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Woodford goes to Africa

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Abstract

This paper analyses the effects of inflation shocks, demands shocks, and aid shocks on low-income, quasi-emerging-market economies, and discusses how monetary policy can be used to manage these effects. We make use of a model developed for such economies by Adam et al. (2007). We examine the effects of four things which this model features, which we take to be typical of such economies. These are: the existence of a tradeables/non-tradeables production structure, the fact that international capital movements are – at least initially - confined to the effects of currency substitution by domestic residents, the use of targets for financial assets in the implementation of monetary policy, and the pursuit, in some countries, of a fixed exchange rate. We then modify the model to examine the effect on such economies of three major changes, changes which we take to be part of the transition by such economies towards more fully-fledged emerging-market status: an opening of the capital account so that uncovered-interest-parity comes to hold, a move to floating exchange rates, and the replacement of fixed stocks of financial aggregates by the pursuit of a Taylor rule in the conduct of monetary policy.

JEL classifications: E5, E61, O11

Keywords: currency substitution, emerging market macroeconomics, interactions between fiscal and monetary policy, Taylor rule

1　Introduction

This paper analyses the effects of macroeconomic shocks on a small open economy that is designed to capture the behaviour of a typical African economy. Domestic residents only engage international capital markets through currency substitution. We study fixed and floating exchange rate regimes, and perform analysis making different assumptions about the degree of openness of capital markets. Initially there is no responsiveness of foreign capital inflows to domestic conditions, but, subsequently, we study the effects of highly mobile capital flows. We discuss how fiscal policy and monetary policy can be used to manage these effects. Our work makes use of a model developed for such economies by Adam et al. (2007) for such purposes.

We examine the effects on the results of four things which this model features, which we take to be typical of such economies. These are:

(a) the existence of a tradables/non-tradables production structure,

(b) the fact that international capital movements are confined to the effects of currency substitution,

(c) the use of monetary targets in the implementation of monetary policy, and

(d) the pursuit, in at least some such economies of fixed, or quasi-fixed, exchange rates.

We then modify the model to examine the effect on such economies of four major changes - changes which we take to be essential for the transition by such economies towards more fully-fledged emerging-market status. These are

(i) a move to floating exchange rates,

(ii) an opening of the capital account so that uncovered-interest-parity comes to hold,

(iii) the replacement of financial aggregates by the pursuit of a Taylor rule in the conduct of monetary policy.

Our work is one of the first attempts to examine the effects of the kinds of macroeconomic policy now common in developed countries on emerging market economies. What we present is still very preliminary. Our analysis is in the spirit of Woodford's book *Interest and Prices*, and hence the title of this paper.

2　The Questions which We Consider

Consider an economy that is subjected to demand, inflation, and aid shocks. Suppose that the fiscal institutions for macroeconomic management in this country are not well developed and that it is monetary policy which is required to restrain this economy. Should it have a fixed exchange rate, or float? And how should monetary discipline be conducted?

Let us first suppose that the model of this economy could be analysed using a Mundell Fleming model, with a low degree of capital mobility. The effect of an inflation shock will, if the exchange rate is fixed, cause the real value of the currency to appreciate, which will damage the export sector. If there is a floating exchange rate, then the currency will appreciate and the export sector will again be damaged, not by domestic inflation but by currency appreciation. The effects of government expenditure shock would be that a shock to expenditure would cause an inflation shock, detailed outcomes would depend on the conduct of monetary policy. An aid shock would increase domestic demand and cause an appreciation of the exchange rate, to an extent that is dependent on the openness of the international capital market. This is basically what the Mundell Fleming framework would tell us.

But studying the effects of cost push shocks, demand shocks, and aid shocks is more complex than this. That is because these shocks cause interactions between fiscal policy and monetary policy. It is conventional to study such interactions in systems in which (i) monetary policy follows a Taylor rule and (ii) fiscal policy is conducted so as to ensure longer-term fiscal solvency, allowing short run variations in fiscal outcomes of an unbalanced kind. (See Kirsanova, Stehn and Vines, 2005, for example.) We do not pursue that course in this paper. This is because the interactions between monetary policy and fiscal policy are made more complex by the currency substitution assumption which is at the heart of what we are studying here. Instead we examine the interactions between monetary policy and fiscal policy in which the conduct of fiscal policy is highly simplified. There is fiscal solvency, and no treatment of the automatic stabilisers. But we study the effect of the government budget constraint and of different supplies of assets, caused by different decisions about government funding, and we examine the effects of this on the behaviour of the private sector. Thus the findings of the paper must be treated as tentative, in that there is much that we have simplified.

What we explore here is the way in which outcomes depend on the conduct of monetary policy, and on the nature of the exchange rate regime. That much is clear from the Mundell-Fleming model. What is not clear from that model is how the private sector will respond to the persistent changes in financial assets which will result from the budgetary consequence of the shocks, even ignoring the effects of automatic stabilisers.

The outcomes will clearly depend on the private sector economic structure, in two important ways. The Woodford tradition, and the Adam et al. model supposes that consumption behaviour is forward-looking, and can be modelled by a Euler equation. In such a setup consumption depends on the real interest rate, which will, of course, be influenced by the conduct of monetary in the face of the shock. The outcomes will also depend upon the inflation process. In the Woodford tradition and the Adam et al. model, that is also assumed

to be forward-looking. These strong assumptions will of course have implications for our findings.

3   The Model

This section explains the structure of the model that we use. It is a small open economy model that is designed to capture the behaviour of a typical African economy. It is built based on micro-founded 'New Open Economy Macroeconomics' literature.

There are two types of good produced: exportables X and non-tradables N. There are three factors of production: capital, intermediate goods (oil) which is imported, and labour. Aggregate supply has a specific factors form, i.e. the stock of capital is fixed in the two sectors. Labour is assumed to be mobile across sectors. Relative supplies of tradables and non-traded goods are governed by the real exchange rate. Following the New Keynesian literature, the non-traded goods prices are sticky following a Calvo pricing rule. This means that the output of non-traded goods is demand determined in the short run.

The household consumes both imports and non-tradables. The household holds domestic money, foreign currency holdings, and government bonds. There can be accumulation of foreign currency by the private sector, either as a result of changes in reserves held by the central bank, or by means of a current account surplus. Both domestic money and foreign currency satisfy the transactions demand for money. There is 'currency substitution' between domestic and foreign currency holdings. This means that there is imperfect capital mobility. This feature differs significantly from the common assumption on uncovered interest rate parity as is typical in the small open economy New Keynesian literature. Government bonds are indexed to the CPI (non-tradable).

