University of Pretoria
Department of Economics Working Paper Series

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Working Paper: 2012-32
December 2012

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ABSTRACT

This paper estimates the Bayesian dynamic stochastic general equilibrium (DSGE) model and uses the model to account for the short-run monetary policy response to increased aid inflows in Malawi. The estimates reveal that the monetary authorities reacted to increased foreign aid inflows the same way as was experienced in other African countries. The model also suggests that there was non-existence of the threats of the 'Dutch Disease' in contrast to what was found in Mozambique. The country can continue to receive aid by targeting the supply side of the economy with an aim of improving the competiveness of the export sector. Evidently, the conduct of monetary policy performs better under the assumption of full accessibility of financial assets. In addition, the impact of aid inflows on depreciation and inflation are much smaller when monetary authorities indulge in money targeting other than following the Taylor rule and incomplete sterilisation. On the small note, the study suggests that actual spending of aid should be aligned with the actual absorption of increased aid. Nevertheless, the outcome of the aid effects has been clouded out by the limitation of the exchange rate management in Malawi.

Keywords: Taylor Rule, DSGE Model, Rule-of-Thumb, Spending, Absorption, Foreign Exchange Rate, Bayesian Methods

JEL classification: C11, C13, E52, E62, F31, F35.

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1 Introduction

The main objective of this paper is to examine Malawi's short-run monetary policy response to increased aid flows using a Bayesian dynamic stochastic general equilibrium (DSGE) model. In particular, we analyse the response of the Reserve Bank of Malawi (RBM) to increased aid inflows between 1980 and 2010, assessing whether a fear of "Dutch Disease" existed. Most studies in this area on low income countries use a calibrated DSGE model instead of estimations (Tang and Vines, 2007; Adams, O'Connell, Buffie and Pattillo, 2009; Berg, Mirzoev, Portillo and Zanna, 2010). To the best of our knowledge, the only well-known paper that evaluates the monetary policy response to an aid shock using an estimated DSGE model is by Peiris and Saxegaard (2007) on Mozambique. Thus, we extend the model developed by Berg *et al*. (2010) to estimate a DSGE model using Bayesian techniques on Malawi. In addition, the study tests and compares the performance of different monetary policy rules including Taylor rule, incomplete sterilisation and money growth based on the central bank balance sheet approach.

According to the "Dutch Disease" literature, large aid inflows induce exchange rate appreciation pressures which negatively affect the export sector (Berg *et al*., 2010). The occurrence of this 'Dutch Disease' theoretically happens especially when aid induces an increase in demand for non-traded goods, leading to domestic price increases (Van Wijnbergen, 1986); Elbadawi, 1999; Adam and O'Connell, 2004; Fielding and Gilbson, 2012). Borrowing from Edwards (1989), we define real exchange rate (RER) as relative prices of traded goods sector to non-traded goods sector. Thus, an increase of domestic prices as a result of aid inflows will lead to the reduction in the RER, implying an appreciation of the exchange rate. This real appreciation is detrimental to competition in the export sector thereby damaging growth prospect for the aid recipient country.

Conversely, empirical evidence has shown that aid inflows can be associated with a depreciation of the exchange rate especially in low income countries (Ogun, 1995; Nyoni, 1998, Sackey, 2001; Ouattara and Stobl, 2003). In addition, Berg *at al*. (2010) observe that aid assists in building foreign reserves and finances government spending. This has a similar effect as domestically-financed fiscal expansion which leads to increases in money supply and creates inflationary pressures. Thus, monetary authorities are faced with the challenges of either controlling inflation or dealing with the crowding out of the private sector that arises from the sale of treasury bills due to increased aid.

Generally, two processes have to take place for official aid to be completely transferred to the recipient country. First, aid accrues initially to the government who in most cases can either spend on domestic goods or on imports (Buffie, Adam, O'Connell and Pattillo, 2004; Hussain, Berg and Aiyar, 2009; Fielding and Gibson, 2012). If government chooses to spend aid directly on imports, there will be no initial impact on the exchange rate, price level, or interest rate. But, if government spends more on domestic goods which characterises most low income countries (Gupta, Powell and Yang, 2005), there will be short-run real appreciation of the exchange rate and a shift of resources from the traded to non-traded goods sector (Fielding and Gibson, 2012). Specifically, the authorities will be required to sell the foreign exchange by removing from circulation the local currency spent by government to complete the real transfer of resources to the recipient country.

For that reason, the second option will necessitate the monetary authorities to fully accommodate government expenditures through absorption (Hussain *et al*., 2009). However, complete transfer of resources to recipient countries may yield appreciation pressures and loss of international competiveness. Hence, the authorities may choose to monetise the fiscal expansion by allowing money supply to increase, this however is inflationary. By not selling aid related foreign exchange, the recipient country may experience a larger supply of domestic currency thus pushing up the prices of foreign currency. This leads to increases in import demand and lowers export supply, hence inducing exchange rate depreciation. In addition, as explained by Hussain *et al*. (2009) the fear of inflation pressures makes monetary authorities embark on aid securitisation which raises the interest rate and crowds out private investment. In this case, there is no real transfer of resources from donors to recipient countries but it induces reallocation of resources from private to the public sector through interest rate increases. The impact of this latter option will depend upon the level of financial development and the opening of the capital account of the recipient country. Therefore, the monetary policy response to foreign aid inflows will depend upon the combination of absorption and spending options[1].

The contribution of this paper is two-fold. First, this paper improves technically on previous work in the area by estimating the DSGE model using Bayesian method as opposed to the usual method of calibrating parameters as in Smets and Wouters (2007) and Peiris and Saxegaard (2007). Second, despite the increasing awareness of the advantages of Bayesian DSGE models in recent years, no

[1]For more details about the impact of absorption and spending options of aid see Gupta, Powell and Yang (2005) and Hussain *et al*. (2009).

attempt has yet been made to explore them for the Malawian economy. The DSGE models are less susceptible to the Lucas critique and suitable for policy analysis (Teo, 2009). Borrowing from Teo (2009) explanation, the equations in the DSGE model are derived from the optimisation problems of the economic agents. Hence, the model can capture the effects of policy changes on the expectations of economic agents. As discussed earlier, aid flows involves interactions of various economic agents, namely households, firms, government and the monetary authorities. The structure of the DSGE model accommodates such interactions and allows us to understand theoretical issues and provide some explanations to some macroeconomic outcomes. The DSGE models have also been found to perform well empirically than the traditional autoregressive models (Smets and Wouters, 2003; Adolfson, Laseen, Linde and Villani, 2005; Adolfson, Linde and Villani, 2007).

Furthermore, the choices of Bayesian method of estimating this model are well explained by An and Schorfheide (2007) and Fernandez-Villarde (2009). One factor worth mentioning includes the possible use of prior distributions that incorporate additional information into the parameter estimation. The approach also accommodates the possible examination of the robustness of the results with respect to model misspecification and identification that may distort the parameter estimates in the DSGE model. The paper also takes advantage of the model developed by Ireland (2004) to introduce many shocks to capture additional stochastic dynamics that can be found in the data. This work also contributes to the proper modelling of the country's macroeconomic fluctuations. Thus, the study will help to inform policy makers of the appropriate monetary and exchange rate policy for Malawi at the time when it is anticipating aid increases in FY 2012/13.

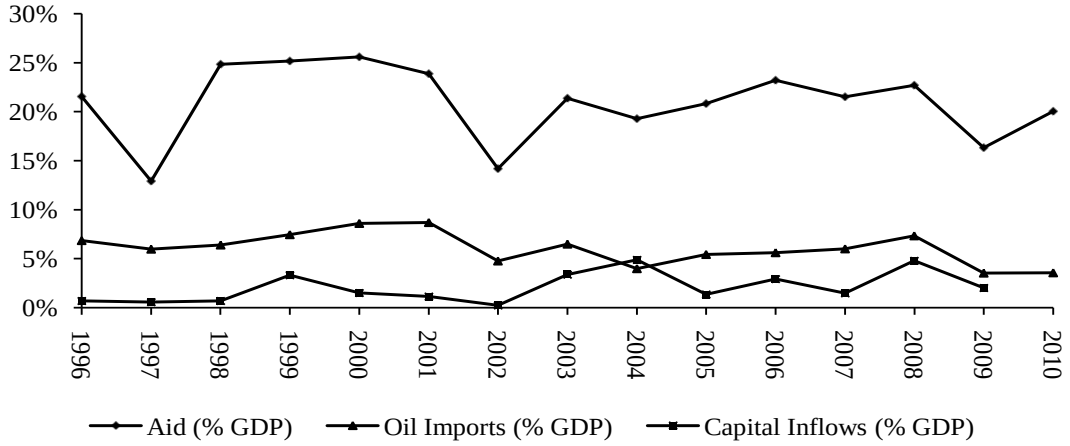
The rest of the paper is organised as follows. Section 2 provides a brief overview of macroeconomic developments and foreign aid in Malawi. Model specification is discussed in section 3. Section 4 discusses the calibration and estimation of the model using Bayesian DSGE model based on the Malawi economic structure. This section highlights in details model simulation and policy response options of managing foreign aid. Conclusion and policy implications are presented in section 5.

2 Macroeconomic Development and Foreign Aid in Malawi

Malawi is a low income country in the Sub-Saharan Africa depending on substantial inflows of foreign aid from the International Monetary Fund (IMF), the World Bank and other individual donor nations to support about 40% of resources to run the national budget (Malawi Government, 2006). In recent years, export earnings from tobacco have declined due to a combination of low international market prices and low demand for tobacco on the international market. The country has also experienced withdrawal of foreign aid due to violations of rule of law and governance issues. In tandem, the supply of foreign exchange has declined to its lowest level on the verge of the country failing to import precious commodity fuel and other raw materials for production. All these macroeconomic imbalances have been well documented in the IMF Country Report 2012 and complemented by Munthali, Simwaka and Mwale (2010).

Figure 1 shows the trend of oil import, private capital inflows and foreign aid. It is observed that the inflows have varied over the past decades and official aid inflows accounts for a lion's share as a percentage of GDP. As explained by Buffie *et al.* (2004), the erratic flows of these inflows have economic implications on achieving broader macroeconomic objective of stable exchange rate, price stability and sustainable economic growth. The big question now lies in understanding whether these shocks have short run macroeconomic consequences on inflation and exchange rate policies.

