the effect that real balances have on the marginal rate of substitution between consumption and leisure and hence the real wage can result in a non-trivial role of money in macroeconomic dynamics. Changes in the real wage do affect marginal costs and hence may have impact on aggregate demand and supply. Furthermore, Benchimol and FourÇans (2012) argue that higher risk aversion which is prevalent in the majority of African economies can lead to a significant role of money in output dynamics. To capture this role, we specify a model similar to Castelnouvo (2012) and Andrés et al. (2009) where money is non-separable from consumption.

All the derivations of the model, except the monetary policy rules, are presented in the Appendix to Chapters 3 and 4. The model used here is the one derived and discussed in Chapter 2. In Table 15, we reproduce the equation and briefly explain them in subsequent subsection. The model is composed of the aggregate demand equation (IS curve), the aggregate supply equation (Phillips curve), the money market dynamics (LM curve) and the exchange rate equation. Consistent with the objectives of this paper, the detailed derivations of the monetary policy reaction functions are presented in subsection 4.3.5.

Table 15: The reduced form New Keynesian DSGE model

$$
\begin{aligned}
\hat{y}_t &= \varphi_1 E_t\hat{y}_{t+1} + \varphi_2\hat{y}_{t-1} - \varphi_3(\hat{r}_t - E_t\hat{\pi}_{t+1}) + \varphi_4\left(\hat{m}_t - E_t\hat{m}_{t+1}\right) \\
&\quad + \varphi_5\left(\hat{q}_t - E_t\hat{q}_{t+1}\right) + \varphi_6\hat{q}_{t+1} + \varphi_7\hat{q}_t - \varphi_8\hat{q}_{t-1} + \varphi_9 E_t\hat{y}^f_{t+1} \\
&\quad + \varphi_{10}\hat{y}^f_t - \varphi_{11}\hat{y}^f_{t-1} + \varepsilon_{yt}, \qquad (4.01) \\
\hat{\pi}_t &= \psi_f E_t\hat{\pi}_{t+1} + \psi_b\hat{\pi}_{t-1} + \psi_1\hat{y}_t + \psi_2 E_t\hat{y}_{t+1} + \psi_3\hat{y}_{t-1} + \psi_4\hat{q}_t \\
&\quad + \psi_5 E_t\hat{q}_{t+1} - \psi_6\hat{q}_{t-1} + \psi_7\hat{m}_t + \psi_8 E_t\hat{y}^f_{t+1} - \psi_9\hat{y}^f_{t-1} \\
&\quad + \psi_{10}\hat{p}_{it} + \varepsilon_{\pi t}, \qquad (4.02) \\
\hat{m}_t &= \varpi_1\hat{y}_t + \varpi_2\hat{y}_{t-1} - \varpi_3(\hat{r}_t - \hat{\pi}_{t+1}) + \varpi_4\hat{\pi}_{t+1} + \varpi_5\hat{q}_t + \varpi_6\hat{q}_{t-1} \\
&\quad + \varpi_7\hat{y}^f_t - \varpi_8\hat{y}^f_{t-1} + \varepsilon_{mdt} \text{ or} \qquad (4.03) \\
\hat{r}_t &= \beta_1\hat{y}_t + \beta_2\hat{y}_{t-1} - \beta_3\hat{m}_t - \beta_4\hat{\pi}_{t+1} + \beta_5\hat{q}_t + \beta_6\hat{q}_{t-1} + \beta_7\hat{y}^f_t \\
&\quad - \beta_8\hat{y}^f_{t-1} + \varepsilon_{rdt}, \qquad (4.04) \\
E_t\Delta\hat{q}_{t+1} &= -\left[(\hat{r}_t - \hat{\pi}_{t+1}) - (\hat{r}^f_t - \hat{\pi}^f_{t+1})\right] + \varepsilon_{qt}. \qquad (4.05)
\end{aligned}
$$

$\hat{y}_t$ = output gap, $\hat{r}_t$ = three months treasury bill rate, $\hat{\pi}_t$ = domestic inflation, $\hat{\pi}^f_t$ = US inflation, $\hat{p}_{it}$ = crude oil price, $\hat{q}_t$ = real exchange rate, $\hat{y}^f_t$ = foreign output, $\hat{r}^f_t$ = LIBOR rate. $\varsigma_t = \rho_\varsigma\varsigma_{t-1} + \upsilon_{\varsigma t}$ and $\vartheta_t = \rho_{\vartheta t}\vartheta_{t-1} + \mu_t$, where $\varsigma_t = \left(\hat{y}^f_t, \hat{r}^f_t, \hat{\pi}^f_t, p\hat{i}t\right)$, and $\vartheta_t = (\varepsilon_{yt}, \varepsilon_{\pi t}, \varepsilon_{mdt}, \ \varepsilon_{rdt}, \varepsilon_{qt}, \varepsilon_{rt}, \varepsilon_{mt},)$. Furthermore, $\upsilon_{\varsigma t} \sim N(0, \sigma^2_\varsigma)$ and $\mu_{\vartheta t} \sim N(0, \sigma^2_\vartheta)$.

4.3.1 Aggregate demand

The aggregate demand (IS) dynamics described by eq.(4.01) arise from households' desire to maximize utility subject to a constrained budget. The IS equation features lead $\hat{y}_{t+1}$ and lagged $\hat{y}_{t-1}$ output variables which affect output positively due to rational expectations and habit formation (see Smets and Wouters 2003). The term $(\hat{r}_t - E_t\hat{\pi}_{t+1})$ represents real interest rate and is negatively related to output. Similar to Ireland (2004) and Zanetti (2012), eq.(4.01) also features real money balances $\hat{m}_t$ which are positively related to output.

The IS equation also features the real exchange $\hat{q}_t$. According to Senbeta (2011), the bulk of Africa's consumption are imports. This makes the exchange rate a key variable in macroeconomic dynamics. Following other studies, e.g. Wollmershäuser (2006), we allow the exchange rate to affect the output dynamics in levels and changes. The equation also features the foreign output $\hat{y}_t^f$ variable which may affect domestic output through foreign direct investments, foreign aid and trade. Similar to Ireland (2004), we include an aggregate demand shock ε_{yt} which follows an AR(1) process.

4.3.2 Aggregate supply

Eq.(4.02) is a hybrid Phillips curve based on Gali and Gertler (1999), Baltini et al. (2005) and Malikane (2014). Parameters ψ_f and ψ_b capture the degree of forward and backward looking price setting, respectively (see Gali and Gertler 1999). Inflation is also positively affected by the output gap at various lags. Consistent with Senbeta (2011), supply dynamics are also driven by the real exchange rate $\hat{q}_t$ since most inputs are imported. The presence of real money balances $\hat{m}_t$ may reduce firms' costs associated with searching for alternative financing to procure inputs. Castelnouvo (2012) argues that real balances may also act as a forcing variable capturing demand push on prices. Money may also affect household labour supply decisions and hence the real wage, due to the non-separability assumption, generating a positive link with inflation. The Phillips curve also exhibits input prices $\hat{p}_{it}$. Recent studies, e.g. Malikane (2014), show that including input prices generates a theoretically consistent response of inflation to the output gap. The term $\varepsilon_{\pi t}$ may capture technology or cost push factors and is assumed to follow an AR(1) process

$\varepsilon_{\pi t} = \rho_\pi \varepsilon_{\pi t-1} + \upsilon_{\pi t}$, where $\upsilon_{\pi t} \sim N(0, \sigma_\pi^2)\upsilon_{\pi t}$ is the aggregate supply shock. According to Clarida et al. (2001), such a shock may arise from stochastic wage mark-up in imperfect labour markets.

4.3.3 Money market dynamics

Eq.(4.03) describes money demand dynamics. Money demand is positively related to current income $\hat{y}_t$. Due to habit formation, eq.(4.03) also features lagged income $\hat{y}_{t-1}$.The term $(\hat{r}_t - \hat{\pi}_{t+1})$ captures the opportunity cost of holding money. The derivations also lead to the inclusion of the real exchange rate in contemporaneous and lagged forms $\hat{q}_t$ and $\hat{q}_{t-1}$ which may affect demand for money positively through several channels, like domestic consumption of imported goods. The foreign output $\hat{y}_t^f$ also affect demand for money positively through its impact on domestic income. The equation also exhibits a money demand shock ε_{mdt} which is assumed to follows AR(1) process. Eq.(4.04) is a corollary of eq.(4.03).

4.3.4 Exchange rate determination

Eq.(4.05) describes the exchange rate behaviour in terms of the Uncovered Interest rate Parity (UIP) condition. The UIP describes the real exchange rate dynamics as a function of real interest rate differentials between domestic and foreign economies. We however extend it with the foreign exchange risk premium term ε_{qt} which captures the probable divergence of the exchange rate behavior from the parity condition (see Wollmershäuser 2006). The risk premium is also assume to follow AR(1) process. This specification is consistent with African economies, where the UIP condition remains contentious. This equation forms the basis of the majority of the recent open economy models and has been used by Coenen and Wieland (2003) and Svensson (2000).

4.3.5 Monetary policy conduct

The conduct of monetary policy is described by two alternatives, inflation targeting and nominal GDP targeting regimes. As opposed to policy rules which only respond to drivers of target variables, a policy regime is characterized by the inclusion of the target variable in the central bank loss function. Following Jensen (2002), monetary policy conduct is characterized by the following state independent quadratic loss function delegated by the government to the central bank:

$$L_t = E_t \sum_{j=0}^{\infty} \beta^j \frac{1}{2} \left(\phi_\pi \hat{\pi}_{t+j}^2 + \phi_y \hat{y}_{t+j}^2 + \phi_n \hat{n}_{t+j}^2 \right), \tag{4.06}$$

where $\hat{n}_t = \hat{\pi}_t + \hat{y}_t - \hat{y}_{t-1}$ is the rate of nominal GDP growth relative to its real trend value. According to McCallum (2011), targeting the growth rates of NGDP instead of levels is consistent with achieving the planned policy path. Among other studies, Mitra (2003), Ball (2000) and Dennis (2001) also advocate targeting the growth in NGDP instead of levels. Parameters ϕ_π, ϕ_y and ϕ_n represent weights with which authorities penalize inflation, real GDP and nominal income deviations from their steady state.

Since monetary policy conduct is delegated by the government to the central bank, fixing the weights on the outset guards against the materialization of the McCallum (1995) critique i.e. where government revises the social loss function it delegates to the central bank. Jensen (2002) argues that a monetary institution whose characteristics are constant across business cycles is less subject to discretionary maneuvers. Mishikin (1999) further argues that transparency and accountability are crucial to constraining discretionary monetary policy so that it produces desirable long-run outcomes. In our context, fixing the weights also helps to eliminate arbitrariness in comparing the performance of the monetary policy regimes.

The regimes are implemented using the Taylor type interest rate rules. To derive these rules, we follow Rotemberg and Woodford (1997) and optimize monetary policy by minimizing eq.(4.06) subject to eq.(4.02). We get the following first order conditions for $\hat{\pi}_t$ and $\hat{y}_t$:

$$\begin{aligned} \phi_\pi \hat{\pi}_t + \phi_n \hat{n}_t + \beta \psi_b \lambda_{t+1} - \lambda_t &= 0, & (4.07) \\ \phi_y \hat{y}_t + \phi_n \hat{n}_t - \beta \phi_n \hat{n}_{t+1} + \lambda_{t+1} \beta \psi_3 + \psi_1 \lambda_t &= 0, & (4.08) \end{aligned}$$

where λ_t is the Lagrangian multiplier. Combining eqs.(4.07) and (4.08) and using the fact that $\hat{n}_t = \hat{\pi}_t + \hat{y}_t - \hat{y}_{t-1}$ yields the following optimal condition:

$$\alpha_1 \hat{\pi}_t + \alpha_2 \hat{\pi}_{t+1} + \alpha_3 \hat{\pi}_{t-1} + \alpha_4 \hat{y}_t + \alpha_5 \hat{y}_{t+1} + \alpha_6 \hat{y}_{t-1} - \alpha_7 \hat{y}_{t-2} = 0, \quad (4.09)$$

where

$$\begin{aligned} \alpha_1 &= \phi_\pi + \phi_n - \frac{\psi_1 \phi_\pi \psi_b - \phi_n \psi_b (1-\psi_1) - 1}{\psi_1 \psi_b + \psi_3}, \ \alpha_2 = \frac{\beta \psi_b \phi_n}{\psi_1 \psi_b + \psi_3} \\ \alpha_3 &= \frac{\phi_\pi \psi_1 + \phi_n (1+\psi_1)}{\psi_1 \psi_b + \psi_3}, \ \alpha_4 = \phi_n - \frac{(1 - \phi_n \psi_b (1-\psi_1)) - \psi_b (\phi_y + \beta \phi_n)}{\psi_1 \psi_b + \psi_3} \\ \alpha_5 &= \frac{\beta \psi_b \phi_n}{\psi_1 \psi_b + \psi_3}, \ \alpha_6 = \frac{\phi_n (1-\psi_1)(1-\phi_n) + \phi_y - \phi_n - 1}{\psi_1 \psi_b + \psi_3}, \\ \alpha_7 &= \frac{\phi_n (1-\psi_1)}{\beta \left(\psi_1 \psi_b + \psi_3\right)}. \end{aligned}$$