In this paper, fiscal policy is 'disciplined'. By fiscal discipline, we meant that an increase in aid does not lead to looser fiscal policy with a corresponding increase in government expenditure. As such, public expenditures for both exportables and non-tradables are assumed to be fixed, and fiscal policy responds to aid increases in terms of cuts in taxes. Again these cuts are 'discplined', lasting only as long as the change in aid. Monetary policy involves choices about transaction in foreign exchange market and buying or selling government securities with the private sector. In this paper we study fixed exchange rates (implemented by managing the accumulation of reserves) and compare these regimes with floating exchange rates, where there are no changes in reserves. We also study regimes in which there is a greater degree of openness in the capital account. For that, UIP is introduced to bring the model closer to the small open economy New Keynesian framework. To bring Woodford to Africa eventually, we introduce a Taylor rule in the conduct of monetary policy.

Table 1: List of variables

Variable	Description
C	Private consumption
L	Liquidity/currencies holding
m	Demand for money (domestic currency)
f	Demand for foreign currency
γ	Share of spending allocated to non-traded goods
G	Government consumption
DN	Output of non-traded goods
π^N	Non-tradable inflation rate
p	Aggregate price level
π	Inflation rate
e	Real exchange rate defined as $\frac{P_{Nt}}{E_t}$.
x	Depreciation of nominal exchange rate (in local currency per unit of foreign currency)
I	Nominal interest rate
R	Real interest rate
y	Aggregate output level
ca	Current account balance
def	Fiscal balance (>0 denotes deficit)
tr	Taxes (net of transfers received from the government)
z	International reserves
b	Government securities held by central bank
a	Aid
g_N	Demand shock
cp	Cost push shock

The definitions of variables used in the model are shown in Table 1. Notice that in some equations, steady state values of the variable, which are exogenous, appear in the equation with a bar.

3.1 Demand

The aggregate consumption C is a CES function of the underlying goods and is defined as

$$C_t = \left[k_N C_{Nt}^{\frac{\alpha-1}{\alpha}} + k_I C_{It}^{\frac{\alpha-1}{\alpha}} \right]^{\frac{\alpha}{\alpha-1}} \tag{1}$$

Both C_N and C_I are non-tradable and imported goods of single variety. Correspondingly, the price level P_t for the consumer price index (CPI) takes the form

$$P_t = \left[k_N^\alpha P_{Nt}^{1-\alpha} + k_I^\alpha P_{It}^{1-\alpha} \right]^{1/(1-\alpha)} \tag{2}$$

The liquidity aggregate L is a CES function of the underlying assets, and is written as follows.

$$L_t = \left[k_M \left(\frac{M_t}{P_t} \right)^{\frac{\alpha-1}{\alpha}} + k_F \left(\frac{E_t f_t}{P_t} \right)^{\frac{\alpha-1}{\alpha}} \right]^{\frac{\alpha}{\alpha-1}} \tag{3}$$

where M_t and f_t are end of period holdings of domestic and foreign currency respectively. The level of nominal exchange rate is denoted by E_t.

The representative household maximises expected utility function:

$$E_t \sum_{s=t}^{\infty} \beta^{s-t} \left(\frac{C_s^{1-\tau^{-1}}}{1-\tau^{-1}} + \frac{h L_s^{1-\tau^{-1}}}{1-\tau^{-1}} \right)$$

where τ is the inter-temporal elasticity of substitution and $\beta \equiv (1+\rho)^{-1}$ is the discount factor. The household budget constraint is derived as follows. Besides domestic and foreign currency, households have access to CPI-indexed government bonds. Thus, household wealth $W_t = M_t + P_t b_t^p + E_t f_t$. Let Y_t denotes the non-interest income of the household and TR that of the taxes net of transfers to the government. The budget constraint is

$$W_t = M_{t-1} + R_{t-1} P_t b_{t-1}^p + E_t f_{t-1} + Y_t - TR_t - P_t C_t$$

where $R_{t-1} = 1 + r_{t-1}$ is the real interest rate to bonds from the period $t-1$. Imposing PPP (i.e. in this context, that importables sell in home markets at prices which reflect foreign prices, after adjustment by the exchange rate) and normalizing the foreign prices of importables to 1, the constraint can be divided throughout by E_t to express in terms of importables. In what follows, lower case letters reflect this normalization. Thus, the budget constraint is re-written as

$$w_t = m_t + p_t b_t^p + f_t = X_t^{-1} m_{t-1} + R_{It} p_t b_{t-1}^p + f_{t-1} + y_t - tr_t - p_t C_t$$

where $R_{It} = 1 + r_{It} = R_{t-1} \frac{\Pi_t}{X_t}$ is the normalized real interest rate, $\Pi_t = 1 + \pi_t = \frac{P_t}{P_{t-1}}$ is the inflation factor, and $X_t = 1 + x_t = \frac{E_t}{E_{t-1}}$ is the exchange rate depreciation factor.

Using the budget constraint, we can obtain optimal consumption and demands for domestic and foreign currency. The Euler equation expresses consumption in terms of the real interest rate R and the price level p_t in each period as follows:

$$C_t^{\tau^{-1}} = \beta E_t \left[\frac{R_{It+1} p_t}{p_{t+1}} C_{t+1}^{\tau^{-1}} \right] = \beta R_t E_t C_{t+1}^{\tau^{-1}} \tag{4}$$

The demand for assets are

$$\left(\frac{m_t}{p_t}\right)^{-\frac{1}{\sigma}} = \frac{1}{hk_M} L_t^{\frac{\sigma-\tau}{\sigma}} \beta E_t \left[\frac{i_{t+1}-1}{1+x_{t+1}} C_{t+1}^{-\frac{1}{\tau}}\right] \tag{5}$$

$$\left(\frac{f_t}{p_t}\right)^{-\frac{1}{\sigma}} = \frac{1}{hk_F} L_t^{\frac{\sigma-\tau}{\sigma}} \beta E_t \left[\frac{i_{t+1}-x_{t+1}}{1+x_{t+1}} C_{t+1}^{-\frac{1}{\tau}}\right] \tag{6}$$

From the CES function of C, we can write the respective demands for tradable and non-tradable goods into $c_{It} = (1-\gamma_t)p_t C_t$ and $\frac{e_t C_{Nt}}{c_{It}} = \frac{\gamma_t}{1-\gamma_t}$ respectively. Let γ denotes the proportion of consumption devoted to non-traded goods.

$$\gamma_t = \frac{k_N^\alpha e_t^{1-\alpha}}{k_N^\alpha e_t^{1-\alpha} + k_T^\alpha} \tag{7}$$

The government consumption for both tradables and non-tradables are given by:

$$G_{Nt} = \overline{eG_N} + \frac{b_N}{e_t}(s_t - \bar{s}) + g_{Nt} \tag{8}$$

$$G_{Tt} = \overline{G_T} + b_T(s_t - \bar{s}) \tag{9}$$

where the public expenditure spending on aid is

$$s_t = \bar{s} + (1-\mu)[W_{t-1} + (1-pdr)(a_t - \bar{a})] \tag{10}$$

and g_{Nt} is an exogenous shock to government expenditure on non-tradables. To reflect this feature, we can set $\mu = 0$ and $pdr = 0$ simultaneously. In what follows, we focus on disciplined fiscal policy, and to do so, we set $b_N = b_T = 0$.