Figure 1: External Inflows in Malawi as % of GDP



Source: IMF, World Bank and OECD Data

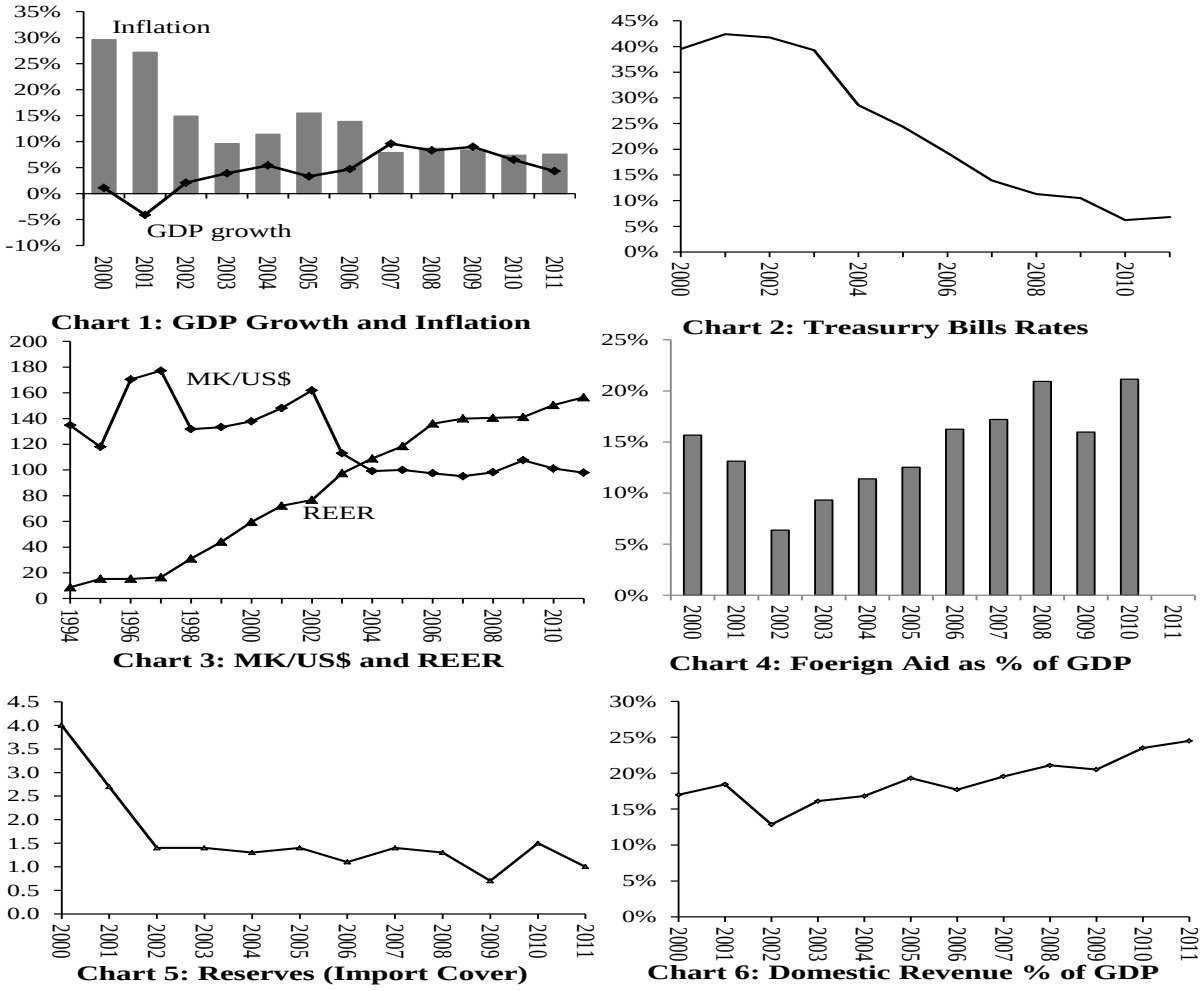
Moreover, an ODI study by Fagernas and Schurich (2004) found that aid inflows to Malawi were volatile due to slippages in the economic management. Specifically, the study observed that slippages in aid flows was due to donor withdrawal of budget support in early 1990s which resumed in 1996 and another which happened 2001 and resumed in 2006. Malawi also benefited from debt forgiveness under the Heavily Indebted Poor Countries (HIPC) initiative in 2006. The resumption of budget support has followed an increase in aid inflows to Malawi as observed from Figure 1. However, Hussain *et al*. (2009) argue that the increase in foreign aid can bring about negative macroeconomic consequences when policy reactions between the fiscal and monetary authorities are not properly coordinated. In particular, these studies argue that macroeconomic imbalances comes about when there is no coordinated response between the fiscal authorities focusing on spending and the monetary authorities indulging in absorption.

Over the same period, the evolution of economic indicators has also varied as shown in Figure 2. For the past 7 years, there has been an increase in economic growth of around 6% on average and an achievement of historical single digit inflation due to high performance of the agricultural sector. Interest rates have been declining and exchange rate per US dollar has been stable with real effective exchange rate depreciation. These movements in the exchange rates have also been documented by Munthali et al. (2010). The country also experienced increased domestic revenue and foreign aid but international reserves in terms of import cover have remained low over this period. The variation of economic indicators moves in tandem with trends in aid inflows. These imbalances between domestic revenue, foreign aid and reserves raise some important questions for further investigation. To understand the economic implication, we isolate the monetary policy response to official foreign aid increases in Malawi.

In terms of the conduct of monetary policy in Malawi, Mangani (2010) provides evidence that Malawi target broad money instead of interest rate rule and Reserve Bank of Malawi (RBM) reacts to inflation and moderate exchange rate in setting the monetary base but it does not react to output gap. In addition, the study found that the bank rate determination is largely influenced by the desire to correct disequilibria rather than economic developments. Furthermore, the conduct of monetary policy is complicated by fiscal dominance as foreign aid is taken as a source of government revenue. Therefore, this monetisation of foreign aid done through expenditure on non-tradable goods may induce inflationary effects and becomes more compounded if fiscal indiscipline is paramount. Hence, monetary

policy decisions on the combination of changes in inflation, exchange rate and interest rates will respond differently to aid inflows when compared to a normal simple Taylor rule.

Figure 2: Some Key Macroeconomic Indicators



Source: IMF Country Reports and World Bank Development Indicators

Table 1 splits the performance of key macroeconomic indicators into two periods, when the country experienced low aid inflows and the period after receiving debt relief and scaled up aid in terms of budget support. Using Hussain *et al*. (2009) methodology in calculating aid inflows, Malawi experienced increased aid inflows by 4.3% of GDP. Aid inflows through budget support also slightly increased by 0.04% of GDP indicating more flexibility for Malawi in spending aid. During the same period, real effective exchange rate depreciated during aid increase instead of the expected appreciation. However, the nominal exchange rate strengthened because the RBM managed the exchange rate peg against the US dollar. This shows that Malawi gained competitiveness which is evident in the

improvement of the terms of trade and strong export performance (Table 1). These findings are in line with what Munthali *et al*. (2010) found in their study on the real exchange rate and growth in Malawi. The study also points out that Malawi managed a crawling peg to the US dollar and exchange rate was deemed overvalued during this period. Thus by implication, Table 1 provides evidence that Malawi did not experience the signs of the Dutch disease.

Table 1: Some Key Macroeconomic Indicators

	Increase average 2004-2006	**Increase average 2007-2009**	**Difference**
Bilateral (US$) - change	11.79	1.25	
REER - change	-4.65	3.48	
Treasury bill rate	24.08	11.91	
Terms of trade	-4.65	3.97	
Exports (% of GDP)	23.88	28.57	
Of which tobacco	9.75	11.85	
Imports (% of GDP)	47.50	45.31	
Of which oil	4.67	4.81	
Net aid inflows (% of GDP -Fiscal)	13.75	16.49	2.74
Net Aid inflows (% of GDP - BoP)	12.89	17.18	4.30
Budget support (% of GDP)	3.25	3.42	0.17
Current account balance (excluding grants	-18.28	-18.32	-0.04
Change in reserves (increase -)	-1.11	0.55	1.66
Tax Revenue (% of GDP)	16.05	18.19	2.14
Domestic revenue (% of GDP)	17.94	20.60	2.66
Expenditure excl. interest payment (% of GDP)	23.57	28.48	4.91
Overall fiscal balance excl. grants	-5.63	-7.88	-2.25

Source: IMF country reports, World Bank Economic Indicators and RBM financial and economic reports

According to Berg *et al*. (2010), it is assumed that once aid is received the fiscal authorities spend all the increased aid while the monetary authority absorbs the foreign exchange proceeds realised from aid to finance imports, hence accumulating part of the aid flows in form of international reserves. With such ideal situation, total spending should match total absorption. However, empirical literature has revealed that four combinations are possible when foreign aid is received: all is a) spent and absorbed; b) neither spent nor absorbed; 3) absorbed but not spent; and 4) spent but not absorbed (Hussain *et al*., 2009). In Malawi, once foreign aid is received, the government immediately sells to the RBM and the local currency realised is spent on domestic goods. Then, the RBM decides how much of the realised aid-related foreign exchange to sell on the market and this may yield discrepancy between spending and absorption, posing great policy challenges. However, as explained by Aiyer, Berg and Hussain (2005), there will be limited policy changes in the case that government could receive aid in kind or spend direct on imports. Thus, following Hussain *et al*. (2009) procedure, the study will determine what type of combinations of absorption and spending options Malawi implemented.

Hussain *et al*. (2009) defines absorption as the extent to which the current account deficit excluding aid widens in response to an increase in aid. According to Table 1, current account deficits excluding aid widened by 0.04 % and aid inflows increased by 4.3% of GDP. Truncating the current account deficits excluding aid as a percentage of increased aid inflows between 0 and 100, incremental aid absorption in Malawi was almost 0.9% indicating that Malawi failed to absorb the increased aid during 2007 and 2009. These results are almost similar to what Hussain *et al*. (2009) found in Ghana and Tanzania.[2] However, the evidence of no absorption in Malawi contradicts what Lea and Hanmer (2009) found of full absorption of aid in Malawi. One of the factors leading to differences may maybe due to the period of the review. The data used was provisional and this time actual flows are obtained. On the other hand, international reserves deteriorated during aid increase period in support of the exchange rate peg against the US dollar. Thus, the monetary authority had control on the operation of absorption through the determination of how much of the foreign exchange is associated with aid sell and keep control over the overvalued exchange rate against the US dollar.

In the same study by Hussain *et al*. 2009, spending is defined as the widening in the government fiscal deficit excluding aid accompanying an increment in foreign aid. Calculating the spending of increased aid shows that 88% of the increased aid was spent in Malawi.[3]This evidence shows that Malawi spent almost all the aid it received during 2007 and 2009. The results in terms of spending are similar to what Lea and Hanmer (2009) found on Malawi. However, Malawi experienced an increase in taxation and domestic revenue by 2.14% and 2.66 %, respectively clouding out the evidence of whether the increased aid was fully spent. Although theory and empirical studies propose that aid can indirectly be spent by lowering taxes (Hussain *et al*. 2009), Malawi's situation was different because domestic revenue and expenditure increased during the period of increased foreign aid. The increased expenditures could be on imports or domestically produced goods and services and this condition could create tension between fiscal policy response through budget and broader macroeconomic objective of maintaining stable exchange rate and inflation.

Henceforth, Malawi fully spent and partly absorbed the increased aid the same way it was observed by Hussain *et al*. (2009) in Tanzania, Mozambique and Uganda. Hence, these patterns of absorption and

[2]Increased aid absorbed (0.9%) calculated as change of current account deficit excluding grant (-0.04) divided by the change of aid inflows (4.3) times 100 (see Table 1).
[3]Increased aid spent (88.2%) calculated as change in fiscal balance excluding grants deterioration (-2.25) divided by the change of aid inflows (2.74) times 100 (see table 1).

spending provide enough challenges for monetary policy in response to the aid increases. The task is to find out now whether increased aid inflows affected exchange rate appreciation or depreciation, inflation, and economic growth. The important question is how the monetary authority responded to these aid increases in Malawi. It will provide immediate suggestions of how to manage the anticipated aid increases following the resumption of budget support expected in FY2012/13.

3 The Model

The structure of the model and much of its notations are taken from Berg *et al*. (2010) and Dagher, Gottschalk and Portillo (2010). It is assumed that the economy comprises of the households, firms, government and Reserve Bank of Malawi (RBM) managing monetary policy. We have a small open economy with traded good (T) and a non-traded good (N) and relax the assumption of cashless economy in order to accommodate the conduct of monetary policy using money targets in low income countries. The household is categorised as either an optimising forward looking consumer who have access to capital markets or current income consumer who have no financial assets and consume their labour income (Campbell and Mankiw, 1989; Gali, Lopez-Salido and Valles, 2004). In this study, the source of uncertainty in the model is a structural shock to foreign capital inflows in form of official foreign aid. Derivations and solving the full model is done as in Berg *et al*. (2010) and Gali, Lopez-Salido and Valles (2007).

3.1 The Households

3.1.1 Optimising Households

The optimising household derives utility from consumption c_t^*, real money balances $\mathrm{m}_t^* = \frac{\mathrm{M}_t^*}{P_t}$, and l_t^* is the amount of labour supplied to the firm. A fraction λ of total households who are optimising consumers are represented by superscript "$*$". These households have access to financial markets to smooth their consumption pattern. The representative agent of this group chooses consumption, labour, money, domestic and foreign bonds to maximise life-time utility as follows:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{{c_t^*}^{1-\frac{1}{\eta}}}{1-\frac{1}{\eta}} + \frac{{m_t^*}^{1-\frac{1}{\eta}}}{1-\frac{1}{\eta}} - \frac{h{l_t^*}^{1+\psi}}{1+\psi} \right] \quad 1$$

subject to the following budget constraint deflated by domestic CPI:

$$c_t^* + m_t^* + b_t^{p*} + s_t f_t^* = w_t l_t^* + \frac{m_{t-1}^*}{\pi_t} + i_{t-1}\frac{b_{t-1}^{p*}}{\pi_t} + s_t i^f f_{t-1}^* - s_t \Psi f_t^* + \Pi_t^{*N} - \tau \qquad (2)$$

where E_0 is the expectations operation. $\beta \in (0,1)$ is the discount factor. $\eta$is the inter-temporal elasticity of substitution. h and ψ determines disutility of participating in labour market and is the inverse of the labour supply elasticity. $b_t^{p*}$is the household's real holding of government bonds earning interest rate i_t. The household also holds foreign assets f_t^* deflated by foreign price index earning interest rate i^f and are subject to portfolio adjustment Ψf_t^* (risk premium tax). $s_t = \frac{E_t P_t^f}{P_t}$ is real exchange rate where E_t is the nominal exchange rate. $w_t$is the real wage and domestic inflation is defined as $\pi_t = \frac{P_t}{P_{t-1}}$, while foreign inflation is assumed constant and equal to one. Π_t^{*N}represents household's profits from domestic firms in the non-traded sector and τ is lump sum tax collected by government.