In eq.(4.09), pushing the output gap terms to the right shows a trade-off that results from a disinflation process. In order to deal with inflation, authorities would raise the interest rates which will negatively affect output. The equation describes optimal dynamics where monetary policy conduct is guided by concerns to stabilize inflation, real GDP and nominal income. Combining eq.(4.01) with eq.(4.09) yields the following:

$$\begin{aligned}\hat{r}_t &= \vartheta_1\hat{y}_{t+1} + \vartheta_2\hat{y}_{t-1} - \vartheta_3\hat{y}_{t-2} + \vartheta_4\hat{\pi}_t + \vartheta_5\hat{\pi}_{t+1} + \vartheta_6\hat{\pi}_{t-1} + \vartheta_7(\hat{m}_t - \hat{m}_{t+1}) \\ &\quad +\vartheta_8(\hat{q}_t - \hat{q}_{t+1}) + \vartheta_9\hat{q}_{t+1} + \vartheta_{10}\hat{q}_t - \vartheta_{11}\hat{q}_{t-1} + \vartheta_{12}\hat{y}^f_{t+1} \\ &\quad +\vartheta_{13}\hat{y}^f_t - \vartheta_{14}\hat{y}^f_{t-1} + \varepsilon_{rt}, \end{aligned} \tag{4.10}$$

where

$$\begin{aligned}\vartheta_1 &= \left(\frac{\varphi_1\alpha_4 + \alpha_5}{\alpha_4\varphi_3}\right),\ \vartheta_2 = \left(\frac{\varphi_2\alpha_4 + \alpha_6}{\alpha_4\varphi_3}\right), \\ \vartheta_3 &= \left(\frac{\alpha_7}{\alpha_4\varphi_3}\right),\ \vartheta_4 = \left(\frac{\alpha_1}{\alpha_4\varphi_3}\right),\ \vartheta_5 = \left(1 + \frac{\alpha_2}{\alpha_4\varphi_3}\right), \\ \vartheta_6 &= \frac{\alpha_3}{\alpha_4\varphi_3},\ \vartheta_7 = \frac{\varphi_4}{\varphi_3},\ \vartheta_8 = \frac{\varphi_5}{\varphi_3},\ \vartheta_9 = \frac{\varphi_6}{\varphi_3}, \\ \vartheta_{10} &= \frac{\varphi_7}{\varphi_3},\ \vartheta_{11} = \frac{\varphi_8}{\varphi_3},\ \vartheta_{12} = \frac{\varphi_9}{\varphi_3},\ \vartheta_{13} = \frac{\varphi_{10}}{\varphi_3},\ \vartheta_{14} = \frac{\varphi_{11}}{\varphi_3}.\end{aligned}$$

Eq.(4.10) is a general Taylor-type interest rate rule and its dynamics are similar to eq. (2.49). In the spirit of the New Keynesian models and also in-line with the current wave of policy conduct sweeping across Africa, we compare the regimes using the interest rate rule. The distinction in the policy regimes is based on the configuration of the weights ϕ_π, ϕ_y and ϕ_n that characterize authorities' aversion towards inflation, output, and nominal GDP fluctuations, respectively. We are interested in assessing the performance of five different monetary policy regimes arising from the general specification in eq. (4.10). These policy regimes are presented in Table 16.

First, is the hybrid policy regime described by Model 1. As shown by Jensen (2002), in Model 1 authorities are required to balance the volatility of inflation, output and nominal income growth. Examination of this case serves to complement the comparison of flexible versions of the IT and NGDPT regimes because it provides information on how strong an emphasis on either variable should achieve if a combination regime is feasible. As can be shown from eq. (4.10), ϕ_n enters positively in all parameters describing the policy rule. This serves to capture the fact that in order to respond to nominal income, the parameters of the policy rule must now be adjusted by ϕ_n. For example, if $\phi_n = 0$, the coefficient ϑ_5 which capture the response of monetary policy to inflation expectations collapses to a value of 1 but if nominal income fluctuations matter, this parameter will be influenced by estimates from the Phillips curve and also the discount factor β. Eq.(4.10) shows that by including nominal income targeting, the interest rate response to expected income, lagged income, current inflation, expected inflation and lagged inflation measured by parameters $\vartheta_1, \vartheta_2, \vartheta_3, \vartheta_4$ and ϑ_5 are adjusted accordingly by the weight that authorities put on nominal income fluctuations..

Similarly, Model 2 captures strict inflation targeting. In this framework, authorities do not pay attention to nominal income and real GDP developments. Therefore , $\phi_y = 0$ and $\phi_n = 0$ but $\phi_\pi > 0$. The authorities are only concerned with the deviations of inflation from the target or steady state. This makes the real GDP and nominal GDP terms to disappear from the authorities' loss function. Jensen (2002) refers to this case as pure discretion, where authorities share society's loss function. It corresponds to a case where a benevolent government conducts discretionary policy by itself. Frisch and Staudier (2003) argues that by design, under strict inflation targeting a supply shock is prevented from affecting inflation while demand contraction reaches its maximum value since the weight on output in the loss function is negligible. The higher the weight on output, the more inflation economic agents expect in future. When the weight is zero, private agents expect sufficient contraction in demand due to a big rise in interest rates.

Model 3 describes Flexible Inflation Targeting framework (see Svensson (1999). In this framework, $\phi_n = 0$ but $\phi_y > 0$ and $\phi_\pi > 0$. This implies that the central is concerned with controlling inflation but not at the expense of real GDP. This case is more consistent with current practice of monetary policy by central banks (see King 1997). Authorities will normally pay some attention to real sector developments as they decide on the course of monetary policy direction that is consistent with inflation objective. Even when both ϕ_y and ϕ_π are greater than zero, authorities may still choose to be more conservative (Hawkish) by setting $\phi_\pi > \phi_y$. This case relates to a scenario where authorities put more weight on stabilizing inflation than real GDP (see Rogoff 1985). By setting $\phi_n = 0$ in the objective function, authorities do not consider nominal GDP developments when setting direction of monetary policy.

Model 4 represents strict nominal GDP where authorities disregard developments in inflation and real GDP but are only concerned with stabilizing nominal GDP. In this framework $\phi_\pi = 0$ and $\phi_y = 0$ making the real GDP and inflation terms disappear from the authorities' loss function. However, Jensen (2002) argues that there is no need for authorities to disregard real GDP just like they do not do so under flexible inflation targeting. He therefore suggest a fifth case which is captured under Model 5 as Flexible nominal GDP. Under this framework, $\phi_\pi = 0$ and hence the inflation objective disappears from the authorities' loss function but $\phi_y > 0$ and $\phi_n > 0$ implying that authorities still pay attention to real GDP developments as they target nominal income.

All policy frameworks exploit cross-equation restrictions in order to constrain

Table 16: Configuration of policy regimes based on the loss function

	Model	Weights		
		ϕ_π	ϕ_y	ϕ_n
1.	Hybrid regime	>0	>0	>0
2.	Strict inflation targeting	>0	$=0$	$=0$
3.	Flexible inflation targeting	>0	>0	$=0$
4.	Strict NGDP targeting	$=0$	$=0$	>0
5.	Flexible NGDP targeting	$=0$	>0	>0

the behavior of the target variables to be consistent with the policymaker's macroeconomic trajectory.

4.4 Data, calibration and simulation

4.4.1 Data and simulation

The data used is obtained from the International Financial Statistics of the International Monetary Fund and is described in Table 17. The sample periods used differ from country to country due to data availability as follows: South Africa, Ghana, Uganda, Malawi and Egypt: 1990-2014; Tanzania and Zambia:1993-2014; Morocco:1995 to 2014; Nigeria:1995-2014; Kenya: 1993-2014. Where quarterly GDP is not available, e.g. Malawi, Tanzania, Zambia, Egypt and Uganda, we interpolate.

We follow Zanetti (2012) and simulate a reduced form model using the Maximum Likelihood Estimation (MLE) method. This is consistent with answering policy questions rather than recovering the underlying parameters. According to Hansen and Sargent (2007), the MLE is consistent and asymptotically efficient in DSGE models. As in Ireland (2004), we add error terms

Table 17: Data description

Inflation	Calculated as a log difference of the CPI between one quarter and the same quarter of the previous year
Real balances	Calculated as the log difference between of the money supply and the CPI
Output gap	Calculated as the difference between the log of real GDP and its trend
Real exchange rate	Calculated as the sum of the logs of the nominal bilateral US dollar exchange rate and the US CPI less the log of the domestic CPI
Foreign interest rate	Proxied by the three months London Interbank Offer Rate
Foreign output	Proxied by the US real GDP
Foreign inflation	Proxied by US inflation
Raw material price	Proxied by Brent crude oil price
Policy rate	Proxied by three months Treasury bill rate

to the observation equations in order to limit the effects of misspecification and to deal with identification issues. The possibility of misspecification abounds since the application of DSGE models in African economies remains a relatively new area of research. We use output, inflation and real balances as our observable variables. In our model, we assume the following exogenous stochastic processes also drive macroeconomic dynamics: $\varsigma_t = \rho_\varsigma \varsigma_{t-1} + \upsilon_{\varsigma t}$ where $\varsigma_t = \left(\hat{y}_t^f, \hat{r}_t^f, \hat{\pi}_t^f, \widehat{oilp_t}\right)$ and $\upsilon_{\varsigma t} \sim N(0, \sigma_\varsigma^2)$. The estimable system is composed of eqs. 4.01, 4.02, 4.03, 4.05, and 4.10.

4.4.2 Calibration

During simulations, we mostly use the estimated parameters which are presented in Tables 21 to Table 23. These parameters together with parameters ρ_o, ρ_{rf}, ρ_{yf}, and ρ_{ff} which measure persistence of AR(1) exogenous processes are presented in the Appendix to Chapters 3 and 4. One key challenge is the choice of weight θ_π, θ_y and θ_n characterizing the central bank loss function. There are several approaches in literature. First, they can be derived from micro-foundations based on utility function of the households. However, Woodford (2003) shows that when this approach is followed, θ_π is frequently found to be abnormally huge. This implies an extremely inflation averse policy which is contrary to what is observed in practice. Due to this problem, Chen et al. (2014) argue that estimation and calibration of these parameters have become natural alternatives. Calibration is more appealing because the conservatism of the central bank may differ from that of the representative households.

In line with this, Rotemberg and Woodford (1997) set $\theta_y = 0.5$ while Jensen (2002) set $\theta_y = 0.25$. Broadbent and Barro (1997) set $\theta_y = 0.33$. Garin et al. (2015) set $\theta_n = 0.037$. Other studies use the grid search to find weights that optimize the loss function. For example, Jensen (2002) uses a grid search and finds that $\theta_n = 1.2$ is consistent with minimizing the loss function. The grid search however also relies on initial calibration to define the grid range and setting of the grid steps may be considered adhoc. In our study, we follow Chen et al. (2014) and calibrate parameters of the loss function. When the weight on nominal income is positive, we follow Jensen (2002) and set $\theta_n = 1.2$. Similar to Ghosh et al. (2015), we set $\theta_\pi = 1$. Furthermore, in line with Taylor's (1993) proposal and other studies, e.g. Leitemo and Söderström (2005), we calibrate the output smoothing parameter at $\theta_y = 0.5$. The calibration of the discount factor follows standard practice in literature i.e. $\beta = 0.99$.

Jensen (2002) and Rudebusch and Svensson (2002) apply 0.01 standard deviation shocks to demand and supply and observe macroeconomic performance under alternative regimes. We build on these studies by including an exchange rate shock. We do this to capture the vulnerability of African economies to terms of trade shocks. For each country, we identify dominant shocks and proceed to find a policy regimes that i) minimizes fluctuations of GDP and Inflation around the steady state and ii) restores these macroeconomic variables back to steady state in a relatively short period of time after each of the three shocks.

4.5 Results

4.5.1 Historical decomposition

The dominant shocks are obtained by analysing historical decomposition of inflation and output. Thus the historical decompositions presented in Figs. 11 and 12 explain the dominant shocks driving inflation and output fluctuations, respectively, in the selected countries. The black line depicts the deviation of the smoothed values of inflation and output at the calibrated parameter values. The colored bars correspond to the contribution of the respective smoothed shocks to the deviation of inflation and output from their steady state. Initial values refer to the part of the deviations from steady state that are not explained by the smoothed shocks but rather by the unknown initial value of the state variables. The influence of the starting values usually dies out relatively quickly.

Inflation decomposition The decompositions of inflation for each of the 10 selected countries are presented in Fig. 11. The decomposition shows that in Zambia, demand shocks are a dominant driver of inflation fluctuations followed by foreign output shocks while in Uganda, the dominant driver of inflation fluctuations are demand shocks followed by supply and exchange rate shocks. Similarly, in Ghana, demand shocks dominate followed by supply shocks while in Egypt, inflation fluctuations are mostly driven by demand shocks followed by foreign output shocks. In Malawi, demand shocks are lead drivers of inflation fluctuations followed by exchange rate, foreign output and oil price shocks in that order. In Tanzania, we find that demand and foreign output shocks explain the bulk of inflation fluctuations. Similarly, in Kenya it is the demand shocks which are lead drivers of inflation fluctuations but are closely trailed by the supply shocks while in South Africa, demand and exchange rate shocks are key drivers of inflation fluctuations. In Nigeria, it is the demand shocks which contribute more significantly to inflation fluctuations followed by supply and crude oil price shocks. We also find that the demand shocks dominate as the main driver of inflation fluctuations in Morocco followed by supply shocks.

Overall, the results show that in all the countries demand shocks explain the bulk of inflation fluctuations. In most cases, they are followed by supply and exchange rate shocks. Several channels in Africa can result in demand factors driving inflation dynamics. First is through the link between commodity prices and government spending. Commodity prices rose from 2006 but started reversing in 2008. The trend in commodity prices has since then remained volatile. Fluctuations in global oil, tobacco, copper, gold and tea prices directly translate into fluctuations in import and export duties resulting in significant swings in consumer as well as government spending patterns. In some countries like Nigeria fiscal spending heavily relies on fuel proceeds. The fluctuations in fiscal spending act as shocks which directly affect aggregate demand and inflation.

Second is through the foreign aid channel. Aid inflows to Africa contribute significantly to total government expenditure. For example until recently, around 40 percent of the budget in Malawi was traditionally financed by donors. Volatility in aid therefore directly affects governments' resource envelopes and translates into fluctuations in aggregate expenditure and inflation. Furthermore fluctuations in terms of trade arising from commodity price changes together with volatile aid have direct effect on the exchange rate behaviour in commodity and aid dependent countries. Due to high pass-through of the exchange rate to inflation, fluctuations in aid and commodity prices directly translate into inflation fluctuations. Thirdly, some countries such as Ghana, Kenya, Uganda and Zambia have relatively higher base for demand. Autonomous changes in demand therefore directly affect inflation fluctuations.