The the total demand for non-traded goods in the economy is

$$Q_{Nt} = \left(\gamma_t \frac{p_t}{e_t}\right) C_t + G_{Nt} \tag{11}$$

3.2 Supply and Prices

The supply of the economy is determined by output in the two sectors as follows

$$\overline{Q} = \left[\delta \overline{Q}_{Nt}^{\frac{1-\eta}{\eta}} + (1-\delta)\overline{Q}_{Xt}^{\frac{1-\eta}{\eta}}\right]^{\frac{\eta}{1-\eta}}$$

$$\frac{\overline{Q}_X}{\overline{Q}_N} = \left[\left(\frac{\delta}{1-\delta}\right)\left(\frac{p_{Xt}}{e_t}\right)\right]^{\eta}$$

where η is the elasticity of transformation in output. In what follows, we impose for simplicity that $\eta = 0$, and $\delta = 1/2$, so that there is no substitutability in production between the sectors in response to changes in relative prices. As a result all such substitution falls on demand. The supply of exports equals capacity supply.

$$Q_X = \overline{Q}_X$$

The price of non-tradables is sticky; the production of non-tradables is equal to demand, which can be different from capacity. Prices of non-tradables adjust to the gap between demand and supply in a Calvo manner, as follows. The 'parameter' ψ is a reduced-form construct derived from the structure implicit in a Calvo model of the adjustment of prices. (See Adam et al. 2007, pp. 11 - 12.)

$$\log \pi_t^N = \log \pi_{t+1}^N + \psi \left(\frac{Q_{Nt} - \overline{Q}_N}{\overline{Q}_N}\right) + cp_t \tag{12}$$

where cp_t is an exogenous shock reflecting cost push shock and a high value of ψ reflects greater price flexibility. Alternatively, we could introduce more persistence in the Phillips curve by rewriting it as $\log \pi_t^N = \chi_f \log \pi_{t+1}^N + \chi_b \log \pi_{t-1}^N + +\psi \left(\frac{Q_{Nt} - \overline{Q}_N}{\overline{Q}_N}\right) + cp_t$. As $\chi_b \to 1$, price rigidity would then be large. We have experimented with this variant, but do not report the results here.

Following (2), the inflation rate is

$$\pi_t = \frac{1}{p_{t-1}} \left[k_N^\alpha \left(\pi_t^N e_{t-1}\right)^{1-\alpha} + k_T^\alpha x_t^{1-\alpha}\right]^{\frac{1}{1-\alpha}} \tag{13}$$

The relative price of non-tradable goods is denoted by e. If we let P_{Nt} be the price level of non-traded goods and E_t the level of nominal exchange rate (in terms of local currency per unit of foreign currency) then we may write

$$e_t = \frac{P_{Nt}}{E_t}, \tag{14}$$

The rate of depreciation of the nominal exchange rate can be inferred from the values of e and π as follows:

$$x_t = \pi_t^N / e_t / e_{t-1} \tag{15}$$

There is clearly a relationship between the nominal and the real interest rate as follows. (The dating convention derives from the fact that both i and π have a backward looking definition whereas the definition of R is forward-looking.)

$$I_t = R_{t-1}\pi_t \tag{16}$$

The total output of the economy is given by the following equation. We have abstracted from any effects of changes in the price of the imports of intermediate inputs, e.g. oil prices. Such analysis has been conducted in Adam et al. (2007).

$$y_t = e_t\omega_N Q_{Nt} + p_{Xt}\omega_X Q_{Xt} \tag{17}$$

3.3 The Fiscal Position, Aid, and the Current Account

To understand how we introduce inflows of foreign capital into the economy, note that we can write the UIP equation as follows

$$I_t = (1 + i_t^*)(1 + x_{t+1})\left[1 + \phi\left(\frac{p_t b_t^f}{y_t} - \frac{\overline{pb^f}}{y}\right)\right] \tag{18}$$

where i_t^* is the nominal interest rate in the rest of the world, x_{t+1} is the expected rate of depreciation, ϕ is a very small parameter capturing the risk premium attached to domestic assets. We study the effect of perfect capital mobility, in which case foreign holdings of domestic bonds are required to adjust to ensure that equation (18) holds, with a very small value of ϕ. This happens for the following reason. We have that

$$b_t = b_t^p + b_t^f \tag{19}$$

If, say, home interest rates are too high for equation (18) to hold then that will cause an increase in b_t^f. But given the supply of total bonds b_t is determined by the fiscal feedback rule presented in Section 3.5 below, that will reduce b_t^p, and will mean that, from a government budget constraint, the supply of money would be higher, and so, from the demand money function, the interest rate will be lower.

By contrast, for the analysis of regimes without inflows of foreign capital these two equations are removed from the model and so are the two variables, b_t^p and b_t^f.

The current account of the balance of payments may be derived by subtracting absorption from output as follows

$$ca_t = y_t - e_t G_{Nt} - G_{Tt} - p_t C_t + a_t - p_t(R_{t-1} - 1)b_{t-1}^f \tag{20}$$

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and a current account surplus enables either the building up of domestic holdings of foreign currency, or an increase in reserves, as follows

$$\Delta f_t + \Delta z_t + \Delta b_t^f = ca_t \tag{21}$$

The budget deficit is given by the following equation, where the first term denotes the nominal value of interest payments, valued in terms of importables

$$def_t = \left(R_{t-1} \frac{\pi_t}{x_t} - 1 \right) p_{t-1} b_{t-1}^p + e_t G_{Nt} + G_{Tt} - tr_t \tag{22}$$

The government budget constraint is given by the following equation. The right hand side shows what we can call the outlays of the government valued in terms of importables. The second term denotes seigniorage receipts and the final term denotes the value of aid, which accrues to the government and reduces its need for other sources of finance. The first terms of the left hand side of the equation is the increase in the real stock of money. The next two terms is the net increase in the real stock of domestic bonds after adjusting for the presence of foreign bonds. The final term exists because, for any given government funding need, the larger is the increase in reserves, the larger will be the increase in the real stock of money.

$$\Delta m_t + p_t b_t^p - p_{t-1} b_{t-1}^p + p_t b_t^f - p_{t-1} b_{t-1}^f - \Delta z_t = def_t + \left(\frac{1}{x_{t-1}} - 1 \right) m_{t-1} - a_t \tag{23}$$

Since this model is designed to study the effects of aid surges, important assumptions are made about how fiscal policy reacts to such changes. The determination of government expenditure, valued in terms of imports, eG_N and G_T, have been described earlier. By assumption there is no change in the value of government expenditure, i.e. $b_N = b_T = 0$. From (8), as the relative price of non-tradables changes, the actual expenditure on non-tradables falls one-for-one with any increase in e. The effects on tax receipts are explained in the following equation. They clearly depend on s_t which clearly depends on aid flow a_t conditional on the value of pdr. In what follows, we set $pdr = 0$, i.e. an increase in aid will be matched one-for-one to a reduction in tax receipts.[1]

$$tr_t = \overline{tr} - (s_t - \overline{s}) + (e_t G_{Nt} - \overline{eG_N}) + G_{Tt} - \overline{G_T} \tag{24}$$

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[1] We could possibly investigate the effects of 'incomplete pass-through' by setting $pdr < 1$. But this is left for further research agenda.