Using the first order conditions calculated from the objective function equation 1 and the budget constraint equation 2, the following solutions are obtained for an optimising household:

$${c_t^*}^{-\frac{1}{\eta}} = \beta E_t \frac{i_t}{\pi_{t+1}} {c_{t+1}^*}^{-\frac{1}{\eta}} \qquad (3)$$

$${c_t^*}^{-\frac{1}{\eta}} = \beta E_t \left[{c_{t+1}^*}^{-\frac{1}{\eta}} \frac{s_{t+1}}{s_t} \frac{i^f}{1+\Psi' f_t^*} \right] \qquad (4)$$

$${m_t^*}^{-\frac{1}{\eta}} = \beta E_t \frac{i_t - 1}{i_t} {c_t^*}^{-\frac{1}{\eta}} \qquad (5)$$

$$h{l_t^*}^{\psi} = w_t {c_t^*}^{-\frac{1}{\eta}} \qquad (6)$$

In order to accommodate international capital mobility as explained by Berg *et al*. (2010), the portfolio adjustment cost is assumed $\Psi f_t^* = \frac{\nu^*}{2} \left[f_t^* - f^* \right]^2$ where f^* is the steady state value of the foreign assets. This accommodates a closed capital account where $\nu^* = \infty$ and partial capital account where $0 < \nu^* < \infty$. In both cases, sterilised exchange rate interventions will influence the exchange rate. As explained by Dagher et al. (2010), if the private sector's holding of foreign assets is reduced, a purchase of foreign

exchange with domestic bonds will increase expected returns on foreign assets net of adjustment costs and cause depreciation.

3.1.2 Rule-of-Thumb Households

The rule-of-thumb consumers represented by a fraction $1-\lambda$ indexed by "$**$" superscript have no access to capital markets and do not invest in financial assets and therefore depend on their current income received from non-interest activities (wages and salaries) net of lump sum tax. Hence, these household will maximise the same lifetime utility of equation 1 but subject to the following budget constraint:

$$c_t^{**} = w_t l_t^{**} - \tau^{**} \tag{7}$$

For the rule of thumb consumers, we obtain a single first order condition

$$h l_t^{**\psi} = w_t c_t^{**-\frac{1}{\eta}} \tag{8}$$

3.2 Aggregation, Consumption basket, Price indices and demand Function

The aggregates related to the consumer variables can be defined using $\aleph_t = \lambda\aleph_t^* + \ 1-\lambda\ \aleph_t^{**}$,where $\aleph_t = \ c_t, c_t^N, c_t^T, l_t, f_t, b_t^c, m_t, \Pi_t^N$, $f_t^{**} = b_t^{**c} = 0$. Individual household $j \in [0,1]$consume from traded and non-traded goods and the structure of consumption basket follows a constant elasticity of substitution (CES). The consumer price index of this basket also follows a CES structure.

$$c_t^j = \ \varphi^{\frac{1}{x}}\ c_t^{jN}\ ^{\frac{x-1}{x}} + \ 1-\varphi\ ^{\frac{1}{x}}\ c_t^{jT}\ ^{\frac{x-1}{x}\ \frac{x}{x-1}} \tag{9}$$

$$P_t = \ \varphi\ P_t^N\ ^{1-x} + \ 1-\varphi\ \ P_t^T\ ^{1-x\ \frac{1}{1-x}} \tag{10}$$

where φ is the degree of home bias in consumption and x represents the elasticity of substitution between traded goods and non-traded goods. P_t^N and P_t^T represent prices for non-traded goods and traded goods, respectively.

Government also consumes traded goods and non-traded goods, its consumption basket and prices expressed in terms of the CPI will be as follows:

$$g_t = \varphi_g^{\frac{1}{x}} g_t^{N\ \frac{x-1}{x}} + (1-\varphi_g)^{\frac{1}{x}} g_t^{T\ \frac{x-1}{x}}\ ^{\frac{x}{x-1}} \quad (11)$$

$$p_t^G = \varphi_g\ p_t^{N\ 1-x} + (1-\varphi_g)\ p_t^{T\ 1-x\ \frac{1}{1-x}} \quad (12)$$

where φ_g represents the degree of home bias in government consumption. Therefore, the demands for the consumer and government in traded goods and non-traded goods are:

$$c_t^{jN} = \varphi\ p_t^{N\ -x} c_t^j; \qquad c_t^{jT} = (1-\varphi)\ s_t\ ^{-x} c_t^j \quad (13)$$

$$g_t^N = \partial\ p_t^{N\ -x} g_t; \qquad g_t^T = (1-\partial)\ s_t\ ^{-x} g_t \quad (14)$$

where $p_t^N = \frac{P_t^N}{P_t}$ and $s_t = \frac{S_t P_t^{Tf}}{P_t}$.

3.3 Firm

In this model, supply is determined from output of non-traded and traded good producers.

3.3.1 Non-Traded Good Producers

In the non-traded goods producer (N), the firm faces the monopolistic competition and price setting behaviour based on a Calvo pricing. Its production technology is expressed as $y_t^N = \left(\int_0^1 y_{it}^{N\ \frac{\theta-1}{\theta}} di\right)^{\frac{\theta}{\theta-1}}$, where θ is the elasticity of substitution between varieties indexed $i \in [0,1]$. Assuming that most firms in Malawi are labour intensive, a simple production technology with only labour as input is adopted. Hence demand and production are represented as follows:

$$y_{it}^N = \left(\frac{p_{it}^N}{p_t^N}\right)^{-\theta} y_t^N \quad (15)$$

$$y_{it}^N = z^N\ l_{it}^{N\ \alpha} \quad (16)$$

where α is the production share of labour and z^N is the productivity coefficient in non-traded sector. And as in Rotemberg (1982), the firm faces price adjustment costs of $F\ p_t^N, y_t^N, \pi_{it}^N = p_t^N \frac{\zeta}{2} \pi_{it}^N - 1\ ^2$, where the non-traded goods inflation π_{it}^N, price and p_{it}^N are:

$$\pi_{it}^N = \pi_t \frac{p_{it}^N}{p_{it-1}^N} \quad \text{and} \quad p_{it}^N = \frac{p_{it}^N}{p_t} \quad (17)$$

The firm in the non-traded good chooses price p_{it}^N to maximise profits as follows:

$$E_0 \sum_{t=0}^{\infty} \beta \frac{c_t^*}{c_{t+1}^*} \left(p_{it}^N \left(\frac{p_{it}^N}{p_t^N} \right)^{-\theta} y_t^N \left(1 + \iota \right) - w_t^N \left(\frac{p_{it}^N}{p_t^N} \right)^{\frac{-\theta}{\alpha}} \left(\frac{y_t^N}{z^N} \right)^{\frac{1}{\alpha}} - \mathrm{F} \left(p_t^N, y_t^N, \pi_{it}^N \right) - \iota p_t^N y_t^N \right) \quad (18)$$

where ι denotes a subsidy from government financed by a tax common to the sector and this addresses the issue of distortions created by monopolistic competition (Berg *et al*., 2010). Therefore, the first order condition with respect to inflation in non-traded sector is:

$$\pi_t^N \left(\pi_t^N - 1 \right) = \beta E_t \left(\frac{c_t^*}{c_{t+1}^*} \pi_{t+1}^N \left(\pi_{t+1}^N - 1 \right) \right) + \frac{1}{\zeta} \left(\frac{\theta}{1+\iota} \left(\theta - 1 \right) \right) \left(\frac{w_t^N}{p_t^N} \right) \left(\frac{y_t^N}{z^N} \right)^{\frac{1-\alpha}{\alpha}} \left(\frac{1}{\alpha} \right) - 1 \quad (19)$$

3.3.2 Traded Good Producers

The traded good producer (T) is assumed to operate in a perfectly competitive market and the law of one price holds. Production in the traded sector is represented as follows:

$$y_{it}^T = z^T \left(l_{it}^T \right)^{\alpha} \quad (20)$$

where l_{it}^T is the amount of labour inputs used in production, α is the labour share and z^T is productivity coefficient. Thus, the firm will choose labour l_{it}^T to maximise its real profits as follows:

$$E_0 \sum_{t=0}^{\infty} J_t \left(s_t z^T \left(l_{it}^T \right)^{\alpha} - w_t^T l_{it}^T \right) \quad (21)$$

Therefore, the first order condition in the traded sector is:

$$\frac{w_t^T}{s_t} = \frac{\left(y_t^T \right)^{\frac{1-\alpha}{\alpha}}}{z^T \left(\frac{1}{\alpha} \right)} \quad (22)$$

3.4 The public Sector

The public sector is constrained with the following budget:

$$p_t^G g_t = \tau + s_t A_t - \left(d_t - \frac{d_{t-1}}{\pi_t} \right) + \left(b_t - \frac{b_{t-1}}{\pi_t} \right) - \frac{i_{t-1} \left(b_{t-1}^p \right)}{\pi_t} \quad (23)$$

where public expenditure is financed by taxes τ_t, direct proceeds earned from foreign aid $s_t A_t$, changes in deposits held at RBM $- \left(d_t - \frac{d_{t-1}}{\pi_t} \right)$ or issuing domestic debt $\left(b_t - \frac{b_{t-1}}{\pi_t} \right)$. Government also pay interest rates on its past debt held by the private sector b_{t-1}^p. Total debt is a composite of RBM debt and

debt to the private sector $b_t = b_t^{RBM} + b_t^p$. Furthermore, the fiscal policy is determined by rules for deposits and gross debt.

$$d_t = \rho_d d_{t-1} + \ 1 - \rho_d \ d + \ 1 - \gamma \ s_t A_t \qquad (24)$$

Given the steady state levels of deposits$d$, short-run initial government spending on increased aid is represented by a fraction γ and $\rho_d$is a rate at which aid related deposits are drawn down. The accumulation of government debt is represented as follows:

$$b_t = b_{t-1} - \varsigma \ b_{t-1}^p - b^p \qquad (25)$$

where ςis assumed small and positive, so that transaction effects on debt held by the private sector do not influence steady interest payments.

3.5 The Reserve Bank of Malawi

3.5.1 The Balance Sheet of RBM

We assume a simple RBM balance sheet as in Berg *et al*. (2010).

$$m_t - \frac{m_{t-1}}{\pi_t} = b_t^{RBM} - \frac{b_t^{RBM}}{\pi_t} + \ d_t - \frac{d_{t-1}}{\pi_t} \ + s_t \ R_t - R_{t-1} \qquad (26)$$

The bond transactions are influenced by changes in the deposits and changes in the reserves which may affect the changes in the monetary injection. This open market operation is adjusted to incorporate the monetary transmission when investigating the effects of absorbing aid through sterilisation. The reserve policy rule $R_t$is:

$$R_t = \rho_R R_{t-1} + \ 1 - \rho_R \ R + \ 1 - \omega \ \ A_t - A \qquad (27)$$

where$R$, and A are steady state levels of reserves, aid and nominal depreciation. The parameter ω measures the fraction of additional aid revenues. This entails that a fraction $1 - \omega$ of aid can initially be accumulated as reserves and drawn at the rate of ρ_R.

3.5.2 The Monetary Policy Rule

RBM follows a simple Taylor rule and targets non-traded sector:

$$i_t = \frac{1}{\beta} \ \pi_t^N \ \phi_\pi \qquad (28)$$

3.6 The Market Equilibrium

The labour market equilibrium is:

$$l_t = l_t^N + l_t^T = \lambda l_t^* + \ 1 - \lambda \ l_t^{**} \tag{29}$$

Equilibrium condition in the two sectors, non-traded goods N and traded goods $T$is:

$$Y_t = p_t^N y_t^N + s_t y_t^T \tag{30}$$

Equilibrium condition in the non-traded goods sector:

$$y_t^N = c_t^N + g_t^N + \mathrm{F}\ p_t^N, y_t^N, \pi_{it}^N\ , \tag{31}$$

Equilibrium condition in the external sector defined by the balance of payment in terms of the use of aid is:

$$A_t = \ c_t^T + g_t^T - y_t^T + \lambda Q \ f_t^* \ - \ i_{t-1}^f - 1 \ f_{t-1} \ + \ f_t - f_{t-1} \ + \ R_t - R_{t-1} \tag{32}$$

Equation 31states that aid can either be used to finance the current account deficit represented by terms in the square brackets or finance the capital account represented by terms in the second brackets or used to accumulate international reserves represented terms in the last bracket.