The significance of supply shocks is equally not surprising considering the dependence of African countries on agriculture. Weather-dependent agricultural production implies that when there is surplus production due to good weather inflation will tend to improve while during lean periods inflation will tend to go up thereby increasing the volatility of inflation. IMF (2011) shows that the probability of supply shocks is higher in Africa which also suggest that the contribution of supply shocks to inflation fluctuations will likely be higher. In the majority of countries, such as Malawi which have high value addition from agriculture ranging from 30 to 40 percent of GDP, the response of inflation to one standard deviation shock to domestic supply therefore tends to be relatively higher. These findings are consistent with Nguyen et al. (2017) who show that demand and supply shocks account for 55 percent and 45 percent, respectively, of inflation fluctuations in Africa.

Output decomposition

Fig. 12, shows the historical decomposition of output for all the selected countries. It can be observed that in Zambia output fluctuations are mostly driven by demand shocks followed by exchange rate shocks while in Uganda, it is the demand shocks that explain the largest portion of output variation followed by the exchange rate and money demand shocks. Similarly, in Ghana and Tanzania, demand, exchange rate and supply factors have historically been major drivers of output fluctuations. In Malawi and Nigeria, apart from demand, exchange rate and oil price shocks are also major factors which explain output fluctuations. In Egypt, the exchange rate and supply shocks are key drivers of output fluctuations. In Kenya, we identify demand and monetary policy shocks as significant contributors to output volatility. In South Africa, demand shocks dominate followed by exchange rate shocks while in Morocco demand shocks are a major determinant of output fluctuations.

Similar to inflation, demand shocks are found to be key drivers of output fluctuations in Africa followed by exchange rate and supply shocks. Demand shocks may arise from donor inflows which if spent by government, significantly contribute to aggregate demand fluctuations. The other source of demand fluctuations are fiscal borrowings which persistently inject liquidity in the economies. Furthermore, in countries like Nigeria, where oil proceeds contribute significantly to government revenue, the fluctuations in global prices directly result in fluctuations in domestic aggregate demand (see Addison and Ghoshray 2013 and Rasaki and Malikane 2014). In the other countries, this effect comes via the impact that commodity prices have on import and export duties. Fluctuations in commodity prices affect consumers via changes in their export proceeds and import costs. They also affect governments spending patterns via changes in tax revenues. These changes generate flcutuations in aggregate demand.

In terms of exchange rate shocks, trade and financial linkages have increased substantially since the 1990s when African countries embarked on structural adjustment programmes which included financial sector liberalization and political democratization. These features have somehow assisted to open African countries to the rest of the world. Although the level of openness remains low, it has assisted to boost trade and foreign direct investment while also exposing African countries to commodity price and terms of trade shocks. The openness therefore has increased the prominence of the exchange rate in influencing output dynamics in African countries (see Raddatz 2008), making the exchange rate a significant driver of inflation and output fluctuations.

These results have several policy implications in African countries. First, the dominance of demand shocks implies that demand management policies are key in dealing with macroeconomic fluctuations in Africa. The results therefore support the current trend where the majority of African countries are seeking support from international partners, such as the IMF, to upgrade their monetary policy frameworks to inflation targeting. According to Frankel (2014), the IT is superior in handling aggregate demand shocks. The growing role of demand in driving inflation and output dynamics, therefore, calls for a rather active role for monetary policy as an aggregate demand management tool. Caution must however be exercised since the huge part of aggregate demand fluctuations may arise from fiscal behavior and agriculture production rather than households and firms.

Secondly, dealing with demand shocks alone is not sufficient to stabilize African economies because supply and exchange rate shocks closely trail demand shocks in explaining macroeconomic fluctuations. The effectiveness and sustainability of the demand management policies will depend on implementation of sound policies that mitigate the impact of supply and exchange rate shocks. These findings therefore bring to the fore the problem of choosing a single suitable policy framework to deal with diverse shocks in African context. The more diverse the shocks affecting a particular economy, as is the case with Malawi, the more complex the macroeconomic management process because a single policy instrument tends to generate pay-off trade offs.

In line with the proposition by IMF (2015), these findings dispel a long-standing perception among policymakers in Africa that supply side factors, particularly global commodity prices and domestic weather-related and sometimes political shocks are the main drivers of inflation. However, our results suggests that the sources of aggregate demand fluctuations must be carefully considered in designing monetary policy. Tightening monetary policy is consistent with dealing with inflationary threats if sources of aggregate demand pressure are consumption and investment which according to the conventional transmission channels will decline when monetary policy is tightened. However, in African countries, imbalances may also arise from government expenditure, weather shocks and trade imbalances.

In such cases, instead of using monetary policy, a review of the fiscal policy might restore external competitiveness. Again, diversification from weather-dependent agricultural production is necessary to reduce macroeconomic fluctuations. Similarly, a review of the exchange rate policy might correct the trade imbalance. This implies that it is not always when actual output is above target that tightening monetary policy would be an effective resort. We, however, underscore the fact that the prevalence of supply shocks does not necessarily invalidate the stabilization role of monetary policy in the medium term. Rather it does imply a limited role for monetary policy.

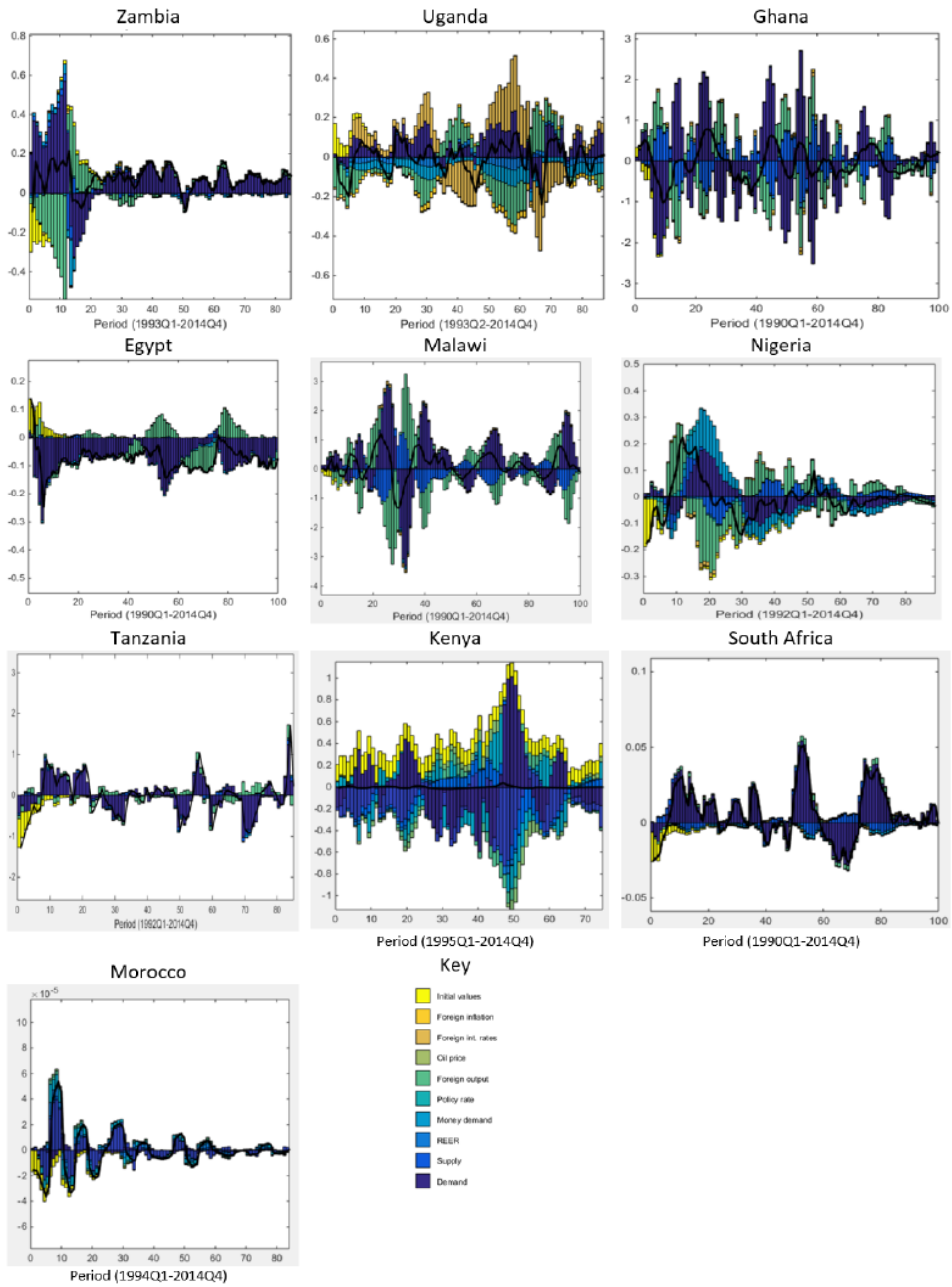


Figure 11: Historical decomposition of inflation

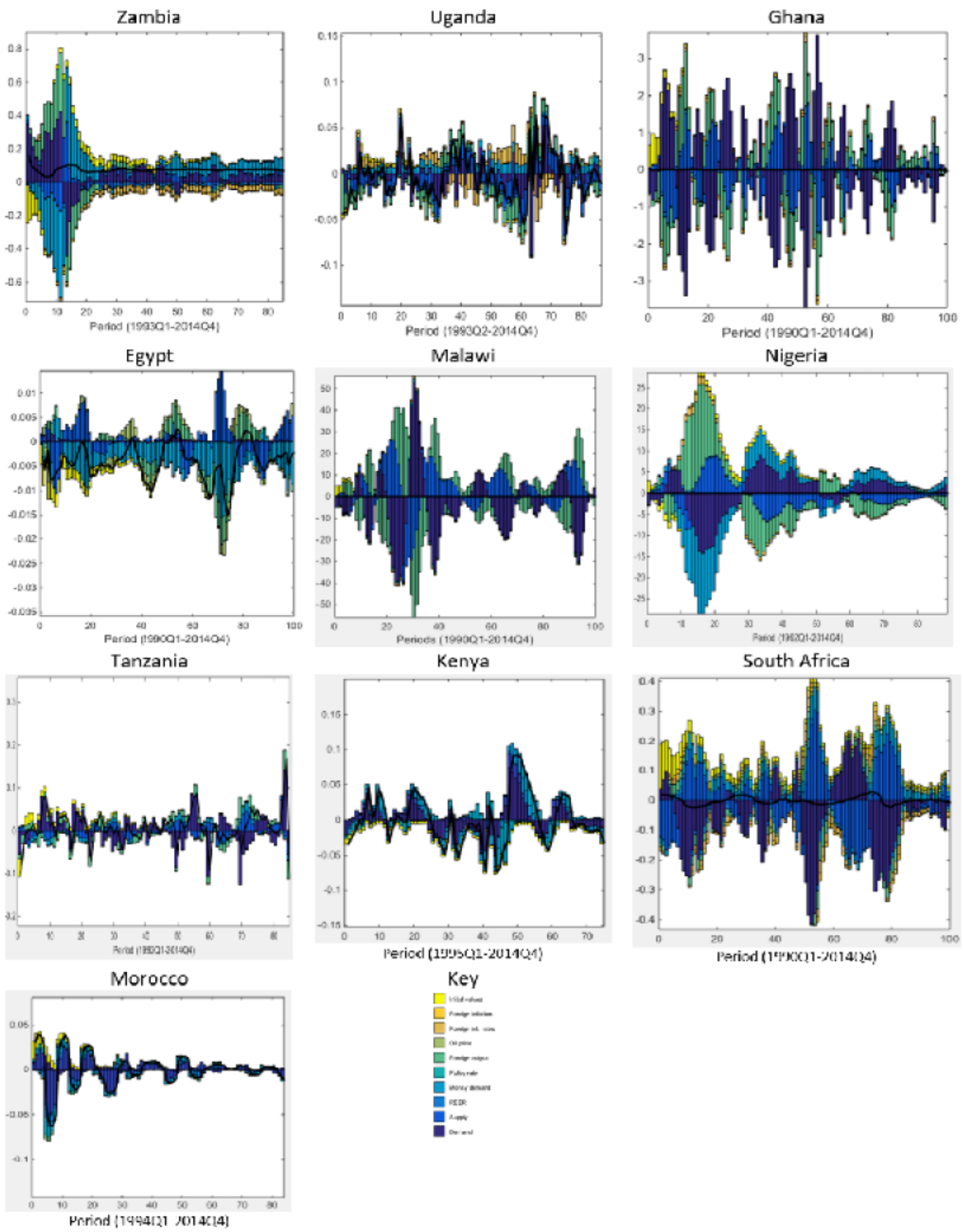


Figure 12: Historical decomposition of output

4.5.2 Impulse responses

The impulse response functions (IRFs) of inflation and output to demand, supply and exchange rate shocks under different monetary policy regimes are presented in Figs. 13-18. Fig. 13 shows impulse responses of inflation to a supply shock. The IRFs are theoretically consistent in all countries. A supply shock in form of a cost push generates a rise in inflation under all regimes. The amplitude of the shock however varies under different monetary policy regimes. On aggregate, the majority of the economies revert to steady state earlier under the hybrid policy regime compared to other regimes.

Fig. 14 presents the response of inflation to a demand shock under various monetary policy frameworks. Consistent with standard economic theory, in 5 countries, namely Zambia, Uganda, Egypt, Tanzania and South Africa, a positive demand shock generates inflationary pressures under all monetary policy regimes. The industrial classification of these countries shows that the agriculture sector is relatively small, suggesting that agricultural contribution to output fluctuations is also less. This implies that these countries have a relatively large demand base. Due to this, output behaviour conforms to the standard New Keynesian theory where aggregate demand is a sole proxy for real marginal costs such that when it goes up inflation also rises (see Gali and Gertler 1999). In the other countries, a rise in output leads to lower inflation. This contradicts the standard New Keynesian theory. This finding, however, reflects the dominance of agriculture as well as the relatively large weight of food in the consumer price index (near 50 percent of the CPI is from food in these countries). Given this setup, an increase in food production positively contributes to output. However, it also forces the price of food items down. This generates downward pressure on overall inflation (see Berg et al. 2006).