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3.4 Monetary Policy: Fixed versus Floating Exchange Rates and Perfect Capital Mobility

If the exchange rate floats in this model then the change in reserves is, by assumption, $\Delta z = 0$. The policymaker can choose to manage the exchange rate by setting z_1 to non-zero values. If the exchange rate is to follow a tightly managed crawl, then we need to set z_1 to a large value, to ensure that x follows the desired path. In what follows, we set $z_1 = 1000$ for a fixed exchange rate regime. The central bank will then need to accumulate whatever change in reserves is necessary to make this possible.

$$\frac{\Delta z_t}{\overline{z}} = -z_1 \left(\frac{x_t - 1 - \overline{\pi}}{1 + \overline{x}} \right) - \left(\frac{z_2}{z_1 + z_2} \right) \left(\frac{z_{t-1} - \overline{z}}{\overline{z}} \right) \tag{25}$$

where $z_1 = 0$ for float and $z_1 = 1000$ for fixed, and z_2 takes a small value to capture accumulation of reserves over time.

3.5 The Funding of the Government Deficit and Taylor rule

We now consider the 'fiscal funding rule'. In Adam et al. (2007), the authors study the case where the government's funding needs are met either by money or by bonds. Recall that these needs are what is left after allowing for 'seigniorage receipts', $\frac{\overline{\pi}}{1+x_t} m_{t-1}$. The equation describing the funding rule can be written as follows.

$$\begin{aligned} p_t \Delta b_t &= b_1 \left[def_t - a_t - \frac{\overline{\pi}}{1 + x_t} m_{t-1} \right] + b_2(z_t - z_{t-1}) - b_3 p_t(b_{t-1} - \overline{b}) \\ &\quad - b_4 \left[i_t - \rho_\pi(\pi_{t+1} - \overline{\pi}) - \rho_y \left(\frac{Q_{Nt} - \overline{Q_N}}{\overline{Q_N}} \right) \right] \end{aligned} \tag{26}$$

There are two alternatives to the funding of fiscal deficit. First, under 'bond finance', none of these needs will be met by increases in money and changes in international reserves will be sterilized. To do so, $b_1 = b_2 = 1$. Alternatively, these needs can be met by increases in the money stock, with no changes in the bond stock, which means that there will be no sterilization of any changes in foreign exchange reserves. In this case, $b_1 = b_2 = 0$.[2] As discussed in Agenor and Montiel (1999), lessons on sterilized intervention remained mixed. In particular, in this model, the private sector can respond to a fixed stock of money by obtaining liquidity through the use of foreign asstes. This can cause large fluctuation in the

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[2] The parameter b_3 is present entirely for computational reasons, and is small. In all simulations it is set equal to 0.05.

exchange rate. Thus, in what follows, we focus on the non-sterilized case.

We explain the implementation of the Taylor rule as follows. Two key assumptions are required: (i) all of the fiscal funding needs are money financed, such that $b_1 = b_2 = 0$ and (ii) the bond stock is chosen so as to drive interest rates in such a way that the economy ends up following a Taylor rule. Of course in doing this we must allow for the fact that foreigners are demanding some of the domestic bond supply and this has been accounted for with the introduction of b_t^f earlier. The Taylor rule takes the form

$$i_t = \rho_\pi(\pi_{t+1} - \overline{\pi}) + \rho_y \left(\frac{Q_{Nt} - \overline{Q_N}}{\overline{Q_N}} \right)$$

where the current interest rate depends on the inflation rate one period into the future; it is thus a form if 'forward-looking' Taylor rule. The coefficients which we have used are are $\rho_\pi = 1.2$, which means that the rule satisfies the 'Taylor principle', and $\rho_y = 0$. We set $b_5 = 100$, a large number. The size of this is decided so as to force the bond stock to be that which the private sector would willingly hold, at the interest rate dictated by the Taylor rule (and after allowing for the fact that some of this bonds stock will be held by foreigners).

3.6   Exogenous Shocks

In this paper, we focus on three shocks: aid, which influences the government's need for funds; demand shock which affects government expenditure on non-tradables; and cost push shock which affects the Phillips curve.

$$a_t - \overline{a} = ar_{aa}(a_{t-1} - \overline{a}) + \epsilon_{at} \tag{27}$$

$$g_{Nt} - \overline{g_N} = ar_{gg}(g_{Nt-1} - \overline{g_N}) + \epsilon_{gt} \tag{28}$$

$$cp_t - \overline{cp} = ar_{cc}(cp_{t-1} - \overline{cp}) + \epsilon_{ct} \tag{29}$$

These shocks are with parameters: $ar_{aa} = ar_{gg} = ar_{cc} = 0.50$.

3.7   Solution

The model is solved using DYNARE. (See Julliard, 1996). There are three forward-looking variables in the model: (i) consumption, (ii) non-traded-goods inflation, and (iii) the exchange

rate. [3] This forward-lookingness is important to the model's behaviour.

4   Results

4.1   Cost push shock

Figures 1 - 4 show the responses to a cost shock, under various exchange rate regimes and differing assumptions concerning the openness of the international capital account.

The shock takes the form of a gradually declining shock to the Calvo-type Phillips curve for non-traded goods, with a persistence parameter of 0.5.

Figure 1 shows the case of a fixed exchange rate regime. Under fixed exchange rates this causes inflation in non-traded goods prices and a smaller rate of inflation in the CPI. Because there is limited international capital market integration, and because the stock of bonds is fixed, the interest rate rises, as domestic asset holders seek to move funds abroad in face of the increase in inflation; although the supply of money increases it does so by less than the increase in the demand for money. As a result of the rise in the interest rate, consumption falls. At the same time, there is a recession, which moderates the increase in inflation. This increase in inflation is further moderated by the fact that, with a fixed exchange rate, the price level must return to base. With forward-looking inflation, this acts in the Phillips curve as an immediate discipline on inflationary pressures. With more persistence in the Phillips curve (i.e. increasing the proportion of backward-looking agents) the degree of overshoot in inflation might well be more.

When the currency is floated, with a fixed stock of money, it is difficult to achieve good system behaviour. This is because currency substitution means that, in the presence of inflation, individuals substitute foreign assets for money in providing liquidity, which loosens the nominal anchor. As a result of this we have simulated a floating exchange rate regime with a fixed stock of bonds, not money. (See Figure 2). The effect of this is to allow more inflation than under fixed exchange rates, because in this model the bonds are real bonds which are indexed with inflation. The anchor to inflation is thus much less in this regime then it would be if there were a fixed nominal asset.