Aid A_t is officially received to carter for government spending and follows an autoregressive (AR) stochastic process:

$$A_t = A + \rho_A \ A_{t-1} - A \ + \epsilon_t^A \tag{33}$$

where$A$ denotes the steady level of aid, ρ_A represents the degree of persistent in aid increase, and ϵ_t^A is an i.i.d. shock.

3.7 The Estimated Model

The estimated model is a solution of the structural model from section 3.1 to 3.6 represented as a log-linear approximation around steady states as derived in Berg *et al*. (2010) based on the method developed by Gali *et al*. (2007). Only key equations used in the estimations are included in this section and the full version of the derived model is provided in Annex 1.The paper also incorporates shocks on key endogenous variables to capture the dynamic behaviour of the estimated model based on Ireland

(2004) paper. The full explanations about having many shocks are briefly discussed under section 2.9. These log-linearized equations include:

Uncovered Interest Parity (UIP): $\iota_t = E_t\ s_{t+1}\ - s_t + \pi_{t+1} - \upsilon_f f_t + e_t^s$ (A1)

where$\upsilon_f = \frac{\upsilon}{\lambda}$is the coefficient of portfolio adjustment costs as in Bert *et al*. (2010).

Consumption Euler Equation:$c_t = E_t\ c_{t+1}\ - \mathrm{b}_2\ \iota_t - \pi_{t+1}\ + \mathrm{b}_3\ y_t - E_t\ y_{t+1}\ + e_t^c$ $(A2)$

where $\mathrm{b}_2 = \frac{\lambda\eta\ k_c\psi - \alpha\eta^{-1}}{k_c\psi + \alpha - \ 1-\lambda\ \alpha\ 1-\psi\ ;}$; $\mathrm{b}_3 = \frac{1-\lambda\ \alpha\psi\ 1+\psi}{k_c\psi + \alpha - \ 1-\lambda\ \alpha\ 1-\psi\ ;}$;$k_c$is the share of consumption in GDP at the steady state.

The new-Keynesian Phillips curve: $\pi_t^N = \beta E_t\ \pi_{t+1}^N\ - \frac{1}{\zeta}u_t^N + e_t^\pi$ $(A3)$

where $u_t^N = -\ \frac{1-\alpha}{\alpha}\ y_t^N - w_t - \xi s_t$ is % change in the mark-up in the non-traded sector.

CPI inflation:$\pi_t^N = \pi_t - \xi\ \ s_t - s_{t-1}$ $(A4)$

Government spending:$k_g g_t = \phi s_t + \gamma k_A A_t + \ \ 1-\rho_d\ \ d_{t-1} - \ \frac{1}{\beta} - 1 + \varsigma\ \ b_{t-1}^p + e_t^g$ $(A5)$

Government deposit: $d_t = \rho_d d_{t-1} + \ \ 1-\gamma\ \ k_A A_t$ $(A6)$

Simple Taylor rule: $\iota_t = \phi_\pi \pi_t^N + e_t^i\ \ A7$

Aggregate money demand: $m_t = c_t - \epsilon\iota_t$ $(A8)$

Reserve accumulation:$R_t = \rho_R R_{t-1} + \ \ 1-\omega\ \ A_t k_A + e_t^R$ $(A9)$

Debt:$b_t^p = -km\ \ m_t - m_{t-1} + \pi_t\ \ + \ \ R_t - R_{t-1}\ \ - \ \ d_t - d_{t-1}\ \ + \ \ 1-\varsigma\ \ b_{t-1}^p + e_t^b$ $(A10)$

Labour market equilibrium: $w_t = \frac{1-\alpha}{\eta\ 1-\alpha+\psi} c_t - \frac{\psi\phi}{1-\alpha+\psi} s_t - \frac{\delta\psi}{1-\alpha+\psi} u_t^N$ $(A11)$

Output level:$y_t = -\ \frac{1-\alpha+\psi}{\alpha}\ \ \frac{1}{\eta} c_t + \phi s_t + \delta u_t^N$ $(A12)$

Internal balance: $s_t = -z_w w_t - z_c c_t - z_A A_t - z_\pi \pi_t - z_d d_{t-1} + z_b b_{t-1}^c - z_u u_t$ $(A13)$

where$\mathrm{z}_w = z_u = \frac{\alpha\delta}{1-\alpha\ \mathrm{z}}$,$\mathrm{z}_c = \frac{\varphi k_c}{\mathrm{z}}$, $\mathrm{z}_A = \frac{\gamma\varphi_g k_A}{\mathrm{z}}$,$z_\pi = \frac{km}{\mathrm{z}}$,$\mathrm{z}_d = \frac{\varphi_g\ 1-\rho_d}{\mathrm{z}}$, $\mathrm{z}_b = \frac{\varphi_g}{\mathrm{z}}\ \ \frac{1}{\beta} - 1 + \varsigma$, and $\mathrm{z} = \ 1-\varphi\ \ k_c\chi + \varphi_\mathrm{g}\phi + \delta\xi\ \ \frac{\alpha}{1-\alpha}$.

External balance: $s_t = x_w w_t + x_c c_t + x_d d_{t-1} - \ x_f\ \ f_t - \frac{1}{\beta} f_{t-1}\ \ - x_A A_t - x_R R_{t-1} - x_b b_{t-1}^c$ $(A14)$

where $x_w = \frac{\alpha\ 1-\delta}{1-\alpha\ \mathcal{H}}$, $x_c = \frac{1-\varphi\ k_c}{\mathcal{H}}$, $x_A = \frac{k_A\ \omega - \ 1-\varphi_g\ \gamma}{\mathcal{H}}$, $x_R = \frac{1-\rho_R}{\mathcal{H}}$, $x_f = \frac{1}{\mathcal{H}}$, $x_d = \varepsilon_d \frac{\mathrm{E}}{\mathcal{H}}$, $x_b = \varepsilon_b \frac{\mathrm{E}}{\mathcal{H}}$, and $\mathcal{H} = \ \ 1-\varphi\ \ k_c\chi - \ \ 1-\varphi_g\ \ \phi + \frac{\alpha\ 1-\delta}{1-\alpha}$.

Aid: $A_t = \rho_A A_{t-1} + \epsilon_t$ $(A15)$

The impact of the combination of spending and absorption options on exchange rate can be explained by equation A13 and A14. In particular, spending on aid can be explained by the internal balance Equation A13. An increase in aid A_t will lead to the appreciation of the exchange rates_t. Specifically, the coefficient z_A entails that when the degree of initial aid spent γ increases combined with positive share of government spending of non-traded goods φ_g and share of aid in GDPk_A, the exchange rate appreciates while a decline leads to the depreciation of the exchange rate. Absorption of aid inflows is defined through the external balance Equation A14. Apart from the share of aid in GDP, initial aid spent and spending on non-traded goods, the exchange rate can appreciate by increasing the rate of reserve accumulationω. Therefore, increasing the degree of reserve accumulation will lead to exchange rate appreciation while a decline will lead to a depreciation of the exchange rate.

3.8 Stochastic Shocks

As in Ireland (2004), the study attempts to augment the log linearised DSGE model with the flexibility of the vector autoregressive (AR) time series. In particular, the model includes many shocks to estimate the model and ensure that it is not stochastically singular. This will allow the model to capture the movements in the actual data used in the estimations that cannot be explained by the theory. In addition, by incorporating only the aid shock as a driver of all business cycle fluctuation, most endogenous variables becomes deterministic and this makes it difficult to estimate the model (see Ireland, 2004; Peiris and Saxegaard, 2007). Accordingly, we assume that all exogenous shocks included in the UIPe_t^s, consumption Euler equation e_t^c, non-traded inflation e_t^π, government spending e_t^g, Taylor rulee_t^i, reservese_t^R, and open market operationse_t^b follow a first order AR stochastic process. Therefore, the basic model comprises of the log linear equations A1 to A15. The actual estimation of this model system is based on the policy requirements to be made to accommodate the interaction of spending and absorption policy mix and various monetary policy instruments.

4 Calibration and Estimation of the Model

In estimating our DSGE model, we adopt the Bayesian procedure which depends on specifications of priors (beliefs) as in Smets and Waters (2007), Peiris and Saxegaard (2007) and DeJong, Ingram and

Whiteman (2000). Before estimations, the study discusses the sources and treatment of actual data, the calibration of the parameters and choice of the priors to be included in the estimation. The study attempts to include many shocks to ensure non-singularity and the number of shocks is assumed at least as large as the number of observations to enable us estimates the model using Bayesian techniques. The section ends with sensitivity analysis of the estimations.

4.1 Data

The estimation of the model is based on the quarterly data for Malawi between 1980:1 and 2010:4.The period was chosen to align with the implementation of the financial reforms under the support of the Britton wood institutions. The key macroeconomic variables used included consumption, output, government expenditures, aid flows, real exchange rate, real interest rate and CPI inflation. Other endogenous variables included in the model are assumed to be unobservable in the estimations. Data collected annually such as GDP, consumption and aid inflows were transformed into quarterly data based on the methodology in Mwabutwa, Bittencourt and Viegi (2012) study. The data series were transformed into real variables by deflating with CPI deflators except the real interest rate data which was calculated according to the formula $1+r_t = \frac{1+i_t}{1+\pi_t}$, where r_t is real interest rate, i_t is nominal interest rate and π_t is inflation (Chipeta and Mkandawire, 1991). The Hodrick-Prescott filter was applied to remove the trend in the observations. In addition, data with evidence of seasonality were transformed using the X12 arima filter as in Peiris and Saxegaard (2007) paper on Mozambique.

4.2 Calibration and Choice of Priors

Calibration is presented in Table 2, but the values used are tentative and work will continue to obtain proper parameters. The structural parameters of the model are based either on the structure of Malawi economy or chosen in line with the literature. The calibrated key steady state parameters were based on the annual data taken from IMF-IFS and WDI over the period of 2000 to 2009.These include non-traded sector, government spending, consumption, money and aid prior to the aid increases from 2004 to 2006. The value of the discounting factor β is a standard measure from Gali and Monacelli (2005). Malawi is agricultural based and agriculture accounts for over 38% of GDP and employs about 85% of the labour force and contributes about 82% of foreign exchange earnings (Regional Programme on Enterprise Development, 2006). Accordingly, labour share is calibrated based on the labour involved in agricultural production as provided in the Malawi Investment Climate Assessment of 2006. The elasticity of

substitution of traded and non-traded goods is estimated using a simple OLS import demand function as in Aydm *et al*. (2004)[4]. The country operates a closed capital account and hence the value of vb is set very large as in Berg *et al*. (2010).

Table 2: Calibration of Model Parameters

Parameters Description	Value	Source
β Discounting factor	0.99	Gali & Monacelli (2005)
ψ Inverse elasticity of labour supply	2	Berg *et al*. (2010)
χ Elasticity of substitution of traded and non-traded goods	0.83	Malawi Data
α Labour share	0.74	MICA 2006
φ Degree of home bias in consumption	0.60	National Accounts
δ Non-traded sector's share of employment and GDP	0.75	National Accounts
λ Access to financial markets	0.45	FinScope Malawi (2008)
κ Aggregate interest semi-elasticity of money demand	0.07	Malawi Data
η Elasticity of substitution	2	Adam *et al* (2007)
Vb Measures international capital mobility	100000000	Berg et al. (2010)
κ_c Share of consumption in GDP	0.80	Ngalawa *et al.* (2010)
κ_g Share of government spending in GDP	0.24	IMF-Country Report
κ_A Share of Aid in GDP	0.12	IMF-County Report
κ_m Share of money in GDP (13.91%)	0.13	IMF-Country Report

Peiris and Saxegaard (2007) argue that Bayesian estimation technique allows the incorporation of prior based on theoretical or empirical knowledge through the specifications of prior distribution for the parameters to be estimated. Thus, some priors are chosen based on the convention of the main theoretical and empirical restrictions imposed on some parameters. Where there is little theoretical and empirical evidence, diffuse priors are employed. Specifically, for positive parameters, gamma distribution is assumed, beta distribution is chosen for parameters which vary between one and zero, all shocks carry an inverse gamma distribution with a mean of 0.10 and the rest have a normal distribution. For instance, empirical investigations show that most African countries do not set targets on interest rates (Berg *et al*. 2010). Thus, a simple Taylor rule is included with a standard ϕ_π equal to 1.5 as in Gali and Monacelli (2005). Assuming the prices are sticky for almost 4 quarters, we adopt the standard measure of nominal rigidities ζ as in Dagher *et al*. (2010). The choice of the rate of spending on aid

[4]For the simple import demand function see appendix 2a

and rate of drawing down accumulated reserves is based on the Uganda study which assumed persistent accumulation of reserves and an increase in aid having a short term life of less than six months. Access to financial markets represented by λ is based on FinScope Malawi 2008 survey. The survey found that about 55% of the adult population of Malawi manage their lives without using any formal and informal financial products.