Fig. 15 shows impulse responses of inflation to exchange rate shocks. In all countries, exchange rate depreciation is found to be inflationary. As shown by Senbeta (2011), Africa's production and consumption patterns are largely based on imports. Furthermore, Senhadji (1997) shows that Africa has inelastic demand for imports. When the exchange rate depreciates, the price of imports goes up. Given inelastic demand for imports, the depreciation in the exchange rate directly translates into high prices of imported goods. This generates a positive link between the exchange rate and inflation.

Fig.16, shows the impulse responses of output to a supply shock. Output contracts in all countries following a negative supply shock. This result, which is standard in economic theory, is also found by Alpanda et al. (2010). A positive innovation in the price cost-push poses a policy trade-off for the authorities. Since a cost push raises real marginal costs, it translates into a rise in inflation. At the same time a rise in cost of inputs depresses production thereby reducing output. In some countries, such as South Africa and Morocco, the behavior of the impulse responses for the different frameworks is such that the differences are minimal and may not be discernible graphically (see Tables 18 and 19).

Fig. 17 shows the impulse responses of output to a demand shock. These IRFs are all theoretically consistent. A rise in aggregate demand raises output. However, there are some marked differences on how different monetary policy regimes respond. Inflation targeting stabilizes output relatively fast compared to other regimes. Fig. 18 shows the response of output to a positive shock to the exchange rate. It shows that depreciations are contractionary in 5 countries, namely Malawi, Zambia, Ghana, Kenya and Tanzania. This is consistent with findings by Bahmani-Oskoee and Gelan (2013 who show that depreciations are mostly contractionary in Africa. This result can partly be attributed to inelastic demand for imports (see Senhadji 1997). When the exchange rate depreciates, imports and exports respond sluggishly. Therefore, the trade balance worsens. Furthermore, since imports are a leakage in the national income identity, it lowers aggregate demand. Exchange rate depreciation also raises inflation which negatively affects output.

4.5.3 Optimal monetary policy regimes

Tables 18 and 19 present the variances of output and inflation under different monetary policy frameworks when the economies are faced with demand (dd), supply (ss) and exchange rate (xr) shocks. For tractability, the variances are rounded to two decimal places and scaled by (10^n). Due to this, some variances may look similar but are not necessarily the same. Table 19 lists dominant shocks to output and inflation. It also lists the regimes that generate least volatility in inflation and output under each shock. From this table, we select regimes which generate least macroeconomic volatility when the economy is faced with the dominant shocks. These regimes are presented in Table 20.

The results show that in Uganda, it is the hybrid regime which is superior in handling the dominant demand shock. In Ghana, strict inflation targeting is superior in handling demand, supply and exchange rate shocks. In Zambia, the hybrid policy regime supersedes all other regimes in handling the demand shocks. In Egypt, we find the hybrid regime to be optimal since it is capable of handling a majority of shocks that drive inflation and output fluctuations. In South Africa, strict inflation targeting is superior in handling demand shocks.

In Malawi, demand, supply and exchange rate shocks are optimally handled using the hybrid policy regime. In Nigeria, the optimal framework to deal with the dominant demand shocks is the flexible inflation targeting. In Tanzania, the hybrid framework is superior as it robust to 67 percent of the shocks driving macroeconomic fluctuations. The results also show that in Kenya, it is strict inflation targeting which is superior in handling the demand shocks. In Morocco, we find that strict inflation targeting is an optimal framework to handle both, demand shocks that generate output fluctuations as well as supply shocks that generate inflation fluctuations.

Overall, our results suggest that in 5 countries, namely Zambia, Uganda, Egypt, Tanzania and Malawi, the hybrid policy framework performs better in handling macroeconomic fluctuations. The superiority of the hybrid framework in these countries reflects the dual nature of shocks affecting African economies. Since the hybrid framework combines elements of both inflation targeting and nominal GDP, it is not surprising that we find it to be able to respond to a variety of shocks. Jensen (2002) however suggests that to operationalise the hybrid regime, a relatively small weight must be put on the inflation target compared to the real GDP and NGDP targets in the loss function. However, when this happens then authorities are sliding more towards NGDP targeting regime. Put differently, sliding more toward nominal GDP targeting regime will generate nearly similar results with the hybrid regime. This partly explains the small differences in estimated variances under the hybrid and NGDP targeting regime.

In 4 countries, name South Africa, Ghana, Kenya and Morocco, it is the strict inflation targeting regime that performs better. The response of inflation to current output is relatively high in these countries. In South Africa, it is the lagged output that carries a relatively high value. Jensen (2002) shows that under such circumstances, inflation targeting will be inferior to nominal GDP targeting because NGDP targeting induces inertia in policy making. When inflation is very sensitive to output gap measures, technological shocks play a much more prominent role in inflation determination. Changes in the output gap become very powerful in stabilizing inflation which in turn reduces the importance of inflation expectations as a stabilizing device. This suggests that there exists some level of sensitivity of inflation to aggregate demand beyond which strict IT will be preferable to NGDP targeting. Jensen (2002) suggests a value of 0.4. The majority of the parameters in these countries are way above this value (see Table 22).

The dominance of SIT also reflects the fact that these countries have relatively small share of food inflation in the overall Consumer Price Index. This together with a comparatively large demand base provides fertile ground for the success of inflation targeting. Due to these factors, strict inflation targeting does not generate a policy trade off which normally arises when output is mostly driven by agriculture. The authorities' reaction to inflation is also relatively stronger in these countries. This suggests that the actual weight that authorities place on inflation stabilization is comparatively high than other countries (see Table 24). According to Frankel (2014) high weight on inflation makes SIT perform better than NGDPT. This study also identifies demand and exchange rate shocks as key drivers of macroeconomic fluctuations. The dominance of demand and exchange rate shocks create a favorable ground for the success of IT regimes in these countries.

Table 18: The variance of output and inflation under different monetary policy regimes

	$Var\ (y)$						$Var\ (\pi)$					
	Shock	HY	SI	FI	SN	FN		HY	SI	FI	SN	FN
Kenya	ss ($x10^{0}$)	2.97	1.74	1.68	2.58	1.74	ss ($x10^{-2}$)	41.0	0.00	0.10	22.0	0.12
	dd ($x10^{-3}$)	1.80	0.00	8.60	1.50	8.70	dd ($x10^{-3}$)	2.00	8.00	6.00	1.00	6.00
	xr ($x10^{-5}$)	1.50	0.00	9.80	1.30	1.00	xr ($x10^{-4}$)	2.20	9.60	1.00	1.20	9.80
Mal.	ss ($x10^{-4}$)	2.25	4.18	4.48	2.27	2.27	ss ($x10^{-5}$)	0.03	970	120	0.05	0.04
	dd ($x10^{-2}$)	1.31	5.14	5.66	131.0	1.32	dd ($x10^{-3}$)	0.05	444	500	0.07	0.06
	xr ($x10^{-4}$)	2.30	4.56	5.12	2.30	2.30	xr ($x10^{-5}$)	0.01	446	508	0.02	0.02
Mor.	ss ($x10^{-5}$)	5.60	9.80	5.60	5.60	5.60	ss ($x10^{-5}$)	6.00	0.00	6.00	5.70	6.00
	dd ($x10^{-6}$)	7.00	3.00	7.00	6.00	7.00	dd ($x10^{-4}$)	1.19	0.00	1.14	1.40	1.19
	xr ($x10^{-6}$)	4.00	5.00	4.00	4.00	4.00	xr ($x10^{-6}$)	3.90	0.00	0.00	0.00	0.00
S.Afr.	ss ($x10^{-4}$)	1.67	1.94	1.90	1.69	1.69	ss ($x10^{-4}$)	0.45	0.45	0.45	0.46	0.45
	dd ($x10^{-3}$)	6.50	8.30	8.10	6.70	6.55	dd ($x10^{-3}$)	24.6	23.9	24.03	24.5	24.6
	xr ($x10^{-9}$)	6.89	9.03	8.65	7.23	7.06	xr ($x10^{-5}$)	2.80	2.70	2.70	2.80	2.80
Zam.	ss ($x10^{-5}$)	4.90	4.70	4.88	4.91	4.92	ss ($x10^{-4}$)	0.03	0.69	0.77	0.04	0.03
	dd ($x10^{-3}$)	0.25	8.18	9.93	2.71	0.26	dd ($x10^{-2}$)	0.03	11.2	51.26	0.04	0.04
	xr ($x10^{-6}$)	1.90	2.00	1.96	2.00	1.87	xr ($x10^{-6}$)	0.16	3.00	4.00	0.20	0.19

Table 19: The variance of output and inflation and optimal monetary policy regimes, cont'd

	$Var(y)$						$Var(\pi)$					
		HY	SI	FI	SN	FN		HY	SI	FI	SN	FN
Ugan.	ss (x10^{-4})	0.40	0.71	0.68	0.40	0.39	ss (x10^{-4})	0.07	6.43	6.43	0.09	0.09
	dd (x10^{-4})	0.49	7.80	7.87	0.58	0.58	dd (x10^{-2})	0.09	4.21	42.1	0.11	0.12
	xr (x10^{-5})	0.03	4.70	4.70	6.72	0.04	xr (x10^{-4})	0.16	84.73	84.7	0.67	0.67
Ghana.	ss (x10^{-4})	0.40	0.36	0.53	0.42	0.41	ss (x10^{-4})	0.16	0.00	3.33	2.60	0.21
	dd (x10^{-4})	0.48	0.39	0.74	0.51	0.50	dd (x10^{-3})	0.03	0.00	0.98	0.04	0.03
	xr (x10^{-4})	0.20	0.10	0.30	0.20	0.20	xr (x10^{-4})	5.06	0.00	0.48	0.01	0.01
Nig.	ss (x10^{-3})	3.39	3.45	3.53	3.45	3.40	ss (x10^{-7})	3.23	2.14	0.07	2.78	4.19
	dd (x10^{-3})	7.30	7.30	1.49	7.32	7.30	dd (x10^{-6})	1.01	1.00	0.00	1.01	2.00
	xr (x10^{-3})	8.60	8.60	8.56	8.60	8.60	dd (x10^{-9})	7.92	5.32	2.00	6.89	10.0
Tanz.	ss (x10^{-4})	1.13	1.16	1.14	9.90	1.00	ss (x10^{-7})	3.23	2.14	0.07	2.78	4.19
	dd (x10^{-4})	1.06	1.05	1.06	3.44	3.46	dd (x10^{-6})	1.01	1.00	0.00	1.01	2.00
	xr (x10^{-4})	1.00	5.04	5.01	2.60	2.70	xr (x10^{-9})	7.92	5.32	2.00	6.89	10.0
Egy	ss (x10^{-4})	0.55	0.05	0.05	0.47	0.47	ss (x10^{-3})	0.05	1.50	1.49	3.26	3.26
	dd (x10^{-3})	0.00	2.10	2.10	4.75	4.49	dd (x10^{-1})	0.10	4.29	1.29	9.53	9.52
	xr (x10^{-6})	1.13	7.06	7.06	5.01	5.04	xr (x10^{-6})	7.67	2.90	3.00	6.00	6.00

HY: Hybrid, SI: Strict inflation, FI: Flexible inflation, SN: Strict nominal, FN: Flexible nominal GDP. ( ) variance scaling factors

Table 20: Optimal monetary policy regimes under dominant shocks

	Dominant Shocks		Optimal policy regime
	Inflation	Output	
Zambia	DD, FO	DD, XR	Hybrid
Uganda	DD, SS, XR	DD, XR, MD	Hybrid
Ghana	DD, XR	DD, XR	SIT
Egypt	DD, FO	XR, SS	Hybrid
South Africa	DD, XR	DD, XR	SIT
Malawi	DD, XR, FO	DD, XR, Oil	Hybrid
Nigeria	DD, SS	DD, XR, Oil	FIT
Tanzania	DD, FO	DD, XR	Hybrid
Kenya	DD	DD, MP	SIT
Morocco.	DD	DD	SIT

HY: Hybrid, SIT: Strict inflation targeting, FI: Flexible inflation,
SN: Strict nominal, FN: Flexible nominal GDP, FO: Foreign Output,
MD: Money demand, MP: Monetary policy

4.6 Conclusion

In this study, we use an open economy new-Keynesian model to examine the relative performance of inflation targeting and nominal GDP targeting as alternative monetary policy frameworks for macroeconomic stabilization in 10 selected African economies. Terms of trade and supply shocks confront policymakers with difficult choices in Africa. These shocks create a trade-off between inflation and output stabilization. African countries are particularly vulnerable given the large share of food in consumption, the exposure of the agricultural sector to weather-related shocks and the exposure to terms of trade shocks. Identifying coherent monetary policy regimes robust to these shocks is therefore of first order importance. To address this question, we use a New Keynesian model estimated using the Maximum Likelihood technique with quarterly data mostly ranging from 1990 to 2014.

We find several results. First, aggregate demand shocks are key in explaining inflation and output fluctuations in Africa. This finding is in line with Nguyen et al. (2017) who shows that 55 percent of inflation variation in some African countries results from demand shocks. Our results also corroborate those of IMF (2015) that supply features and weather related issues are not the main drivers of macroeconomic fluctuations in Africa. This result supports the view that inflation targeting which is superior in handling demand shocks can be suitable for the majority of African countries. As argued by Frankel (2014), the performance of inflation targeting is superior when demand shocks dominate. It is not surprising therefore that, some African countries, such as Tanzania, Nigeria, Malawi and Zambia, are attempting to improve monetary policy performance with the support from the International Monetary Fund by moving to inflation targeting frameworks (see IMF 2008).