The outcome is such that asset stock decisions – the decision to float but to fix the stock of bonds - has real consequences for both the long run, and the short run. In this case the short run real interest rate rises by more, but the downwards float in the exchange rate means that the real exchange rate appreciates by less, so that there is actually less of an appreciation of

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[3]Even when the exchange rate follows a tightly crawling peg, the model is solved with the exchange rate as a jump variable; the solution method simply forces the jump to be nearly zero.

the real exchange rate than under fixed exchange rates.

As shown in Figure 3, when there is an open international capital account, with foreign asset holders following UIP entering the market, then the rise in the interest rate just described will attract capital inflow. This will further appreciate the exchange rate, relative to what it would have been under a floating regime without UIP and will also lower the real interest rate. The capital mobility moderates the shock. But the behaviour of real interest rates is quite surprising in the short run – it actually falls in the very short-run, in the presence of a cost-push shock. This is because the inflow of funds into domestic bonds decreases the supply of bonds available for the domestic private sector.

The introduction of a Taylor rule along with an open international capital account smooths the behaviour of the real interest rate – it rises by less but the short term fall is also avoided. It also dampens, overall, the effect of the shock on the economy (see Figure 4). The outcome is that there is more inflation but the effect on domestic consumption of monetary policy is moderated.

In summary, the cost push shock under a fixed exchange rate regime leads to what is shown here. This is a satisfactory process of adjustment, and appears to result from the a high degree of price flexibility. In the floating exchange rate regime with currency substitution, the fixed supply of bonds leads to a significant increase in the real interest rate which causes an appreciation of the real exchange rate. Given a fixed level of bonds, the dynamics of money and foreign currency holdings are complicated without a high degree of capital mobility, i.e. if there are no foreign capital inflows, and this significantly influences the resulting outcome. When there is foreign capital inflow, and the floating exchange rate regime is coupled with UIP, but with a fixed level of the bond stock, rather than with a Taylor rule, the real interest rate initially falls with the inflow of foreign capital. This effect is moderated by the inclusion of a Taylor rule. It appears possible that the effects of the inflationary shock on the non-traded goods sector can be shifted abroad by the introduction of UIP and Taylor rule.

4.2   Demand shock – government expenditure shock

Figures 5 - 8 show the response to a demand shock, in the form of a gradually declining government expenditure shock, which is financed by the issue of money. The autoregressive parameter is 0.5.

In Figure 5, this shock causes inflation in non-traded goods prices and a smaller increase in inflation of the CPI. Because there is limited international capital-market integration, and the stock of bonds is fixed, the interest rate rises, as domestic asset holders seek to move funds abroad in face of the increase in inflation; although the supply of money increases it does so by less than the increase in the demand for money, just as in the case of a cost push

shock. As a result of the rise in the interest-rate, consumption falls – a crowding out of the shock under fixed exchange rates - and the real exchange rate appreciates, adding to this crowding out. As a result, there is a recession, which moderates the increase in inflation. The increase in inflation is further moderated by the fact that, with a fixed exchange rate, the price level must return to base. With forward-looking inflation, this requirement acts as an immediate discipline on inflationary pressure. With more persistence the degree of overshoot of inflation might well be larger.

As before we have simulated a floating exchange rate regime with a fixed stock of bonds, not money. (See Figure 6). The effect is that there can be more inflation than under fixed exchange rates, again because the bonds are real bonds which are indexed with inflation, and the anchor to inflation is thus less in this regime than it would be if there were a fixed nominal asset. The outcome is one in which the short run real interest rate rises by more than under a fixed exchange rate, but the downwards float in the nominal exchange rate means that the real exchange rate appreciates by less, so that there is actually less of an appreciation of the real exchange rate than under fixed exchange rates. Thus floating the exchange rate serves to moderate the shock.

If there is an open international capital account, with foreign asset holders following UIP, then the rise in the interest rate just described will attract capital inflow. (See Figure 7). This will appreciate the exchange rate, and that will also lower the interest rate relative to what it would have been. The capital mobility thus moderates the shock. But the behaviour of the real interest rate is again quite surprising in the short run – it actually falls in the very short-run, just like in the presence of a cost-push shock. This is again because the inflow of funds into domestic bonds decreases the supply of bonds available for the domestic private sector, which forces down the interest rate in such a way as to make the real interest rate fall.

The introduction of Taylor rule, along with the open international capital account overcomes this short-term fall in the real interest rate – the nominal interest rate rises by more and the real interest rate rises initially. (See Figure 8). But just as with the inflation shock the control of the shock is more gradual; the boom remains larger and the period of inflation lasts longer.

4.3   Aid shock

Figures 9 - 12 show the response to an aid shock, in which the aid is all passed on to the private sector by means of a cut in taxes. Figure 9 shows the effect with a fixed exchange rate. Again this causes inflation in non-traded goods prices and a smaller rate of inflation in the CPI. But, as in previous shocks, because there is limited international capital market

integration, and the stock of bonds is fixed, the interest rate initially rises, as domestic asset holders seek to move funds abroad, in face of the increase in inflation; but very quickly the supply of money increases, and does so by more than the increase in the demand for money, and so the interest rate falls. As a result of the fall in interest rates, consumption rises. This means that there is a boom in the short run. The increase in the inflation is however moderated by the fact that, with a fixed exchange rate, the price level must return to base. With forward-looking inflation, this again acts as a discipline on inflationary pressure, even in the short run.

As in the case of the other shocks, we have simulated a floating exchange rate regime with a fixed stock of bonds, not money, when the only international integration of the capital market is through currency substitution. (See Figure 10). The effect is there can be more inflation than under fixed exchange rates, because the bonds are real bonds which are indexed with inflation. Again, as previously, asset stock decisions have real consequences for both the long run and the short run. In this case in the short run the exchange rate appreciates. The reason for this is clear - under a fixed exchange rate there has been a balance of payments surplus, which, if the exchange rate floats and causes an appreciation. The outcome is such a large appreciation of the exchange rate that inflation actually falls, again because there is little openness of the capital market internationally. But the size of the shock is not greatly dampened; it has its effect though the increase in domestic demand which it causes.

If there is an open international capital account, with foreign asset holders following UIP then the exchange rate jump appreciates, as shown in Figure 11. The behaviour of the exchange rate, and that of the real interest rate, are influenced in the short run by the movement in asset stocks.

Figure 12 shows that the introduction of Taylor rule along with the open international capital account curtails these short-run movements and means that the real exchange rate jumps to its long run equilibrium rate, along with consumption. The combination of an open international capital account and a Taylor rule causes an immediate external adjustment to the shock, though currency adjustment, something which is not possible if monetary policy is tied down by an explicit rule limiting the availability of one or other of the asset stocks.