4.3 Estimation Results

Table 3 and plots in annex 5A-5C provide visual representation of priors and estimations which were conducted in Dynare software Package using Matlab (Juillard, 2004). The estimates are only obtained from the baseline scenarios and are discussed in line with key findings by Bert *et al.* (2010), Peiris and Saxegaard (2007) and Tang and Vines (2007). The mode, means and the 5 and 95 percentiles of the posterior distribution of the parameters were obtained by the Metropolis-Hastings algorithm in Dynare. According to the plots, the data used is informative about the parameter estimates for the model. The Bayesian estimation method appears to deliver reasonable parameter estimates.

Table 3 also shows that the behaviour of the main parameters of the mean of the posterior distributions is typically relatively close to the mean of the prior assumption. However, there are few discrepancies that are worth discussing. The rate of drawing down reserves is estimated about 1.01 a bit higher than 1.00. These higher drawings are an indication in support of maintaining the fixed or managed exchange rate regime. This is also evident that the coefficient of fixed price is about 12.37 higher than the prior estimates. On the monetary policy reaction function, the estimated coefficient of the mean of the long-run coefficient to inflation 2.2 is relatively higher than the standard of 1.5.This implies that monetary authorities reacted to inflation pressures. The rate of spending is estimated at 0.95 and the coefficient of drawing down aid related deposits is about 0.59 lower than what was expected. In terms of exogenous shocks, data appears to provide informative data. The Taylor rule and government spending processes are estimated to be the most persistent with an AR (1) coefficient of 0.87 and 0.67, respectively. The mean of the standard error of the shock to the aid process is 0.12 less persistent than ones on government debt and reserves. This implies that most of the forecast error variances of the real variables are explained by government debt and reserves.

Table 3: Estimated Parameters of the Model

		Prior distribution		Posterior distribution			
Parameters	**Density**	**Mean**	**Stdev**	**Mode**	**Mean**	**5 %**	**95 %**
Structural Parameters							
ζ	gamma	12.000	1.000	12.317	12.374	10.872	13.889
λ	beta	0.450	0.100	0.445	0.443	0.278	0.601
ε	gamma	0.900	0.100	0.889	0.896	0.727	1.062
ω	gamma	1.000	0.100	0.985	1.008	0.849	1.159
γ	gamma	1.000	0.100	0.941	0.950	0.798	1.105
φ_g	beta	0.700	0.100	0.722	0.700	0.543	0.871
ϕ_π	normal	1.500	0.500	2.154	2.163	1.912	2.420
ρ_R	gamma	0.900	0.010	0.923	0.923	0.914	0.932
ρ_d	gamma	0.900	0.500	0.571	0.591	0.273	0.999
Shocks							
ρ_A	gamma	0.900	0.100	0.664	0.667	0.579	0.754
Rho1	beta	0.500	0.100	0.500	0.499	0.332	0.670
Rho2	beta	0.500	0.100	0.445	0.439	0.345	0.533
Rho3	beta	0.500	0.100	0.889	0.873	0.815	0.933
Rho4	beta	0.500	0.100	0.352	0.352	0.297	0.404
Rho5	beta	0.500	0.100	0.286	0.296	0.194	0.394
Rho6	beta	0.500	0.100	0.670	0.666	0.586	0.740
Rho7	beta	0.500	0.100	0.356	0.357	0.300	0.418
Standard deviation of shocks							
eA	invg	0.150	0.150	0.119	0.121	0.108	0.134
eS	invg	0.150	0.150	0.086	0.149	0.045	0.258
eINFL	invg	0.150	0.150	0.026	0.027	0.024	0.030
eI	invg	0.150	0.150	0.095	0.097	0.083	0.111
eB	invg	0.150	0.150	2.304	2.329	2.103	2.558
eC	invg	0.150	0.150	0.144	0.149	0.124	0.173
eG	invg	0.150	0.150	0.123	0.124	0.111	0.137
eR	invg	0.150	0.150	1.642	1.662	1.500	1.834

4.4 Monetary Policy Response Options

This section analyses the dynamic effects of positive aid shock on key macroeconomic variables. The discussions are based on two main policy scenarios. The first scenario is when aid is fully spent and absorbed and the second is when aid is fully spent but not fully absorbed in a closed capital account. Under each scenario, three different monetary policy reactions to increased aid are analysed and these include monetary authorities a) reacting to CPI inflation using simple Taylor rule; b) conducting sterilisation in the money market and c) using money target in the conduct of their monetary policy. The section closes with the sensitivity analysis examining the responses when all households are assumed

optimising agents, under flexible prices, open capital account and government spend what the monetary authorities can absorb.

4.4.1 A Scenario When Aid is Completely Spent and Completely Absorbed

The baseline response of the shocks in the model variables when aid is completely spent and fully absorbed are summarised in Figure 3.[5]Under closed capital account with nominal rigidities, increased aid leads to increased government expenditures. The increased government expenditure especially on domestic goods induces demand on non-traded goods fuelling inflation pressures. Accordingly, the real exchange rate appreciates and creates a reallocation of resources from traded goods sector to domestic goods sector. The latter happens only when the foreign exchange realised from aid induces an increase in net imports also called absorption. This implies that consumption expands for a given output level. However, the increase in the overall output will depend upon the net effect of appreciation in the traded and non-traded sector. In this situation, the increase in non-traded inflation is minimal and thus the effects on output are almost negative. The deflation in the traded sector leads to CPI inflation decreases and real interest rates remain unchanged.

The study also modify the Taylor rule in the baseline as in Berg *et al.* (2010) to accommodate the incomplete sterilisation mechanism that increases in reserves cannot only be financed from sterilisation but also from increases in the stock of money.[6] In addition, Mangani (2010) observed that the implementation of monetary policy in Malawi is based on setting operational targets on monetary aggregates. Following this pertinent observation, the study also modify the simple Taylor rule as was done in Berg *et al*. (2010) on Uganda study.[7]In simple terms, interest rates increases when consumption growth increases with coefficient of past interest rates equal one. When the two variant Taylor rules are compared with the base line in Figure 3, the monetary policy response between the simple Taylor rule and incomplete sterilisation are almost similar. However, responses under money targeting results in minimal appreciation of the exchange rate. Real interests are slight higher because of domestic inflation pressures.

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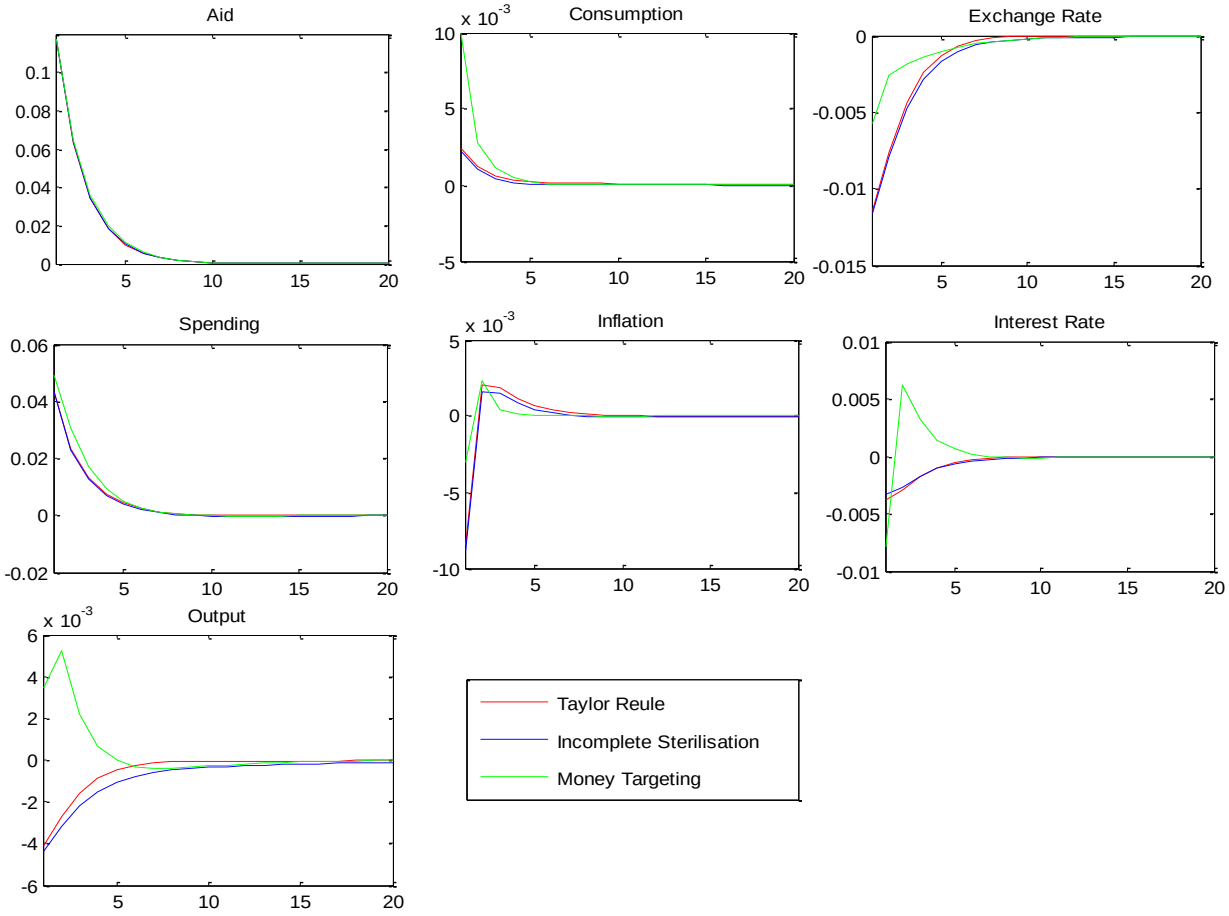
[5]The current account deficit equation $ca_t = k_A \quad 1 + \phi \; s_t + A_t - y_t \; - \; R_t - R_{t-1}$ is also included in the estimations (Berg *et al*., 2010).

[6]Modified variant Taylor rule is$r_t = \phi_\pi \pi_t^N - \frac{1-\varepsilon}{k_m \vartheta} \; R_t - R_{t-1}$ and the full derivation is done by Berg et al (2010).

[7]We use the following variant Taylor rule $r_t = \frac{1+\phi_\pi^m}{\vartheta}\pi_t + \frac{1}{\vartheta} \; c_t - c_{t-1} \; + r_{t-1}$ as in Berg et al. (2010).

Figure 3: Response to Aid Shock - Aid Fully Spent and Fully Absorbed



4.4.2 A Scenario When Aid is Completely Spent and Not Absorbed

Based on the discussions from section 2, impulse responses to aid shock presented in Figure 4 describes a situation whereby Malawi completely spent aid but failed to absorb the increased aid in a closed capital account. Specifically, the government increased expenditures but the RBM did not sell the foreign exchange required to finance additional net imports. In this scenario, the real exchange rate depreciates in the short run resulting from the larger supply of local currency pushing up the prices of foreign exchange. The lack of sales of foreign exchange to mop up the increased liquidity also leads to increases in money supply which fuels inflation pressures. In order to counter inflation pressures, the monetary authorities react through sterilisation and inducing more private sector participation in the purchase of domestic bonds leading to real interest rate increase.