However, our results also suggest caution as supply and terms of trade shocks are the second and third largest drivers of macroeconomic fluctuations in Africa, respectively. This follows the dependence of African countries on commodity exports and agriculture. It is therefore not surprising that in 5 countries, namely Zambia, Uganda, Egypt, Malawi and Tanzania, it is the hybrid policy framework which is robust to macroeconomic fluctuations. The superiority of the hybrid framework in these countries reflects the dual nature of shocks affecting African economies. Being a hybrid regime, the demand shocks are taken care of but not completely at the expense of the supply shocks since the hybrid framework combines elements of both inflation targeting and nominal GDP. This result stands in contrast to the current direction of monetary policy that is sweeping across African countries where a majority of them are adopting inflation targeting.

In the other 4 countries, namely Ghana, Kenya, South Africa and Morocco, it is the strict inflation targeting framework that performs better. In these countries the demand base is relatively large which is a favorable condition for inflation targeting. These results somehow render credence to the current policy practice in Ghana, South Africa and Uganda which are using inflation targeting frameworks. However, they suggest that monetary policy performance can be enhanced in South Africa and Ghana if authorities implement strict versions of the inflation targeting regime. In Uganda, augmenting the IT regime with NGDP targeting resulting into a hybrid policy regime is more consistent with macroeconomic stabilization. Similarly, our finding are somewhat consistent with Kenya which is in transition to inflation targeting. The results however suggest that Kenya should implement a strict version of the IT rather than the flexible version.

On the other hand, in Zambia, Egypt, Tanzania and Malawi we find the current drive to migrate from monetary aggregate targeting to inflation targeting to be inconsistent with macroeconomic stabilisation. Rather, our findings suggest that macroeconomic performance can be enhanced in these countries by adopting hybrid monetary policy regimes which combine elements of both inflation targeting as well as nominal GDP targeting. In doing so, authorities will be able to deal with multiple shocks that can neither be handled by inflation targeting nor nominal GDP targeting alone (see Jensen 2002).

Overall, the variation in the optimal monetary policy frameworks reflects the diversity in shocks affecting African countries. The findings therefore throw caution against a blanket adoption of specific monetary policy regimes for all the countries in Africa. These findings suggest that there is room to enhance the performance of monetary policy in Africa by adopting regimes which are robust to prevailing shocks. However, the diversity in shocks also imply that the choice of monetary policy frameworks is not a straight forward issue. Identifying sources of macroeconomic volatility is thus critical for the choice of robust monetary policy regimes. The larger the number of shocks affecting a particular economy, the more complex the macroeconomic management process. This finding brings to the fore the problem of a one-size-fits-all approach to choices in monetary policy frameworks in Africa.

Lastly, the findings suggest that controlling inflation in Africa is not a demand management issue alone. Authorities need to address supply side bottlenecks to ensure sustainable agriculture/food production. Furthermore, according to Engel's Law, raising incomes will allow people to devote less spending on food items. This will leave the bulk part of their income to be affected by monetary policy developments. This together with addressing fiscal slippages can assist improving interest rate transmission which could result in inflation targeting regimes becoming more effective in Africa.