5   Conclusion

In summary, we have shown that, under a fixed-exchange-rate regime, there is a satisfactory process of adjustment, something which is to be expected, given the high degree of price flexibility which is assumed. In the floating exchange rate regime with currency substitution, experiments not reported here show that managing the economy with fixed stock of money

can give rise to significant oscillations, due to movements by the private sector out of money and into foreign assets as a result of currency substitution. But similarly, a fixed supply of bonds can lead to large changes in the real interest rate, again because the dynamics of money and foreign currency holdings are complex. We have shown that this can happen if there are no foreign capital inflows. We have also shown that it can happen when there is a floating exchange rate regime with UIP, but with a fixed level of the stock of bonds. However we have also shown that such effects are moderated by the inclusion of a Taylor rule. It appears, from this work, that if there is not to be a fixed exchange rate regime - or a crawling exchange-rate regime of the kind which we have not examined in this paper – then floating exchange-rate regimes can present some difficulties if the stocks of one of the financial assets is fixed. These difficulties are magnified if there is international capital inflow which is not moderated but the stocks of one of the financial assets is fixed. It appears that, in these circumstances, what is needed is that monetary policy also adopt a Taylor rule.

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Figure 1: Africa fixed exchange rate - cost push shock
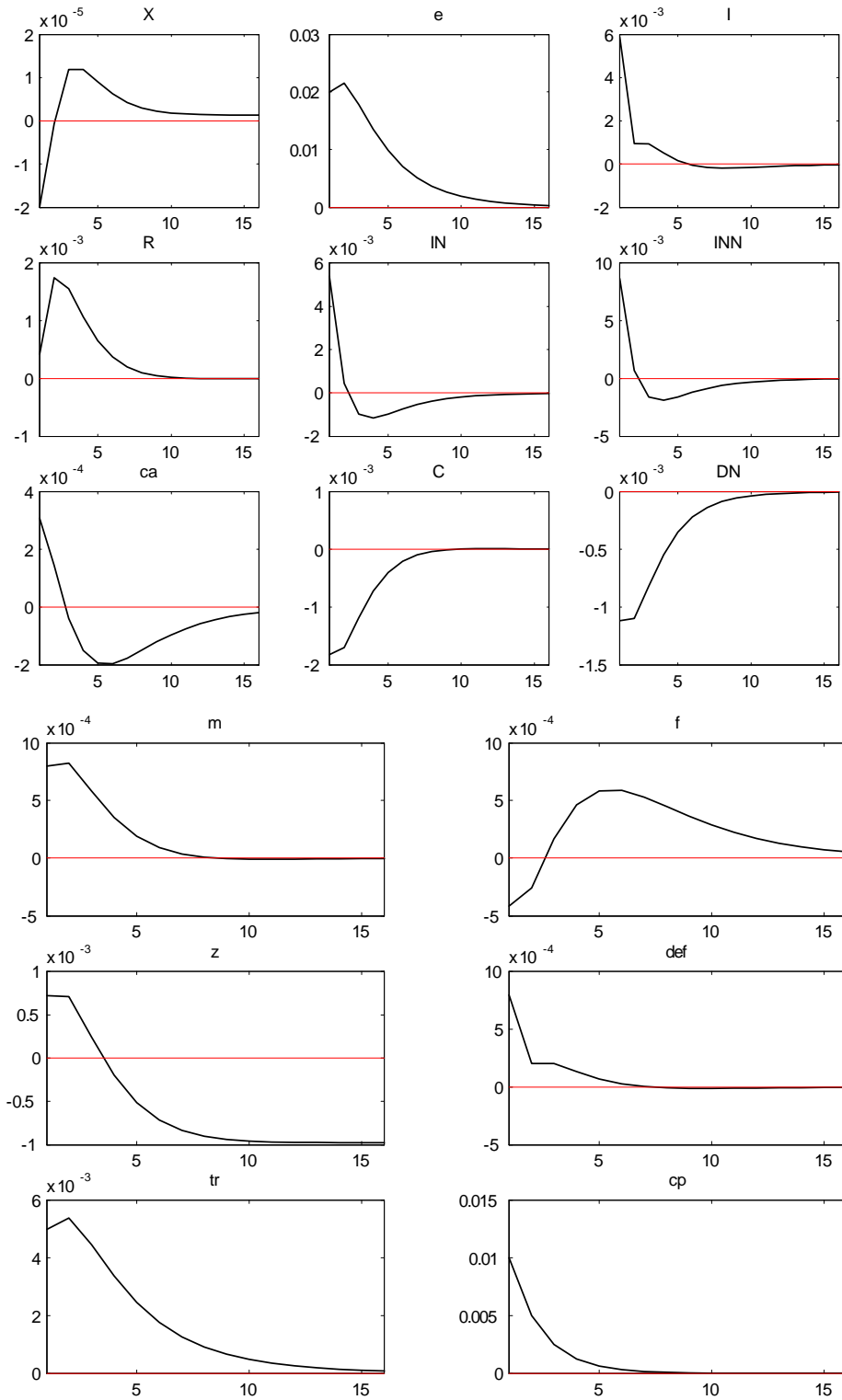
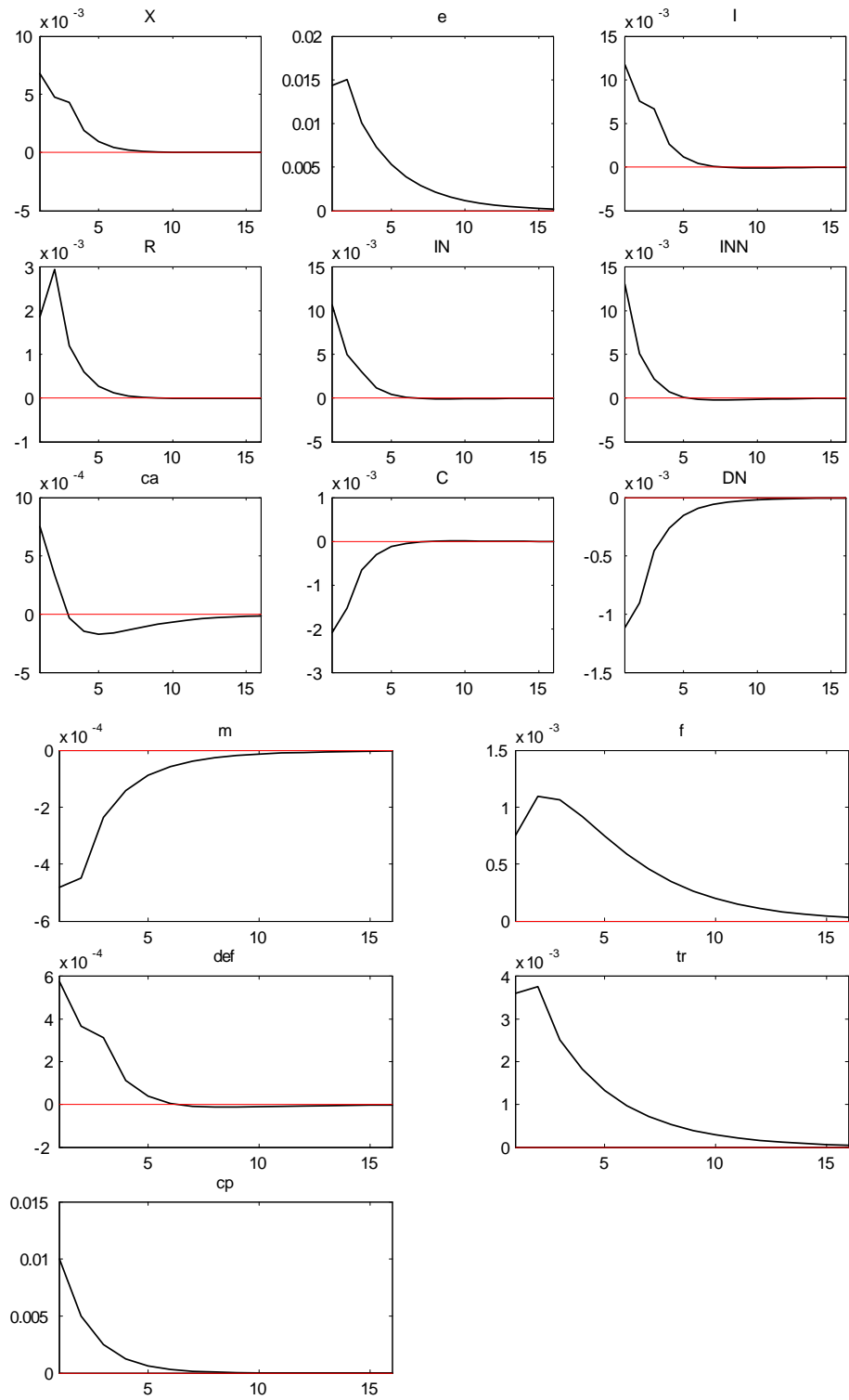Figure 2: Africa float exchange rate - cost push shock