Figure 4: Response to Aid Shock - Aid Fully Spent and Not Absorbed

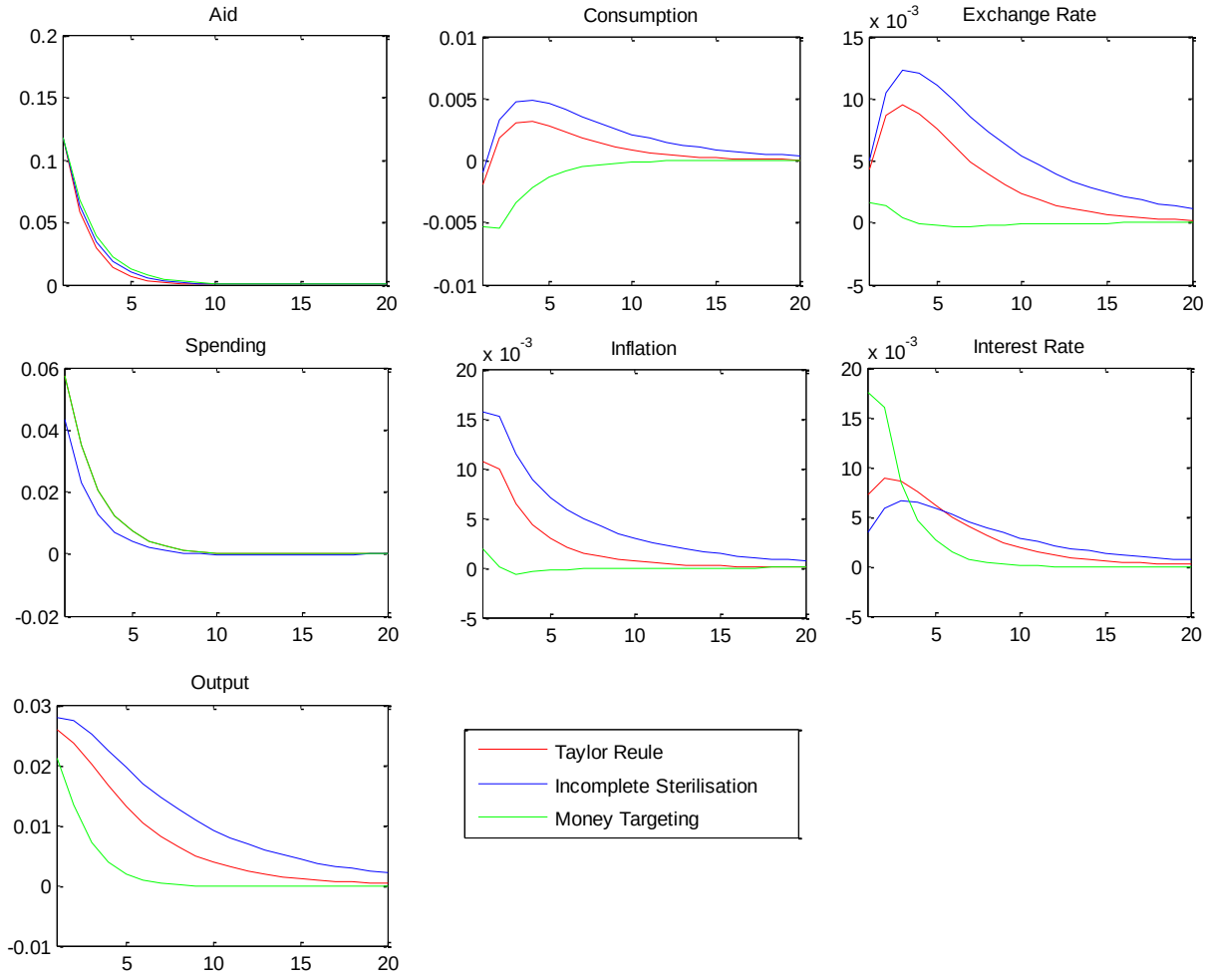


Figure 4 also illustrates the performance among the three monetary policy rules including Taylor rule, incomplete sterilisation and money targeting. Larger depreciation of the exchange rate and output are observed under the incomplete sterilisation rule emanating from increased demand pressures. In particular, significant private consumption is crowded out which comes at the cost of using increased aid resources twice. The realised foreign exchange value of increased aid resources are used to accumulate reserves and at the same time the equivalent domestic currency counterpart are used to increase government spending. Real interest rates also increase responding to CPI higher inflation. The impact on inflation is smaller under money targeting when increased aid is fully spent and not absorbed because the inflation remains well fixed by the presence of the lagged interest rate in the policy rule. Berg *et al.*(2010), however, argue that this does not mean the superiority of money targeting policy to the simple interest rate rule. Arguments are based on what Woodford (1999) found that fixing the role of lagged

interest rate is not specific to money targeting but is instead a general property of optimal rules. Furthermore, these studies argue that money targeting is subject to the instability and volatility of money demand.

4.5 Sensitivity Analysis

The robust check of the model is cross examined in Annex 3 and 4. First, the study assumes that the non-asset holders fall from 55% to 0%. The monetary policy response varies when aid received is fully absorbed or not. In the situation whereby the aid is fully absorbed, the results are almost similar to the baseline (Taylor rule) despite having different magnitudes. However, the results changes when the aid is not fully absorbed. The demand pressures become smaller and the real exchange rate slightly appreciates when compared with bigger depreciation in the Malawi scenario. This entails that the presence of non-asset holders amplifies demand pressures and the effects are larger than when we have many households who are non-optimising agents.

Second, simulations under sticky prices are similar to the flexible price counter-part of no reserve accumulation. However, the performance under flexible price is different from the fixed price scenario when aid is fully spent and not absorbed (see Annex 4). It is observed that output and inflation increases with small exchange rate appreciation under flexible price but lower than the baseline scenario. The outcome contradicts with what Bert *et al.* (2010) found on Uganda and is consistent with the reality whereby the exchange rate was believed to be overvalued and deliberately kept stable against macroeconomic conditions prevailing in the country (Munthali *et al*., 2010).

Third, in the case of open capital account, a small value of capital mobility (vb = 0.0125) is assumed. When all aid is fully absorbed, adjustments entails significantly more increase in domestic relative prices, while the annualised interest rate increases. However, appreciation of exchange rate is smaller when compared with the baseline scenario. Other impacts on inflation and real interest rate are smaller under less aid absorption. With open account, the private sector's consumption is less pro-cyclical as it can now smooth more efficiently over temporary aid flow by indirectly accumulating net foreign assets vial bond market. In case of reserve accumulation, opening the capital account will allow capital inflows when the private sector borrows from the rest of the world.

Last, attempts have also been made to cross check the impulse response in terms of spending only what the monetary authorities can manage to absorb. In this case, we assume that 0.5 of increased aid is initially spent and the same 0.5 is fully absorbed by RBM. Annex 3 shows that minimal exchange rate appreciation which remains flatter over time can be observed. There are also minimal changes in inflation and interest with high consumption and income under this scenario. However, the interpretation of these results should be taken cautiously because variations of the coefficients also depend upon the combination of other variables. In addition, the choice of this option is in violation with donor agreements and government who would like to see that aid is immediately and fully spent for accountability purposes.

5 Conclusion

Generally the estimation results are robust in the numerical posterior kernel maximisation and the convergence of the MH algorithm. Information about many parameters seems to be well explained by the actual data. Specifically, the parameter estimates of interest are mostly in line with what is found in the literature and trends in most macroeconomic variables in Malawi. However, worth noting is the estimated coefficient of inflation in the Phillips curve which is higher than what was found by Peiris and Saxegaard (2007) on Mozambique. This finding provides evidence that monetary authorities reacts to aid inflows in Malawi. In addition, the study reveals that other exogenous shocks are driving the Malawi business economic fluctuations.

The paper evidently shows that aid inflows appear to be associated with depreciations of the exchange rate than the expected real appreciation. However, the impact of aid inflows on depreciation and inflation are much smaller when monetary authorities indulge in money targeting other than following the Taylor rule and incomplete sterilisation. The result of depreciated exchange rate is similar to what was found in Uganda by Berg *et al.* (2010), in Ghana by Sackey 2001 and in Tanzania by Nyoni (1998), though the latter two used different methodologies. However, Peiris and Saxegaard (2007) estimated an appreciation of the exchange rate in Mozambique. Other studies in support of the appreciation of the exchange rate are Ouattara and Strobl (2008) on CFA Franc countries and Adenauer and Vagassky (1998) on Francophone West African countries. Based on Berg *et al*. (2010) observations, this paper would have argued that the monetary authorities in Malawi deliberately limited the absorption of the

increased aid because of the fear of the 'Dutch Disease'. In addition, it would have been fare to conclude that the increased aid in Malawi was used to build up foreign reserves. However, the country experienced a decline in the already low level of international reserves. As discussed in several IMF country reviews, the management of exchange rate was not in tandem with the prevailing macroeconomic conditions experienced during the aid surge. This may have contributed to the puzzle of short-run monetary policy effects coming out from the management of aid increases between 2006 and 2009.

The paper also demonstrates that Malawi can continue receiving donor assistance because aid increases in Malawi is associated with exchange rate depreciation. Hence, the increased aid in Malawi does not impact negatively on the competitiveness of the export sector. The increased aid can be used to finance the supply side of the economy which can boost further the export sector. In the long run, the country may achieve sustainable supply of foreign exchange and economic growth. Nevertheless, the misalignment of the exchange rate clouds out the actual effects of the increased aid and hence the interpretation of the outcomes has to be done cautiously. Evidently, scaling up of foreign aid requires strong absorption capacity on the part of RBM but in support with proper fiscal policy decisions. Though with caution, it would be suggestive for RBM to only convert the aid related foreign exchange in line with what government is supposed to spend at a particular time. The unsterilized aid should be kept in the foreign denominated account as a buffer until government needs arises. This will cushion pressure on the part of RBM from sterilisation so that the private sector is not crowded out. In essence, this will require heavy lobbying and commitment on the part of government with development partners.

Furthermore, the study shows that the implications of increased aid inflows become more prominent in an economy comprising of few economic agents having access to financial assets. This calls for a need to refocus on improving or developing a vibrant financial sector that will allow households having more access to financial assets. In addition, other facilities such as opening the capital account and non-interference in prices will cement the proper conduct of monetary policy in Malawi. The study particularly shows that the impacts are dampened when the economy is open with minimal controls over prices.

In future, this paper can be extended to consider other aspects not covered in this study to further enhance the possibilities surrounding the estimation of the Bayesian DSGE model. Specifically, more

work is required to examine how the real sector (e.g. investment) reacts to aid increases. It would also be interesting to estimate the effects of other inflows such as private capital inflows, remittances, commodity prices (tobacco prices) and proceeds realised from uranium on Malawi economy. Moreover, issues of heterogeneity of aid inflows are not covered in this paper as aid can either be categorised in terms of project or programme/budget support. Thus the effects will depend upon the focus of these modalities.

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Annex 1: The log-Linearised Model

Following the methodology by Gali *et al*. (2007) and full version derived in Berg *et al*. (2010), the solutions of the general model is represented as a log-linear approximation around the steady state. The lower cases with hats represent log-deviations from the steady state ($x_t \equiv log\, X_t \;\; X$), otherwise indicates changes in % of steady states. The derived solutions of some log-linear versions are a combination of set of equations and only key equations are included in this section.

In steady state as in Berg *et al.* (2010), stock variables ($b^c, d^g, R,$ and f) are set equal to zero. The productivity parameter in the non-traded good Z^N and traded good sector Z^T and the labour disutility h are set as follows:

$$Z^N = \delta^{1-\alpha};\; Z^T = \;\; 1-\delta \;^{1-\alpha};\; h = \tfrac{\alpha}{k_c}.$$

δ is the share of non-traded good sector in GDP and k_i is the share of variable i in GDP. Other constraints regarding solving problems of distortions in monopolistic completion, non-traded equilibrium and the balance of payments are set as follows:

$$\iota = \tfrac{1}{\theta-1};\; \delta = \varphi k_c + \varphi_g k_g;\; 1-\delta = \;\; 1-\varphi \;\; k_c + \;\; 1-\varphi_g \;\; k_g - k_A$$

Home bias in consumption ξ and home bias in production relative to consumption ϕ are set as:

$$\xi = \tfrac{1-\varphi}{\varphi} > 0;\; \text{and}\; \phi = \delta\xi - \;\; 1-\delta \;\; = k_A + \xi k_g \;\; \varphi_g - \;\; 1-\varphi_g \;\; \tfrac{1}{\xi} \;\; > 0$$

where ξ measures home bias in consumption. The share of aid is related to ϕ and the share of government spending on non-traded good φ_g. This study is limited to where $\phi > 0$ so that home bias in production is larger than home bias in consumption.