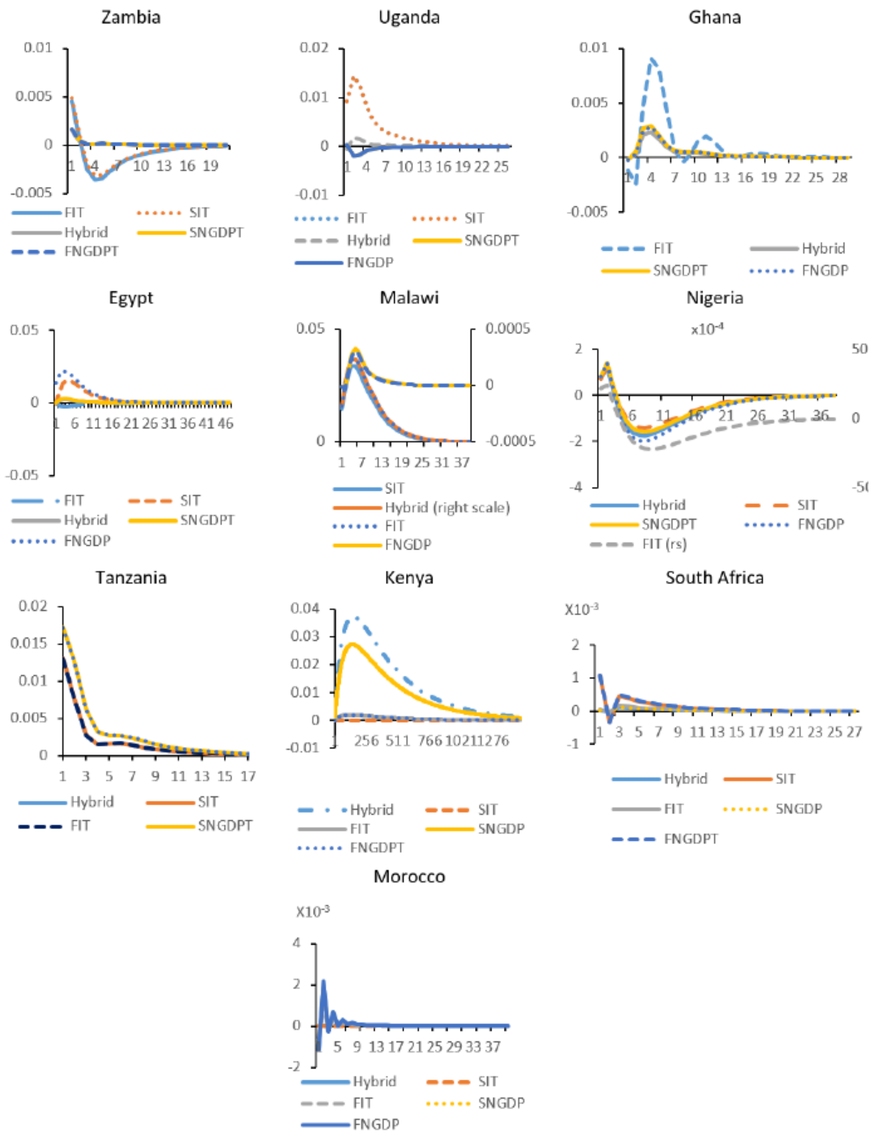


Figure 13: Impulse responses of inflation to the supply shock

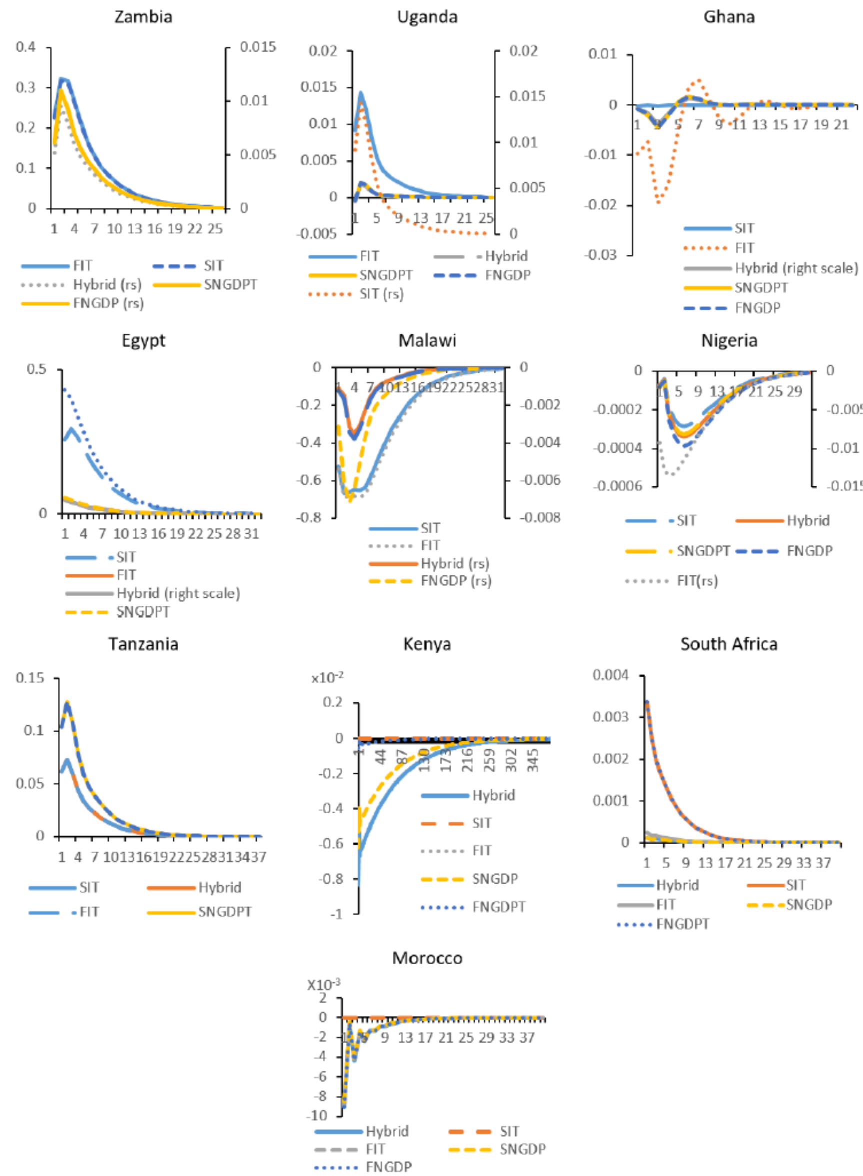


Figure 14: Impulse responses of inflation to the demand shock

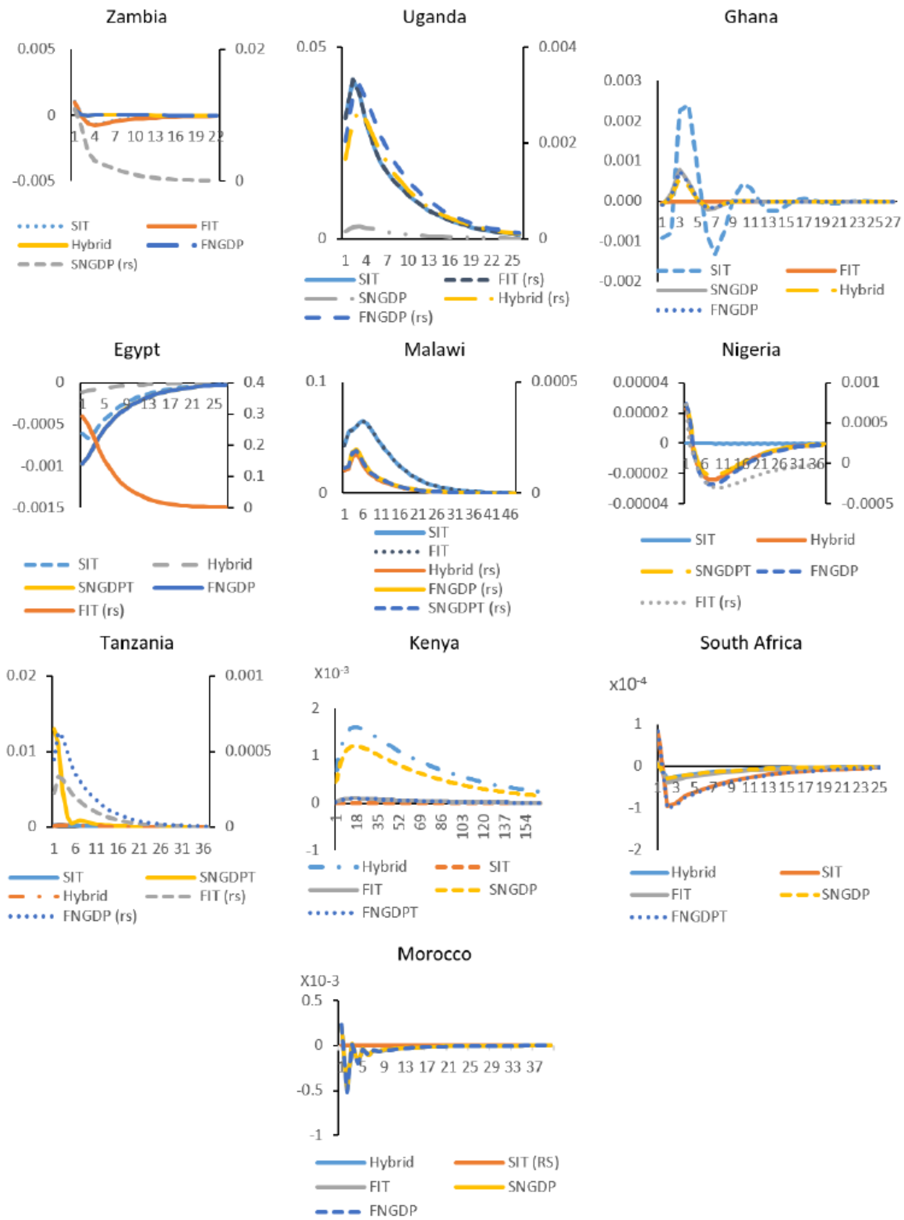


Figure 15: Impulse responses of inflation to the exchange rate shock

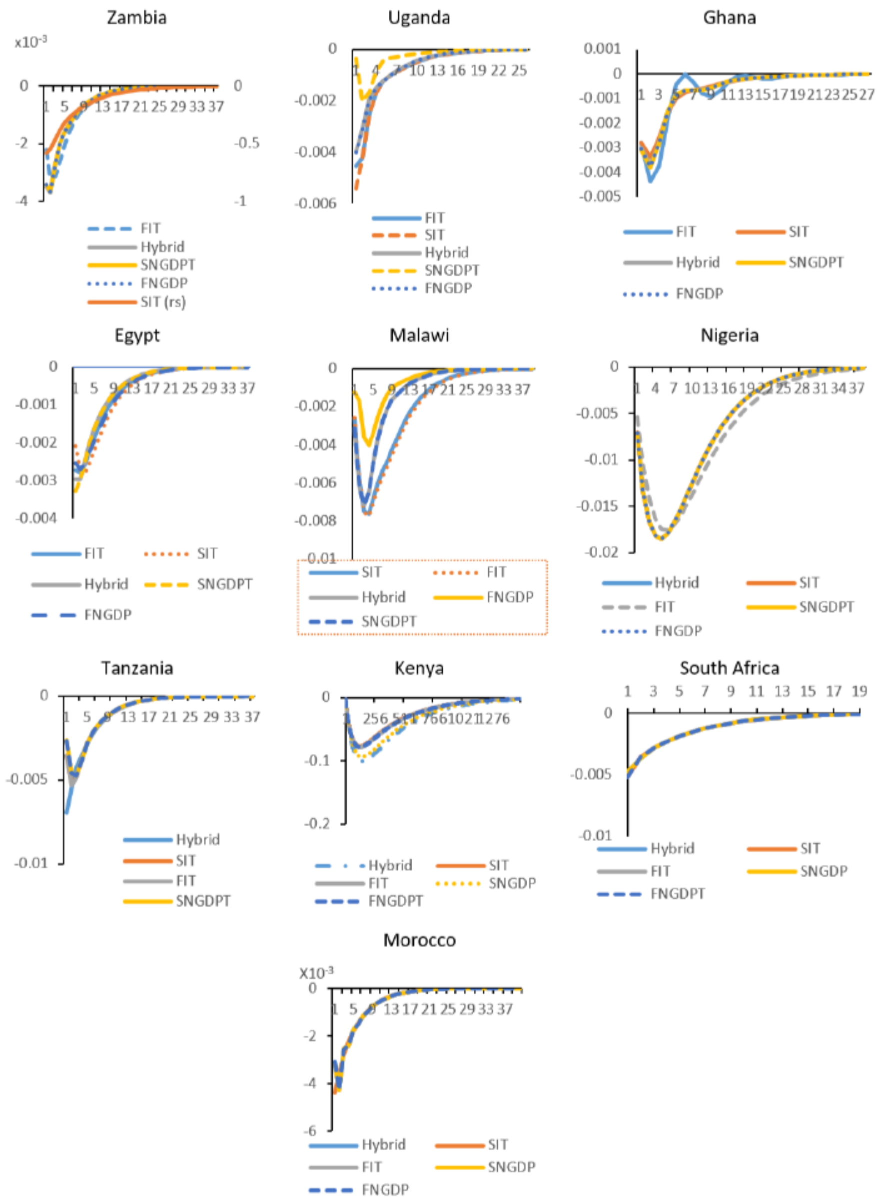


Figure 16: Impulse responses of output to the supply shock

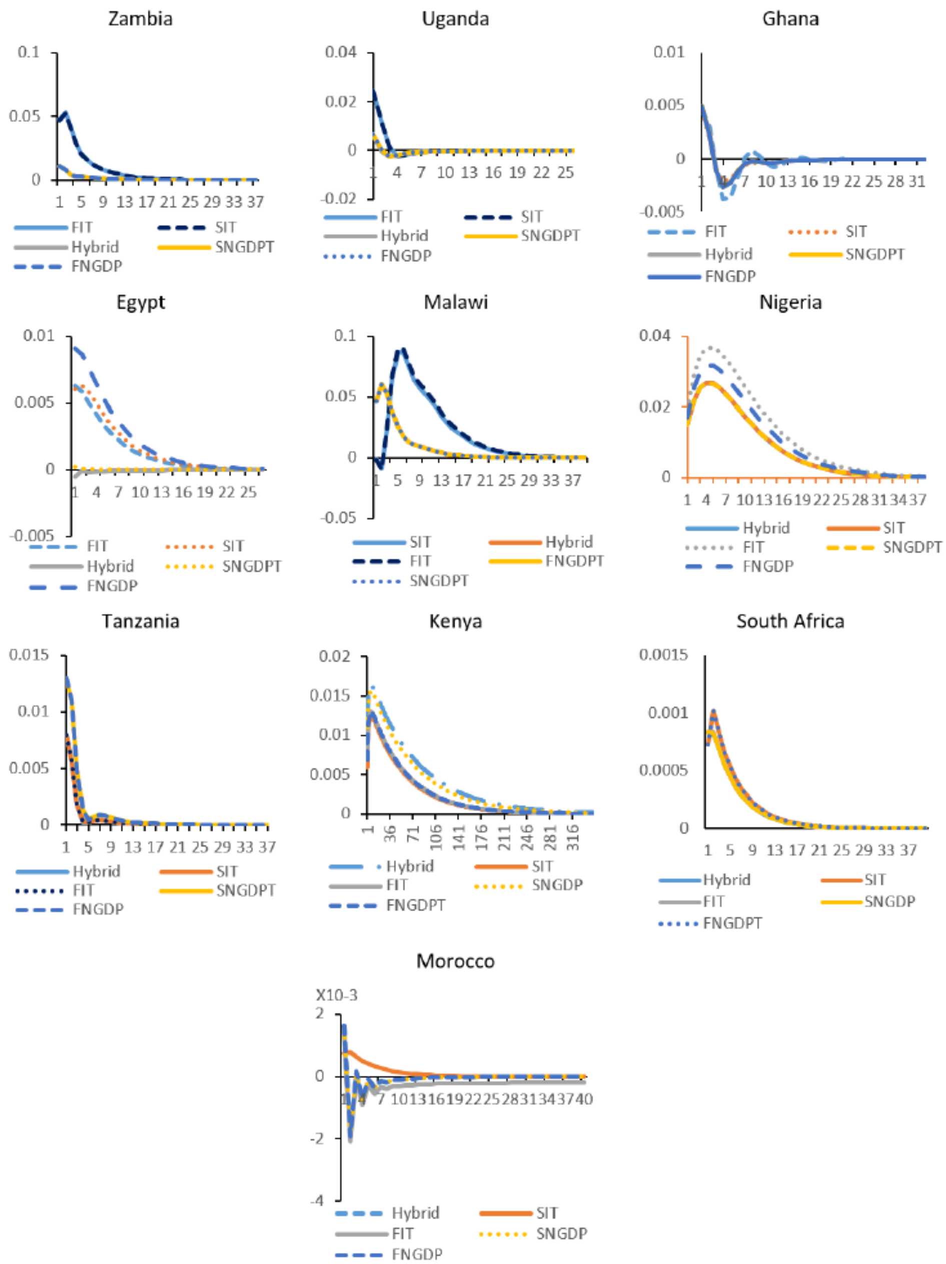


Figure 17: Impulse responses of output to the demand shock

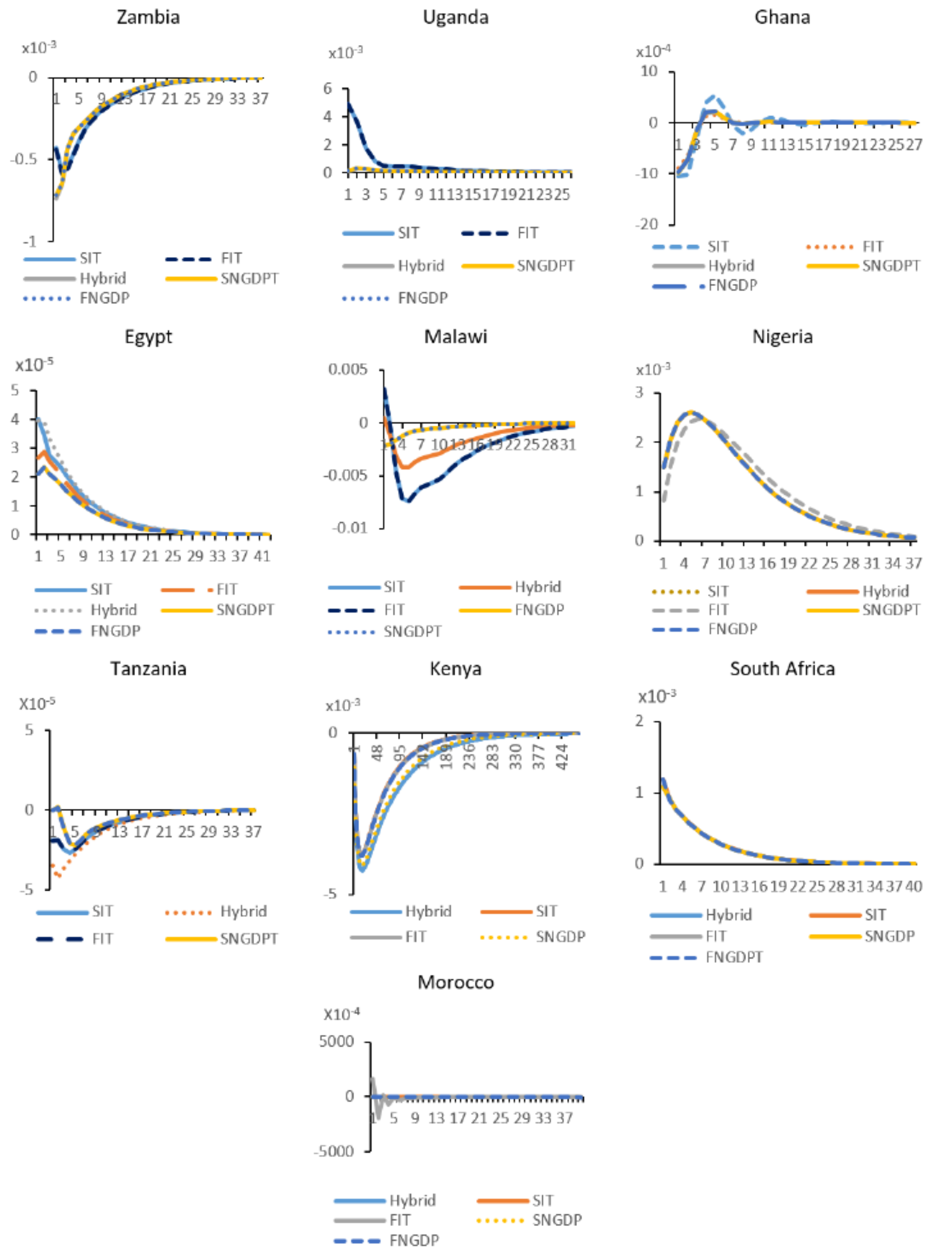


Figure 18: Impulse responses of output to the exchange rate shock

5 Conclusion and policy options

The global direction in monetary policy conduct shows that the majority of countries are adopting inflation targeting with active use of interest rate instruments. However, as observed by Berg et al. (2010), the practice in African countries is somewhat different from the global trend. The difference arises due to several factors, such as underdeveloped financial markets, high frequency of terms of trade shocks and dominance of supply shocks, that characterize African economies (see Nguyen et al. 2017). These factors pose unique macroeconomic management challenges which include inefficient transmission of interest rate signals. Furthermore, these factors impede the speedy adoption of IT and interest rate based regimes as they raise doubts as to whether standard monetary policy as practiced in Advanced Economies can be applied to Africa. At the same time, money demand is perceived to be unstable leading to authorities' dissatisfaction with the performance of the monetary aggregate targeting regimes.

African authorities are thus caught up with the need to re-examine the reach and limits of their monetary policy frameworks and instruments to address these challenges. The re-examination also occurs on the backdrop of several factors, such as global push towards IT and interest rate regimes and the absence of clear monetary policy frameworks in Africa. Although achieving macroeconomic stability through monetary policy largely relies on appropriate configuration of monetary policy frameworks and instruments, literature on the subject is little and mostly focused on Advanced Economies. Findings from these studies are also divided making choices on the subject difficult for African countries.

In order to address these issues, this thesis investigates the relative performance of alternative monetary policy frameworks and instruments in macroeconomic stabilization of 10 selected African economies. Specifically, we examine three issues. First, we compare the relative performance of the monetary aggregate and the interest rate as policy instruments for macroeconomic stabilization in the selected countries. Secondly, we examine the implications of exchange rate smoothing using monetary policy rules on macroeconomic stabilization in these countries. Lastly, we compare the relative performance of inflation targeting and nominal GDP targeting as alternative frameworks for macroeconomic stabilization in the selected countries. In order to perform these comparisons, we derive and estimate a New Keynesian Dynamic Stochastic General Equilibrium model where money is non-separable from consumption in the utility function. We mostly use quarterly data from 1990 to 2014 obtained from the International Financial Statistics of the International Monetary Fund. The model is estimated using the maximum likelihood technique.

We find several results. First, In 5 of the 10 countries, namely Nigeria, Malawi, Tanzania, Morocco and Zambia, it is the monetary aggregate instrument which performs better in macroeconomic stabilization. These results reflects the fact that macroeconomic dynamics respond relatively more to changes in the monetary aggregate than the interest rate in these countries. In the other 5 countries, namely South Africa, Egypt, Ghana, Uganda and Kenya, it is the interest rate instrument which performs better. Literature suggests that interest rate instrument perform better when aggregate demand is mostly driven by the core rather than food and other supply related factors (Mishra et al. 2012). Furthermore, interest rate instruments perform better under developed financial markets. It is therefore not surprising that in the latter group of countries where weight on food inflation is relatively small and financial infrastructure developments is comparatively high, the interest rate instrument is more successful in stabilizing the economies than the monetary aggregate.

Our results further suggest an overall weak role of the interest rate in driving aggregate demand dynamics. This signals a weak interest rate transmission process. Therefore, for authorities to use the interest rate as an effective policy instrument, they need to adjust it with relatively large magnitudes. At times such huge adjustments may be inconsistent with exchange rate, fiscal and financial stability objectives. Given this finding, efforts to modernize monetary policy conduct must also include those that enhance interest rate transmission mechanism, such as development of domestic financial markets. On the other hand, we find la relatively large economic significance of the monetary aggregate. This suggests that a blanket abandonment of the monetary aggregate as a policy instrument in Africa may be inconsistent with macroeconomic stabilization goals.

Secondly, in 4 of the 10 countries, namely Ghana, Kenya, Malawi and Tanzania, there is strong evidence for countries to engage in exchange rate smoothing as doing so enhances macroeconomic performance. In these countries, the pass-through of the exchange rate to inflation is relatively high. The significance of the exchange rate therefore compels authorities to minimize the pass-through by engaging in exchange rate smoothing. Despite facing declining terms of trade, these countries' currencies remained relatively stable in the 2000s suggesting that authorities smoothed the exchange rate fluctuations. This resulted in less pass-through to inflation with marked improvements in macroeconomic performance.