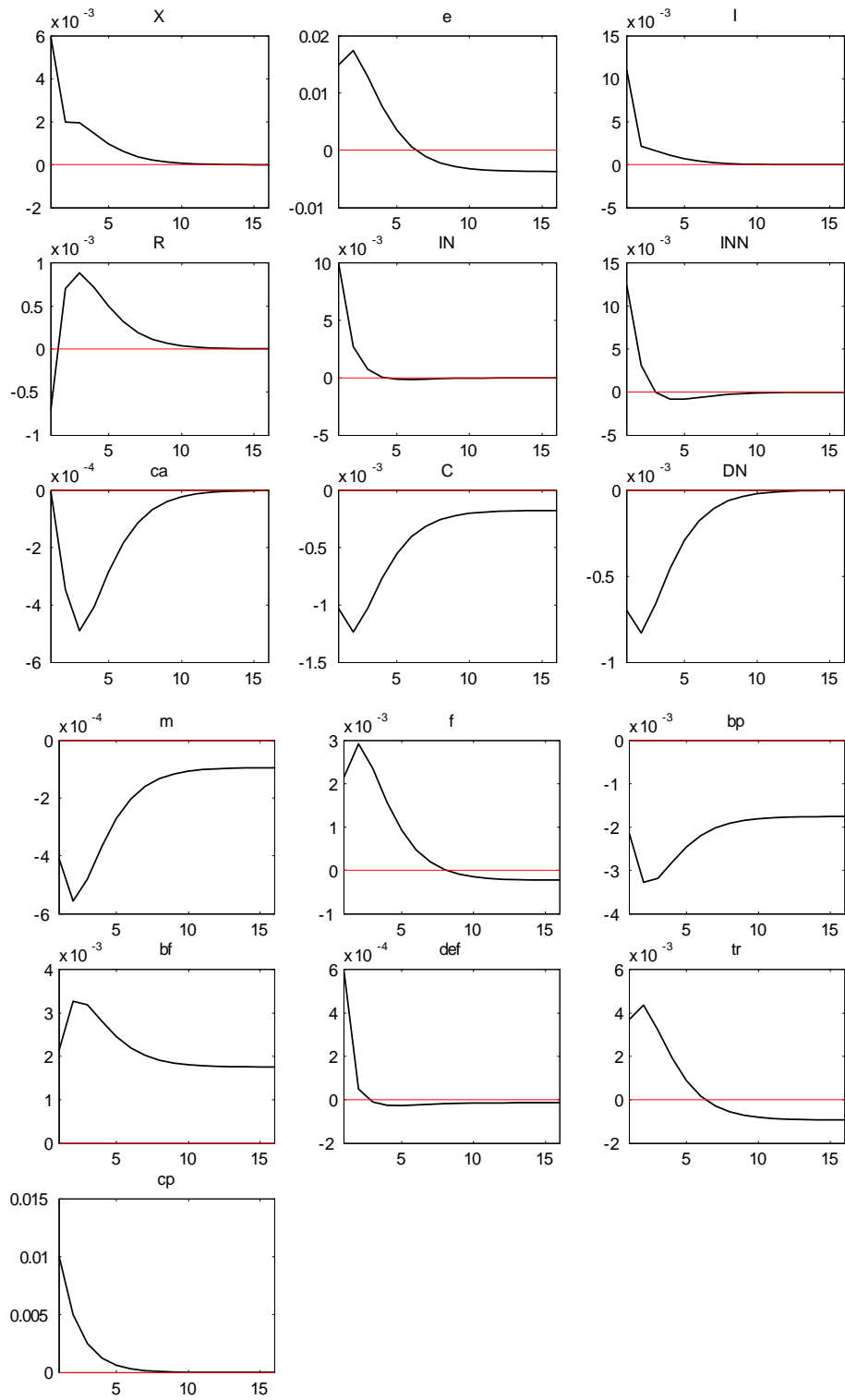Figure 3: Africa float exchange rate with UIP - cost push shock