The Consumer Price Index (CPI) is derived from equation 10:

$$p_t{}^N = -\xi s_t; \qquad \text{where } \xi = \tfrac{1-\varphi}{\varphi} \qquad (A1)$$

The real GDP is derived by combining the log-linear equations 16 and 20:

$$y_t = \alpha\, l_t \qquad (A2)$$

The labour supply is obtained by combining the log-linear equations 6 and 8:

$$y_t = \tfrac{\alpha}{\psi} \;\; w_t - \tfrac{1}{\eta} c_t \qquad (A3)$$

The interest rate parity is derived by combining the log-linear equations of 3 and 4:

$$\iota_t = E_t\ s_{t+1}\ - s_t + \pi_{t+1} - \upsilon_f f_t \qquad (A4)$$

where$\upsilon_f = \frac{\upsilon}{\lambda}$is the coefficient of portfolio adjustment costs as in Bert et al. (2010).

The consumption Euler equation is obtained by combing the log-linear equations of 3, 7, and 8:

$$c_t = E_t\ c_{t+1}\ - \mathrm{b}_2\ \iota_t - \pi_{t+1}\ + \mathrm{b}_3\ y_t - E_t\ y_{t+1} \qquad (A5)$$

where $\mathrm{b}_2 = \frac{\lambda\eta\ k_c\psi - \alpha\eta^{-1}}{k_c\psi + \alpha - \ 1-\lambda\ \alpha\ 1-\psi\ ;}$; $\mathrm{b}_3 = \frac{1-\lambda\ \alpha\psi\ 1+\psi}{k_c\psi + \alpha - \ 1-\lambda\ \alpha\ 1-\psi\ ;}$;$k_c$is the share of consumption in GDP at the steady state.

The new-Keynesian Phillips curve is derived from equation 19:

$$\pi_t^N = \beta E_t\ \pi_{t+1}^N\ - \frac{1}{\zeta} u_t^N \qquad (A6)$$

where $u_t^N = -\ \frac{1-\alpha}{\alpha}\ y_t^N - w_t - \xi s_t$ is % change in the mark-up in the non-traded sector.

CPI inflation is obtained by deriving equation 17:

$$\pi_t^N = \pi_t - \xi\ \ s_t - s_{t-1} \qquad (A7)$$

The supply of traded goods is obtained from equation 22:

$$y_t^T = -\frac{\alpha}{1-\alpha}\ w_t - s_t \qquad (A8)$$

Government total spending is obtained by combining log-linear equations of 12, 23, 24and 25:

$$k_g g_t = \phi s_t + \gamma k_A A_t + \ \ 1 - \rho_d\ \ d_{t-1} - \ \ \frac{1}{\beta} - 1 + \varsigma\ \ \ b_{t-1}^p \qquad (A9)$$

The government deposit is obtained by taking log-linear equations 24:

$$d_t = \rho_d d_{t-1} + \ \ 1 - \gamma\ \ k_A A_t \qquad (A10)$$

The simple Taylor rule is obtained by taking the log-linear of equation 28:

$$\iota_t = \phi_\pi \pi_t^N + e_t^i \qquad (A11)$$

The reserve accumulation rule is derived from 27:

$$R_t = \rho_R R_{t-1} + \ \ 1 - \omega\ \ A_t k_A \qquad (A12)$$

The government debt is derived from equation 24 and 26:

$$b_t^p = -km\ \ m_t - m_{t-1} + \pi_t\ \ +\ \ R_t - R_{t-1}\ \ -\ \ d_t - d_{t-1}\ \ +\ \ 1 - \varsigma\ \ b_{t-1}^p \qquad (A13)$$

The labour market equilibrium is derived from equation 31and labour demands in each sector and labour supply.

$$w_t = \frac{1-\alpha}{\eta\ 1-\alpha+\psi}c_t - \frac{\psi\phi}{1-\alpha+\psi}s_t - \frac{\delta\psi}{1-\alpha+\psi}u_t^N \quad (A14)$$

The output level consistent with the equilibrium labour market is:

$$y_t = -\ \frac{1-\alpha+\psi}{\alpha}\quad \frac{1}{\eta}c_t + \phi s_t + \delta u_t^N \quad (A15)$$

Internal balance explaining behaviour of exchange rate is derived by combining demand for non-traded goods $c_t^N = c_t + \ 1-\varphi\ \chi s_t$, government spending on non-traded goods $g_t^N = g_t$and supply into equation 31.

$$s_t = -\varepsilon_w w_t - \varepsilon_c c_t - \varepsilon_A A_t - \varepsilon_d d_{t-1} + \varepsilon_b b_{t-1}^c - \varepsilon_u u_t \quad (A16)$$

where $\mathrm{z}_w = z_u = \frac{\alpha\delta}{1-\alpha\ \mathrm{E}}$, $\mathrm{z}_c = \frac{\varphi k_c}{\mathrm{E}}$, $\mathrm{z}_A = \frac{\gamma\varphi_g k_A}{\mathrm{E}}$, $\mathrm{z}_d = \frac{\varphi_g\ 1-\rho_d}{\mathrm{E}}$, $\mathrm{z}_b = \frac{\varphi_g}{\mathrm{E}}\ \frac{1}{\beta} - 1 + \varsigma$, and $\mathrm{z} = 1-\varphi\ k_c\chi + \varphi_g\phi + \delta\xi\ \frac{\alpha}{1-\alpha}$.

External balance explaining the behaviour of exchange rate is derived by combining demand for traded goods $c_t^T = c_t + \ 1-\varphi\ \chi s_t$, government spending on traded goods $g_t^T = g_t$and supply into equation 32.

$$s_t = x_w w_t + x_c c_t + x_d d_{t-1} - \ x_f\ \ f_t - \frac{1}{\beta}f_{t-1}\ \ - x_A A_t - x_R R_{t-1} - x_b b_{t-1}^c \quad (A17)$$

where $x_w = \frac{\alpha\ 1-\delta}{1-\alpha\ \mathcal{H}}$, $x_c = \frac{1-\varphi\ k_c}{\mathcal{H}}$, $x_A = \frac{k_A\ \omega - \ 1-\varphi_g\ \gamma}{\mathcal{H}}$, $x_R = \frac{1-\rho_R}{\mathcal{H}}$, $x_f = \frac{1}{\mathcal{H}}$, $x_d = \varepsilon_d\frac{\mathrm{E}}{\mathcal{H}}$, $x_b = \varepsilon_b\frac{\mathrm{E}}{\mathcal{H}}$, and $\mathcal{H} = \ 1-\varphi\ k_c\chi - \ 1-\varphi_g\ \phi + \frac{\alpha\ 1-\delta}{1-\alpha}$.

Annex 2 a: The Import Demand Function based on Aydem et al. (2004)

The elasticity of substitution is estimated using the following import demand function:

$$lnZ_t = a_1 + a_2 lnY_t + a_3 ln\ \left(\frac{PZ}{PD}\right)_t + \mu_t$$

Where Z_t is the quantity of imports, PZ is the import price, PD is the domestic price level, Y_t is GDP and μ_t is the error term. The parameter representing the elasticity of import demand is a_3.

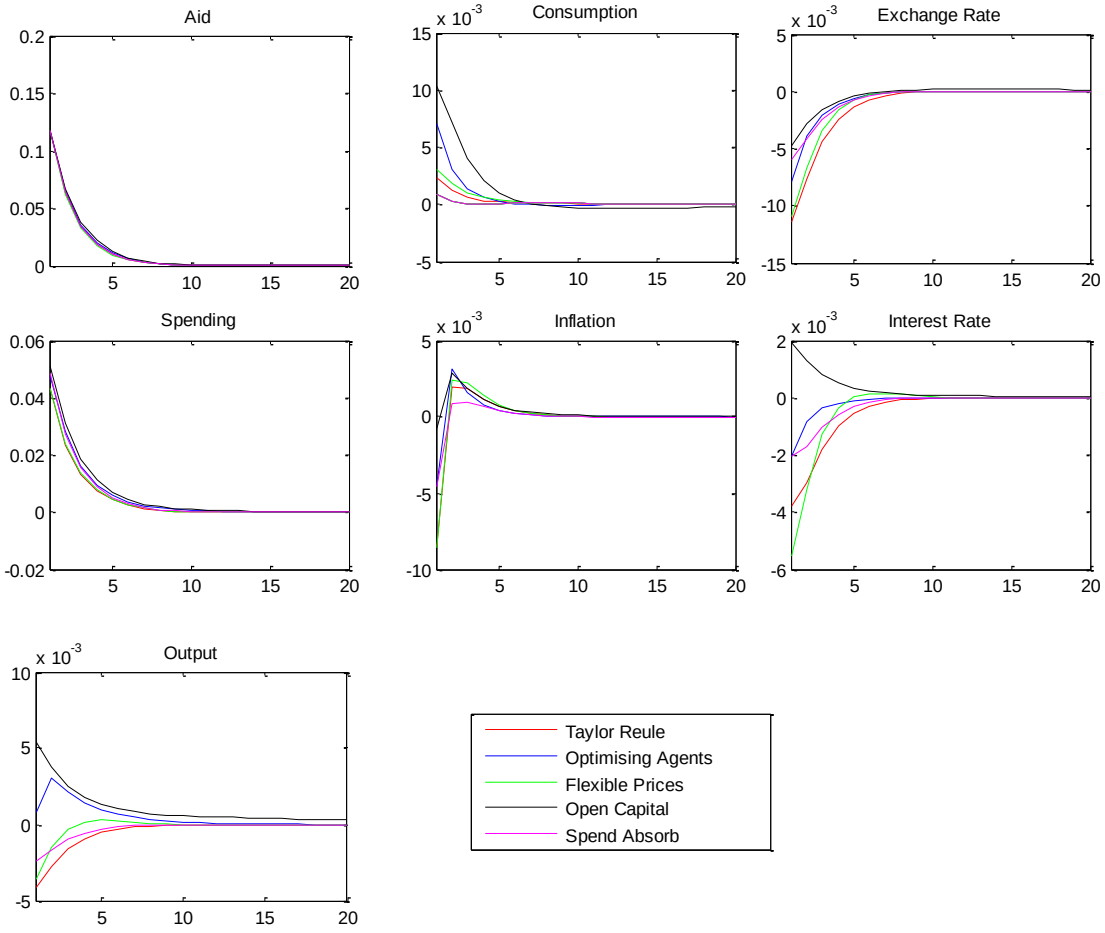
Annex 2 b: The Money Demand Function

The calibration of the aggregate interest semi-elasticity of money demand is based on an OLS regression of nominal money balances on nominal interest rates and nominal output.

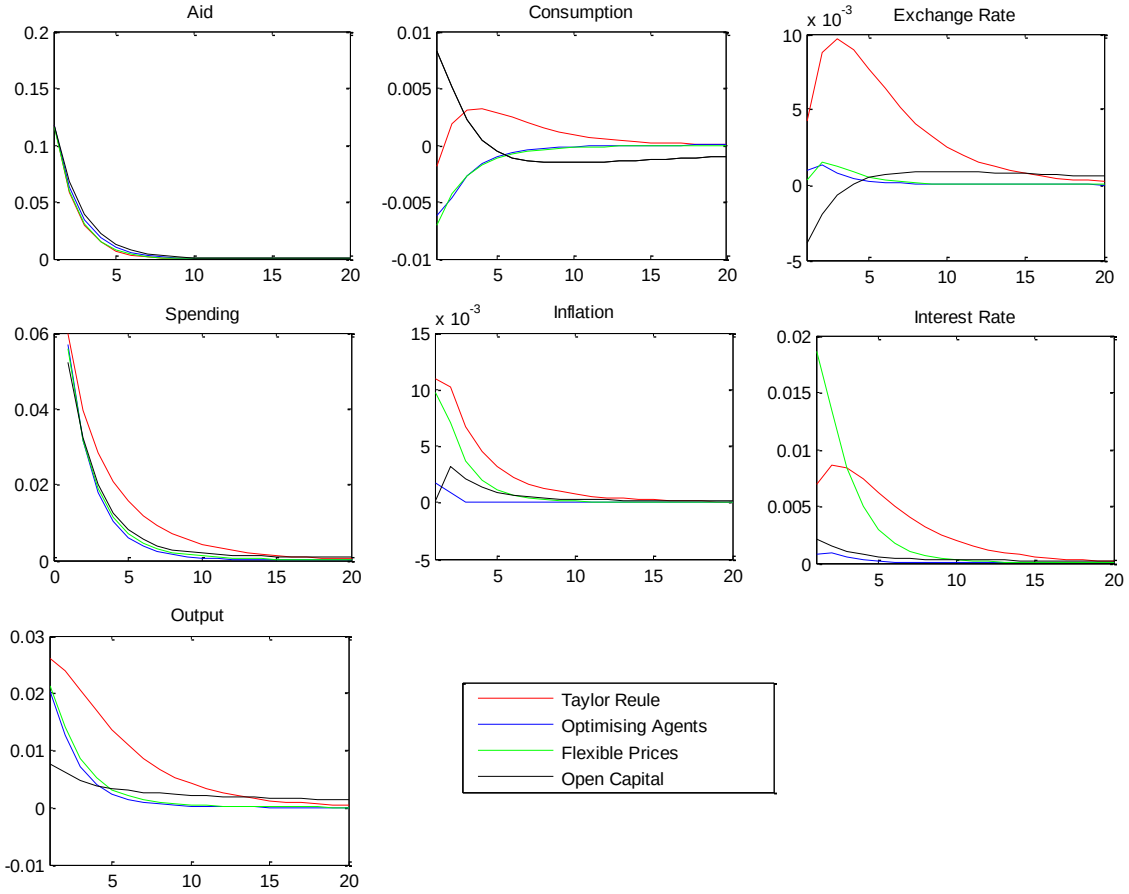
$$lnM_t = b_1 + b_2 lni_t + b_3 lnY_t + \mu_t$$

Where M_t is the nominal money balances (M2), i_t is nominal interest rates, Y_t is the nominal output (GDP). $b_2$represents the aggregate interest semi-elasticity of money demand.