In the other 6 countries, namely Egypt, South Africa, Morocco, Nigeria, Uganda and Zambia, engaging in exchange rate smoothing worsens macroeconomic performance. These results are consistent with IMF (2008), Taylor (2001) and Calvo et al. (1995). In some countries, such as Nigeria and Morocco, which pursue near fixed regimes, the exchange rate does not carry any additional information from the domestic economy. Adjusting monetary policy to deal with fluctuations therefore only makes interest rates more volatile. The link between aggregate demand and interest rates implies that volatile interest rates will lead to volatile macroeconomic activity (Calvo 1995). In other countries such as South Africa, which are relatively open economies, monetary policy responds to external and domestic factors. Interest rate developments elsewhere trigger monetary policy action due to the UIP condition. At the same time monetary policy responds to domestic developments. This may result in overly frequent adjustments to monetary policy which translates into volatile interest rates and hence volatile macroeconomic performance.

We also find evidence that macroeconomic performance is sensitive to the level of aggressiveness towards exchange rate fluctuations. Below certain thresholds, the pass-through of the exchange rate remains high. In this case, increasing the level of smoothing improves macroeconomic performance. Beyond certain thresholds, smoothing is tantamount to implementing a near fixed exchange rate regime which as shown by Baldini et al. (2015) raises macroeconomic instability. Heavy exchange rate management can also reduce the exchange rate's shock-absorbing role. In view of the vulnerability of African economies to external shocks, it is important that African countries maintain flexible exchange rate system to act as cushions during times of shocks. However, as argued by IMF (2015), finding the right role for the exchange rate is likely to be an unsettled, evolving, and ultimately country-specific challenge. Authorities need to be able to identify episodes that require smoothing to avoid straying from mitigating disorderly conditions or volatility to managing the exchange rate away from fundamentals. Exchange rate smoothing should not ideally be a substitute for macroeconomic adjustments.

Since exchange rate depreciations are contractionary in some countries, reacting to exchange rate movements due to inflation concerns may stabilize inflation but jeopardize output. Given that many African countries rely on very few, if not one, commodity for foreign exchange earnings, it is necessary that these countries pursue policies that promote industrial diversification and pursue import substitution policies to mitigate external shocks. Developing deep and liquid foreign exchange rate markets together with coherent foreign exchange intervention strategies is key in ensuring that the exchange rate policy is consistent with other macroeconomic objectives.

Fourth, the results also show that demand shocks are dominant drivers of macroeconomic fluctuations in Africa. The dominance of demand shocks implies that African countries can adopt the inflation targeting framework which according to Frankel (2014) is superior in handling aggregate demand shocks. It is not surprising, therefore, that some African countries, such as Tanzania, Nigeria, Malawi and Zambia, are attempting to improve monetary policy performance with the support from the IMF by moving to inflation targeting regimes (see IMF 2008). However, these results also throw caution as supply and exchange rate shocks closely trail demand shocks in driving macroeconomic fluctuations in Africa. This suggests that choosing a suitable monetary policy framework is a complex process for authorities in African economies.

Given this setup, in 5 countries, namely Zambia, Uganda, Egypt, Malawi and Tanzania, it is the hybrid policy framework which is robust to macroeconomic fluctuations arising from diverse shocks. In the other 4 countries, namely Ghana, Kenya, South Africa and Morocco, it is strict inflation targeting framework that performs better. In Nigeria, it is the flexible inflation targeting that yields lowest macroeconomic fluctuations. The superiority of the hybrid framework in the majority of the countries reflects the dual nature of shocks affecting African economies since the hybrid framework combines elements of both inflation targeting and nominal GDP.

Our findings suggest that there is room to improve the performance of monetary policy in Africa by adopting suitable monetary policy regimes and instruments as well as appropriate configuration of the policy instruments which are consistent with the dominant shocks. As argued by IMF (2015), in considering these improvements, it is essential that countries take into account the specific conditions and challenges facing them. These findings therefore throw caution against a generalized adoption of some specific monetary policy regimes or instruments across all the countries in Africa. Rather, the findings suggest that the process must be guided by periodic and country-specific analyses to ascertain the relevance of particular policies. Policy-makers must proceed at their own pace, taking into account local conditions.

This thesis contributes to the current state of knowledge and debate on monetary policy frameworks and instruments in Africa. To the best of our knowledge, this is a first study in African economies cast within the general equilibrium rendition which makes a comparative analysis of the performance of alternative monetary policy regimes and instruments, where instruments are further adjusted to account for exchange rate smoothing. We however opine that inclusion of debt, fiscal and financial sector dynamics in our model may enhance model dynamics and are therefore necessary avenues for further research.

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7 Appendix to Chapters 3 and 4: Model derivations and parameter estimates

A.1 Households

Maximize utility:

$$U_t = E_t \sum_{j=0}^{\infty} \beta^j \left\{ \tfrac{1}{1-\sigma} \left[\left(C_t^d - hC_{t-1}^d\right)^{1-\sigma} + \left(C_t^m - hC_{t-1}^m\right)^{1-\sigma} \right] \left(\tfrac{M_t}{P_t}\right)^{\phi} - \tfrac{N_t^{1+\varphi}}{1+\varphi} \right\}, \quad \text{(A.01)}$$

Subject to a HH Budget Constraint:

$$\frac{M_t}{P_t}+\frac{B_t}{P_t}+\frac{Z_tB_t^f}{P_t} = \frac{W_tN_t}{P_t}+\frac{M_{t-1}}{P_t}+\frac{(1+r_{t-1})B_{t-1}}{P_t}+\frac{Z_t(1+r_{t-1}^f)B_{t-1}^f}{P_t}-C_t^d-Q_tC_t^m, \quad \text{((A.02))}$$

where $\beta^j \in (0,1)$ = discount factor, $\sigma > 0$ = elasticity of intertemporal substitution, $0 \leq \phi \leq 1$ = elasticity of money demand, h = habit formation, N_t =

labour, φ = Frisch labour supply elasticity, M_t = money, B_t = bonds, B_t^f = foreign bonds, W_t = wages, Z_t = nominal exchange rate, Q_t = real exchange rate, P_t = domestic price level, P_t^f = foreign price level, r_t = domestic interest rate, r_t^f = foreign bonds, C_t^d=consumption of domestic goods, C_t^m = consumption of foreign goods.

The first order conditions are:

$$\left(C_t^d - hC_{t-1}^d\right)^{-\sigma}\left(\frac{M_t}{P_t}\right)^{\phi} = \lambda_t, \tag{A.03}$$

$$\left(C_t^m - hC_{t-1}^m\right)^{-\sigma}\left(\frac{M_t}{P_t}\right)^{\phi} = Q_t\lambda_t, \tag{A.04}$$

$$\beta E_t\lambda_{t+1}\left(\frac{1+r_t}{1+\pi_{t+1}}\right) = \lambda_t, \tag{A.05}$$

$$\beta E_t\lambda_{t+1}\left(\frac{1+r_t^f}{1+\pi_{t+1}}\right)\left(\frac{Z_{t+1}}{Z_t}\right) = \lambda_t, \tag{A.06}$$

$$\frac{\phi}{1-\sigma}\left(\frac{M_t}{P_t}\right)^{\phi-1}X_t = \lambda_t - \beta E_t\left\{\lambda_{t+1}\left(\frac{1}{1+\pi_{t+1}}\right)\right\}, \tag{A.07}$$

$$\frac{N_t^{\varphi}}{\lambda_t} = \frac{W_t}{P_t}. \tag{A.08}$$

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

The Taylor approximation of eq.(A.03) to eq.(A.07) around the steady state yields the following:

$$\begin{aligned}\hat{c}_t^d = {} & \frac{1}{1+h}E_t\hat{c}_{t+1}^d + \frac{h}{1+h}\hat{c}_{t-1}^d - \frac{(1-h)}{\sigma(1+h)}(\hat{r}_t - E_t\hat{\pi}_{t+1}) \\ & + \frac{\phi(1-h)}{\sigma(1+h)}(\hat{m}_t - E_t\hat{m}_{t+1}),\end{aligned} \tag{A.09}$$

and

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

A.2 Macro-balance

The Macro-balance is based on McCallum (2000) as follows:

$$\hat{y}_t = \tau_c\hat{c}_t^d + \tau_x\hat{x}_t - \tau_m\hat{c}_t^m, \quad \text{(A.11)}$$

where $\hat{x}_t$ = exports, $\tau_c = \frac{\hat{c}_0^d}{\hat{y}_0}$, $\tau_x = \frac{\hat{x}_0}{\hat{y}_0}$, and $\tau_m = \frac{\hat{c}_0^m}{\hat{y}_t}$ represent steady state ratios of relevant variables to income, γ_q = elasticity of exports with respect to exchange rate , γ_f = elasticity of exports with respect to foreign income. The export function is:

$$\hat{x}_t = \gamma_q\hat{q}_t + \gamma_f\hat{y}_t^f. \quad \text{(A.12)}$$

Substituting eq.(A.10) and eq.(A.12) into eq.(A.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:

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

where

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

A.3 Exchange rate determination

Combining Taylor approximation around steady state of eq.(A.05) and eq.(A.06) yields:

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

The real version of Eq. (A.14) can be given as:

$$
E_t\Delta\hat{q}_{t+1} = -\left[(\hat{r}_t - \hat{\pi}_{t+1}) - (\hat{r}_t^f - \hat{\pi}_{t+1}^f)\right] + \varepsilon_{qt}. \tag{A.15}
$$

As in Wollmershäuser (2006) and Svensson (2000), the term ε_{qt} is included to typically capture deviations from parity and is referred to as foreign exchange risk premium.

A.4 Money demand

We combine steady state forms of eq.(A.07) and eq.(A.05) and use the economy wide resource balance in eq.(A.11) to derive the following money market equilibrium conditions:

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

$$
\begin{aligned}
\hat{r}_t &= \beta_1\hat{y}_t + \beta_2\hat{y}_{t-1} - \beta_3\hat{m}_t - \beta_4\hat{\pi}_{t+1} + \beta_5\hat{q}_t + \beta_6\hat{q}_{t-1} + \beta_7\hat{y}^f_t \\
&\quad -\beta_8\hat{y}^f_{t-1} + \varepsilon_{rdt}, \qquad (A.17)
\end{aligned}
$$

where

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

The terms ε_{rdt} and ε_{mdt} are money demand shocks.

A.5 Firms

Following Batini et al. (2005) and Malikane (2014) , we assume that firms exhibit non-linear input demand. The non-labour input demand therefore takes the following form: $X_{jt} = Y_t^{\eta j}$. X_{jt} are non-labour inputs; η_j is the elasticity of input j in the production process. Firms are assumed to seek profit maximization but operate in a monopolistically competitive environment and face staggered price setting as in Calvo (1983). The production function is Cobb-Douglas in nature and is specified as follows:

$$Y_t = A_t N_t^{\alpha} \left[\prod_{j=1}^{m} Y_t^{\theta_j \eta_j} \right]. \tag{A.18}$$

A_t is an AR (1) technological process. Parameter α = labour share in income, θ_j =elasticity of output with respect to input j. The reduced form for eq.(A.18) is given by:

$$Y_t = \acute{A}_t N_t^{\Upsilon}, \tag{A.19}$$

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:

$$TC_t = \frac{W_t Y_t^{\frac{1}{\Upsilon}}}{P_t \acute{A}^{\frac{1}{\Upsilon}}} + \sum_{j=1}^{m} \frac{P_{jt} Y_t^{\eta_j}}{P_t}, \tag{A.20}$$

Combining eq.(A.08) and eq.(A.19) yields the following real wage expression:

$$\frac{W_t}{P_t} = \left(\frac{Y_t}{\acute{A}_t} \right)^{\frac{\varphi}{\Upsilon}} \frac{1}{\lambda_t}. \tag{A.21}$$

Combining eq.(A.20) and eq.(A.21), and letting p_{it} denote real price of non-labour input yields the following real marginal cost expression:

$$rmc_t = \beta_1 \frac{Y_t^{\beta_2}}{A_t^{\beta_3}} \frac{1}{\lambda_t} + \sum_{j=1}^{m} \eta_j p_{jt} Y_t^{\eta_i - 1}, \tag{A.22}$$

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.(A.22) yields:

$$r\hat{m}c_t = \phi_1 \hat{y}_t - \phi_2 \hat{a}_t - \phi_3 \hat{\lambda}_t + \sum_{j=1}^{m} \phi_4 \hat{p}_{jt}, \tag{A.23}$$

Where

$$\begin{aligned}
\phi_1 &= \frac{1}{MC_0}\left[\frac{\beta_2 Y_0^{\beta_2 - 1}}{\Upsilon A_0^{\beta_3} \lambda_0} + \sum_{j=1}^{m} (\eta_j - 1)\eta_j p_{j0} Y_0^{\eta j - 1}\right],\ \phi_2 = \frac{1}{MC_0}\left[\frac{\beta_3 Y_0^{\beta_2}}{\Upsilon A_0^{\beta_3} \lambda_0}\right], \\
\phi_3 &= \frac{1}{MC_0}\left[\frac{1}{\Upsilon \lambda_0} \frac{Y_0^{\beta_2}}{A_0^{\beta_3}}\right],\ \phi_4 = \frac{1}{MC_0}\left[\sum_{j=1}^{m} \eta_j Y^{\eta j - 1} P_{i0}\right]
\end{aligned}$$