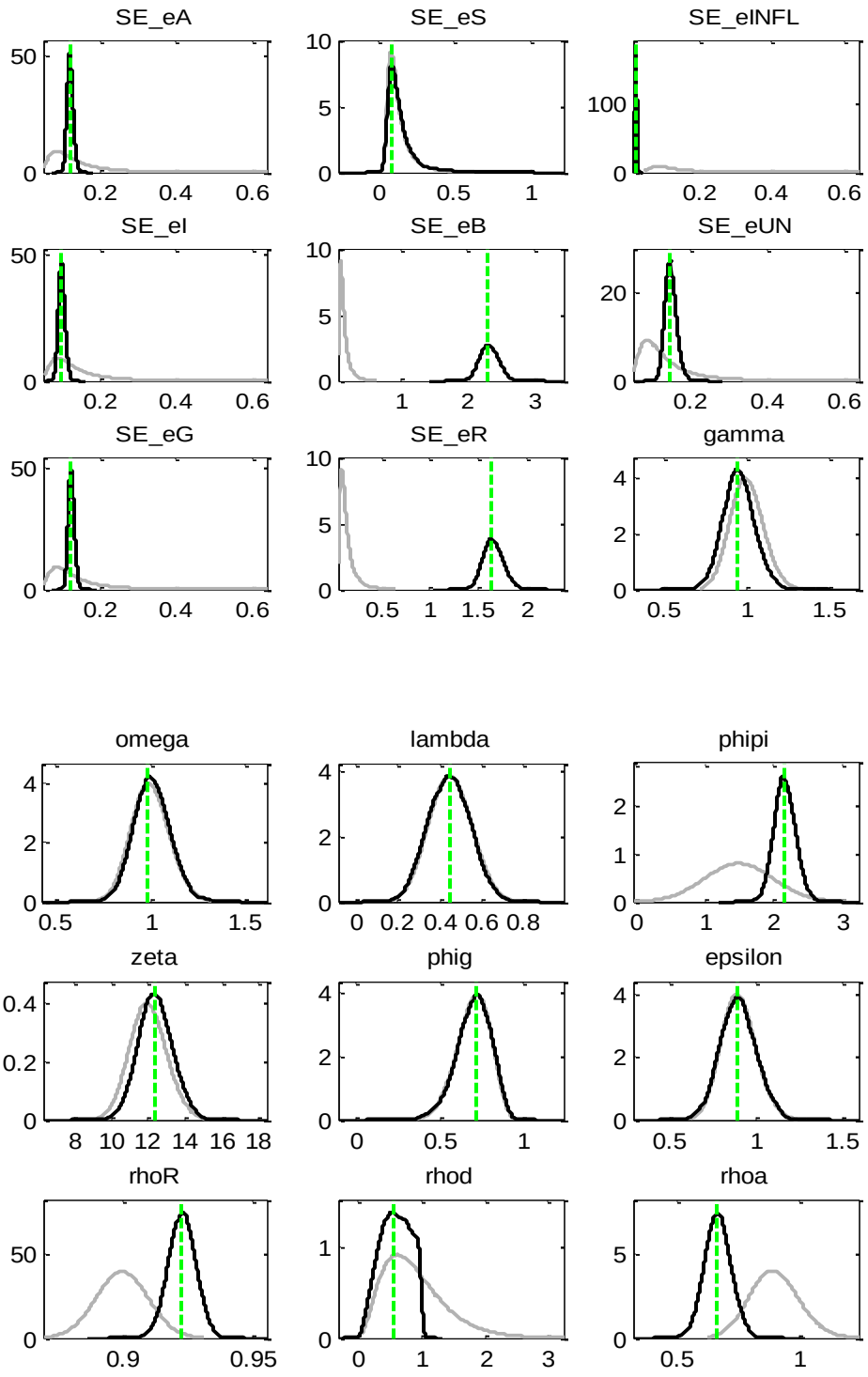
Annex 3: Robust Check Response to Aid Shock - Aid Fully Spent and Absorbed

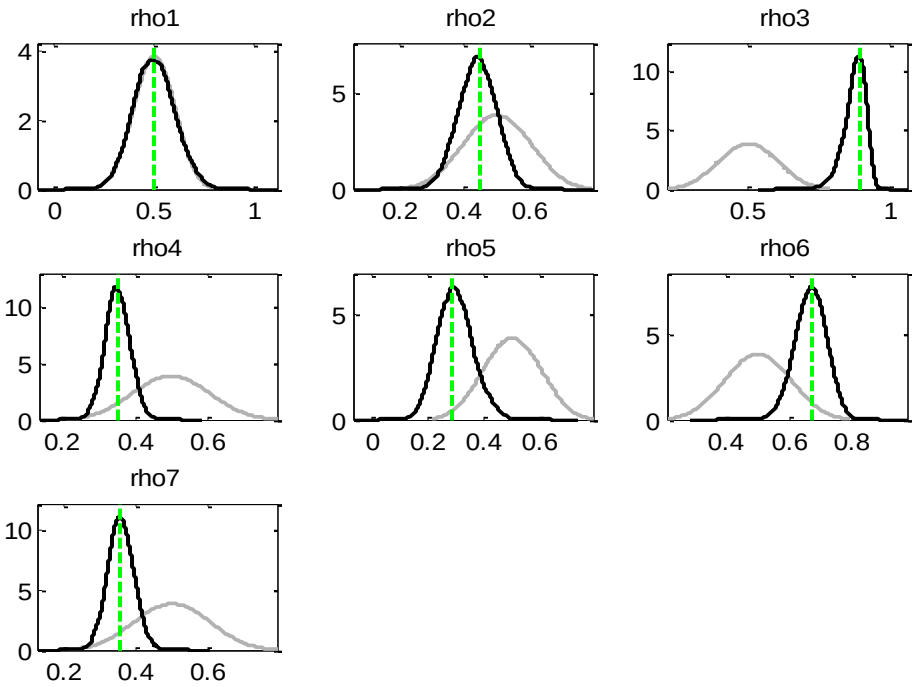


Annex4: Robust Check Response to Aid Shock - Aid Fully Spent and Not Absorbed

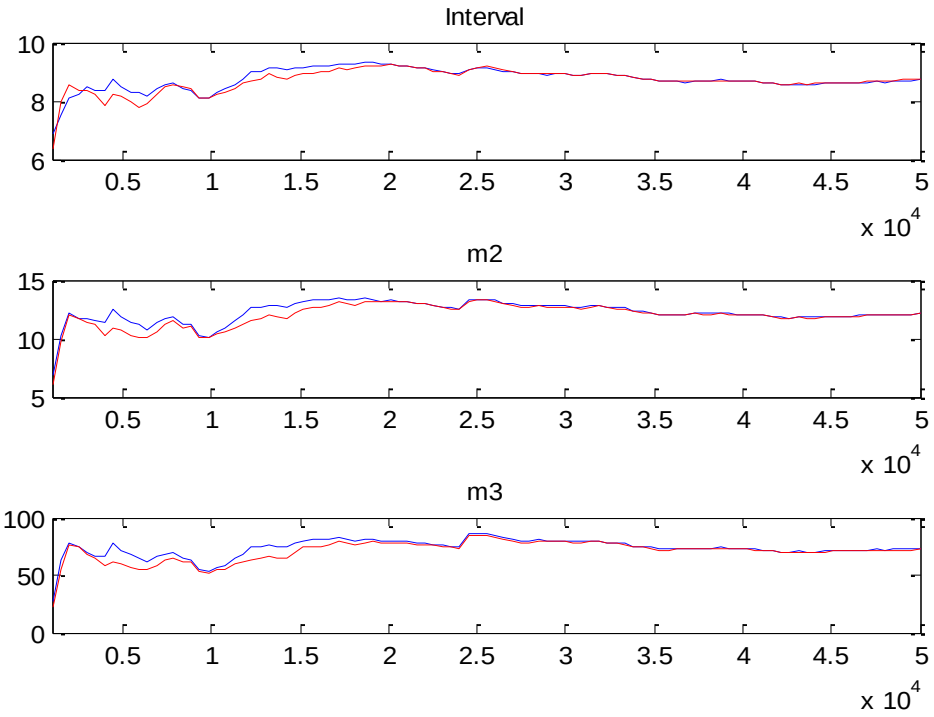


Annex 5A: Prior and Posterior Distributions

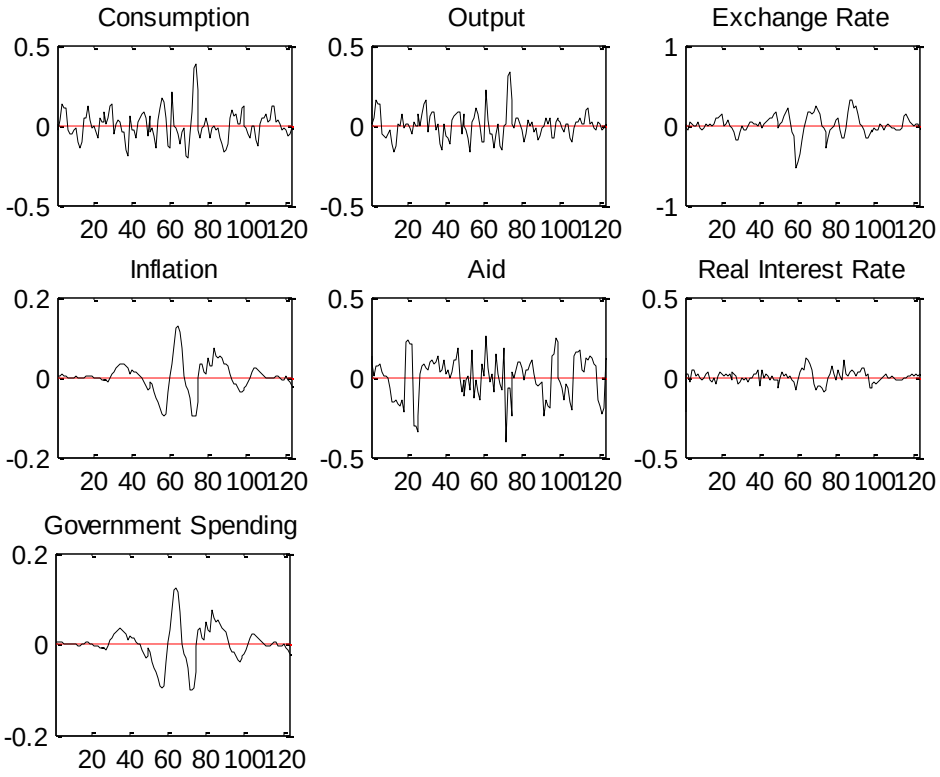




Annex 5B: Multivariate MH Convergence Diagnosis



Annex5C: HP Filtered Actual Data


Consumption
Output
Exchange Rate
Inflation
Aid
Real Interest Rate
Government Spending
0.5
0
-0.5
1
-1
0.2
-0.2
20 40 60 80 100120