Next, we combine the steady state form of eq.(A.04) and eqs.(A.11) and (A.12) and substitute the result in eq.(A.23) to get the following expression:

$$\begin{aligned}
r\hat{m}c_t &= \phi_1 \hat{y}_t + \left(\frac{\phi_3 + \sigma \tau_m \Lambda}{1-h}\right) E_t \hat{y}_{t+1} - \left(\frac{\phi_3 + \sigma h \tau_m \Lambda}{1-h}\right) \hat{y}_{t-1} - \phi_3 \hat{q}_t \\
&\quad + \frac{\phi_3 \gamma_q \sigma \tau_x \tau_m}{1-h} E_t \hat{q}_{t+1} - \frac{\phi_3 \gamma_q \sigma h \tau_x \tau_m}{1-h} \hat{q}_{t-1} - \phi_3 \phi \hat{m}_t \\
&\quad + \frac{\phi_3 \gamma_f \sigma \tau_x \tau_m}{1-h} E_t \hat{y}_{t+1}^f - \frac{\phi_3 \gamma_f \sigma h \tau_x \tau_m}{1-h} \hat{y}_{t-1}^f + \phi_4 \hat{p}_{jt} - \phi_2 \hat{a}_t
\end{aligned} \tag{A.24}$$

Substituting eq.(A.24) into the baseline hybrid new-Keynesian Phillips curve proposed by Gali and Gertler (1999) yields the following hybrid Phillips curve:

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

where

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

Table 21: Parameter estimates for the IS curve

	Egypt	Ghana	Kenya	Malawi	Morocco	Nigeria	S. Africa	Tanzania	Uganda	Zambia
κ_1	0.73***	0.39***	0.37***	0.58***	0.67***	0.44***	0.49***	0.40***	0.78***	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***	0.87***	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	-0.001	0.13***	-0.02**	-0.06	-0.07**	0.01
	[0.00]	[0.00]	[0.00]	[0.06]	[0.00]	[0.00]	[0.01]	[0.08]	[0.03]	[0.00]
κ_4	-0.10***	0.02**	-0.12***	0.05**	-0.09***	0.28***	0.17**	-0.05	-0.63***	-0.001
	[0.02]	[0.01]	[0.00]	[0.02]	[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]	[0.03]	[0.05]	[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	0.10	0.21	0.37**	0.08**
	[69.21]	[20.22]	[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]

Note: [ ] Denote standard errors. *,**, *** denote significance at 10%, 5%, 1%, otherwise not significant

Table 22: Parameter estimates for the Phillips curve

	Egypt	Ghana	Kenya	Mal	Mor.	Nig.	S. Afr	Tanz	Uganda	Zam
χ_f	0.79***	1.01***	0.61***	0.53***	0.61***	0.40***	0.35***	0.71***	0.53***	0.66**
	[0.00]	[0.02]	[0.00]	[0.00]	[0.00]	[0.01]	[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]	[0.02]	[0.00]	[0.00]	[0.00]	[0.01]	[0.00]	[0.00]	[0.00]	[0.03]
δ_1	0.79***	1.96***	1.04***	0.89***	0.85***	0.01	0.26***	0.62***	0.96***	0.88***
	[0.00]	[0.23]	[0.00]	[0.00]	[0.15]	[0.00]	[0.01]	[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]	[0.20]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.30]	[0.00]
δ_3	0.66**	0.92***	-0.26***	0.41**	0.71**	-0.13***	0.15***	0.69***	0.81***	0.55***
	[0.30]	[0.00]	[0.00]	[0.00]	[0.20]	[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***
	[35.1]	[109.2]	[0.00]	[5.50]	[0.18]	[92.9]	[0.00]	[52.51]	[0.50]	[0.03]
δ_9	0.194	0.17	0.67***	0.01	0.18***	0.85	0.22	0.18	0.85***	1.09***
	[26.9]	[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 errors. *,**,*** denote significance at 10%, 5%, 1%, otherwise not significant

Table 23: Parameter estimates for the money demand

	Egypt	Ghana	Kenya	Mal.	Mor.	Nig.	S. Afr	Tanz.	Ugan	Zam.
Ψ_1	0.53**	1.83***	0.87***	0.67***	0.54***	0.73**	1.58**	0.54***	0.39***	0.81***
	[0.20]	[0.00]	[0.01]	[0.00]	[0.00]	[0.31]	[0.50]	[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
	[0.30]	[0.00]	[0.40]	[0.00]	[0.00]	[0.40]	[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]	[0.01]	[0.01]	[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**
	[0.10]	[0.00]	[0.20]	[0.00]	[0.00]	[0.00]	[0.10]	[0.00]	[0.00]	[0.10]
Ψ_6	0.012	-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	0.91	3.16	2.00***	1.33***	2.90***	0.83	0.82***	0.90	1.29***	0.49**
	[2.80]	[81.6]	[0.00]	[0.25]	[0.00]	[54.2]	[0.00]	[45.22]	[0.00]	[0.14]
Ψ_8	0.91***	2.42	0.48***	1.40***	3.29***	0.48**v	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. *, **,*** denote significance at 10%, 5%, 1%, otherwise not significant

Table 24: Parameter estimates for the interest rate policy rule

	Egypt	Ghana	Kenya	Mal.	Mor.	Nig.	S. Afr.	Tanz	Ugan	Zam
δ_{1y}	0.90***	0.89***	0.78***	1.19***	1.10***	0.80***	0.18***	1.11***	0.99***	1.14***
	[0.00]	[0.00]	[0.00]	[0.60]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.70]
δ_{2y}	0.91***	0.97***	0.70***	1.39***	1.89***	0.68***	1.16***	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***	1.02***	0.83***	1.34***	-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***	1.60***	3.99***	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**	1.70***	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***	1.69***	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***	1.75***	-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	1.10	4.48	4.50	0.90	0.92***	0.15***
	[31.32]	[24.98]	[71.34]	[54.11]	[13.48]	[154.6]	[38.64]	[45.20]	[0.00]	[0.02]
δ_{2f}	0.93	0.86	1.27***	1.29	2.30	0.62	0.60	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**	0.89	2.50	1.96	2.01	0.89	0.98***	0.79***
	[98.56]	[65.87]	[0.00]	[2.15]	[5.10]	[27.61]	[4.35]	[19.91]	[0.00]	[0.02]

Note: [ ] Denote standard errors, **Significant at 5 percent, otherwise not significant

Table 25: Parameter estimates for the money supply rule

	Egypt	Ghana	Kenya	Mal.	Mor.	Nig.	S. Afr.	Tanz	Ugan	Zam
σ_{3y}	0.11	-1.64***	0.14	-0.10	0.07	0.31	3.52***	0.39	0.96***	-0.34***
	[0.61]	[0.72]	[0.33]	[0.17]	[0.24]	[1.09]	[0.64]	[0.99]	[0.14]	[0.04]
σ_{1y}	0.24	2.56	1.60**	0.80***	-0.29	-0.49	-0.85	2.68	-0.12	-0.49***
	[0.87]	[1.59]	[0.59]	[0.29]	[0.35]	[1.53]	[1.21]	[1.47]	[0.26]	[0.12]
σ_{2y}	0.58	0.97	-1.53	-0.57	-0.43***	3.60***	-0.02	-2.64***	0.34***	0.82***
	[0.47]	[1.05]	[0.42]	[0.25]	[0.18]	[0.99]	[0.78]	[1.05]	[0.13]	[0.12]
σ_b	-0.47***	-0.08***	-0.58***	-0.07***	0.07	-1.13***	-0.12	-0.41***	-0.69***	-0.17***
	[0.11]	[0.02]	[0.04]	[0.02]	[0.19]	[0.05]	[0.24]	[0.15]	[0.11]	[0.03]
σ_f	-0.16	-0.03	0.01	-0.00	2.58***	0.29**	0.49*	0.70***	-0.12	0.13***
	[0.09]	[0.02]	[0.04]	[0.03]	[0.39]	[0.10]	[0.26]	[0.17]	[0.10]	[0.02]
σ_{3q}	0.04	-0.35***	-0.24***	0.06	0.52**	0.05	0.08	0.13	0.63***	-0.01
	[0.05]	[0.10]	[0.02]	[0.07]	[0.21]	[0.03]	[0.05]	[0.08]	[0.07]	[0.00]
σ_{1q}	0.14	0.40**	-0.05	-0.19**	-0.73***	-0.04	0.13	0.03	-0.35***	0.02**
	[0.09]	[0.19]	[0.03]	[0.09]	[0.17]	[0.04]	[0.07]	[0.11]	[0.07]	[0.01]
σ_{2q}	0.06	-0.47***	0.29**	-0.17**	-0.49***	-0.01	-0.19**	0.19***	-0.58***	-0.01
	[0.08]	[0.14]	[0.03]	[0.08]	[0.14]	[0.02]	[0.07]	[0.06]	[0.06]	[0.01]
σ_{2f}	0.06	0.20	-1.58***	-1.41***	-0.29**	3.16***	-0.28	-0.18	-0.97***	0.03
	[0.19]	[0.42]	[0.12]	[0.70]	[0.10]	[0.25]	[0.40]	[0.14]	[0.30]	[0.03]
σ_{1f}	0.14	0.91	1.50**	-1.51**	0.13	-5.71**	2.29**	1.80**	0.27	-0.15**
	[0.21]	[0.64]	[0.14]	[0.75]	[0.15]	[0.34]	[0.46]	[0.22]	[0.35]	[0.03]
σ_0	-3.45	-0.18***	-0.03**	0.08**	-0.03***	0.16***	-0.10***	0.09***	-0.01	0.01
	[2.05]	[0.03]	[0.01]	[0.03]	[0.01]	[0.02]	[0.02]	[0.01]	[0.01]	[0.00]

Note: [ ] Denote standard errors, *,**,*** denote significant at 10%, 5%. 19%, otherwise not significant

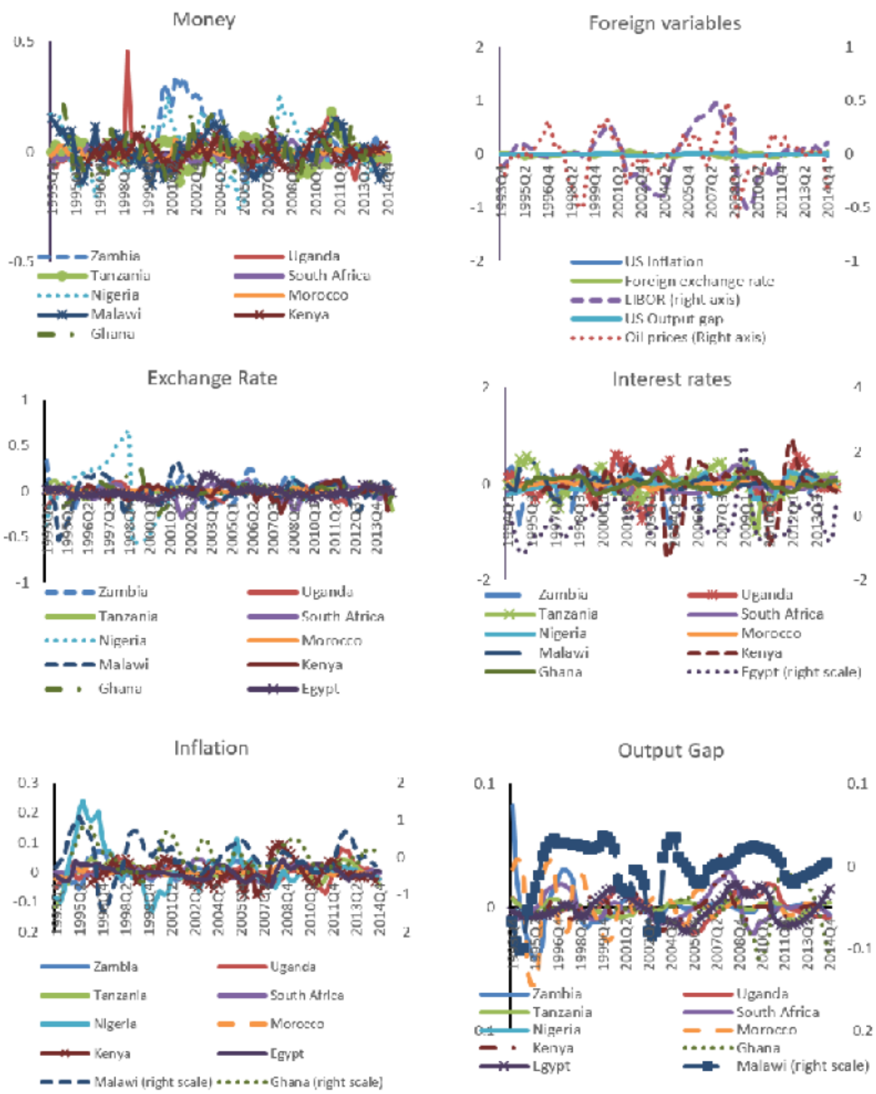
Table 26: Parameters of the exogenous variables-AR(1) coefficients

Equation	Parameter	Description	Value
Foreign output	ρ_{yf}	AR(1)	0.95
Foreign interest rate	ρ_{rf}	AR(1)	0.96
Foreign inflation	ρ_{ff}	AR(1)	0.89
Crude oil prices	ρ_o	AR(1)	0.96

Table 27: Correlation between policy instruments, inflation and output

	Zambia		Uganda		Tanzania		S. Africa		Nigeria	
	m	r	m	r	m	r	m	r	m	r
y	0.31	-0.32	0.01	-0.07	0.02	-0.12	0.57	-0.42	0.62	0.10
π	-0.30	-0.03	-0.41	0.51	-0.01	0.23	-0.30	0.46	-65	-0.16
	Morocco		Malawi		Kenya		Ghana		Egypt	
y	0.01	-0.01	-0.16	-0.36	0.06	-0.22	0.23	-0.28	0.13	0.27
π	-0.15	0.07	-0.29	0.73	-0.69	0.36	-0.34	0.60	-0.47	0.34
	Correlations by monetary policy regimes									
	IT		Other		MAT		CP			
	m	r	m	r	m	r	m	r		
y	0.27	-0.25	0.33	-0.14	-0.003	-0.07	0.01	-0.01		
π	-0.35	0.52	-0.55	0.06	-0.26	0.43	-0.15	0.07		

m=money supply, r=Nominal interest rate, π=Inflation, CP=Conventional peg
MAT=Monetary Targeting, Other=other regimes, IT=Inflation Targeting, y=output gap,



Variables in deviation from steady state

Figure 19: Trend in variables used in the model