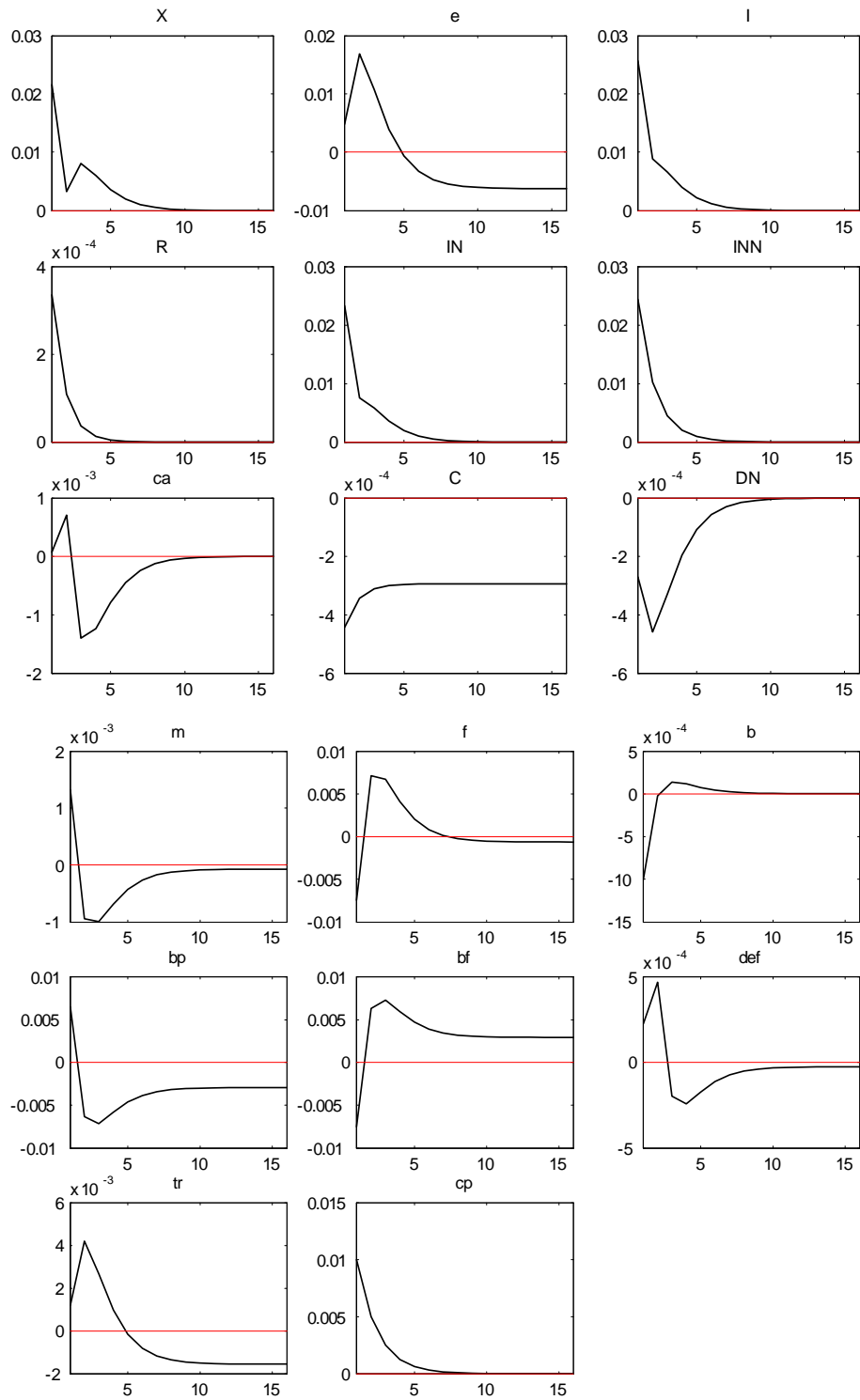Figure 4: Africa float exchange rate with UIP and Taylor rule - cost push shock
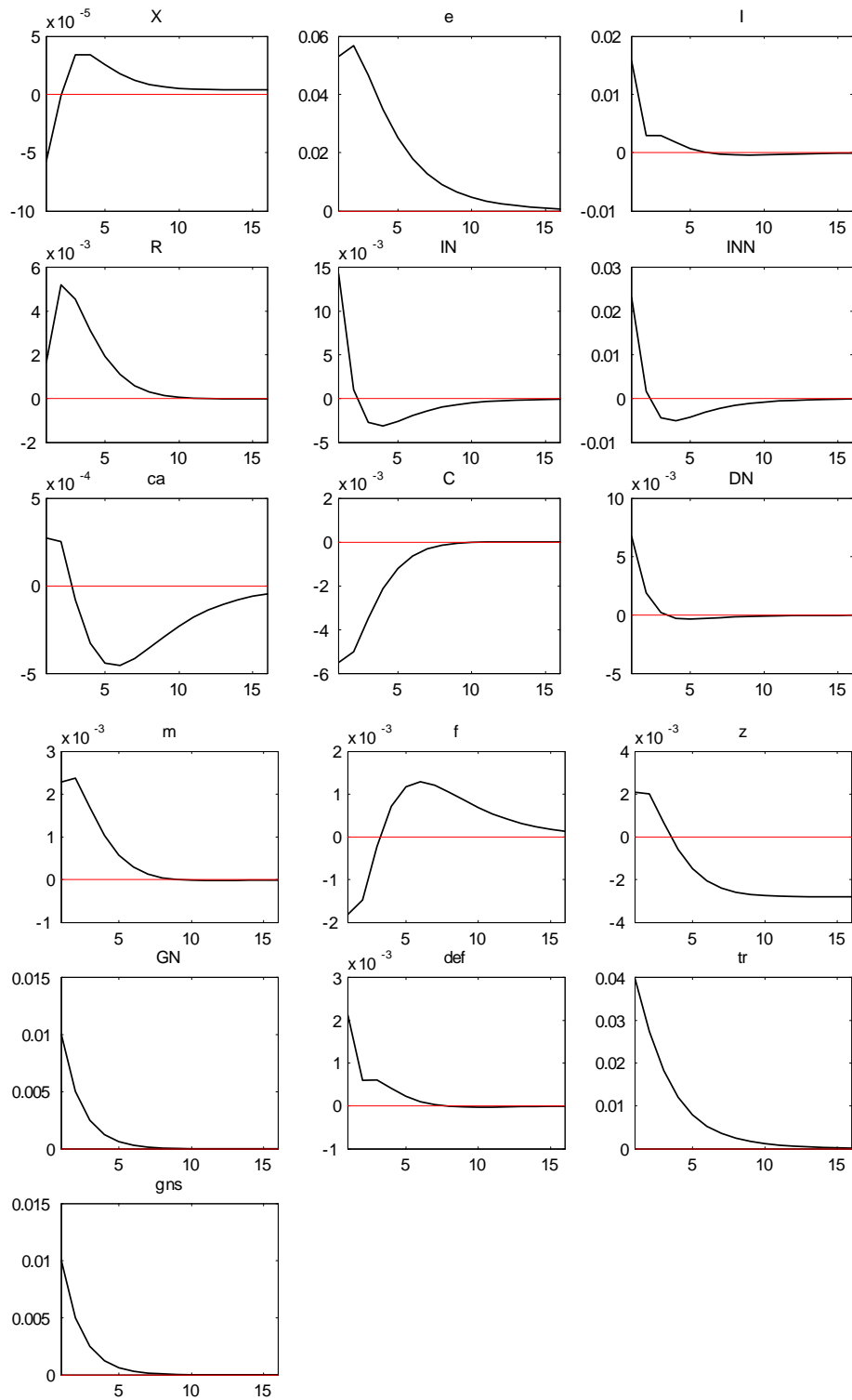
Figure 5: Africa fixed exchange rate - demand shock
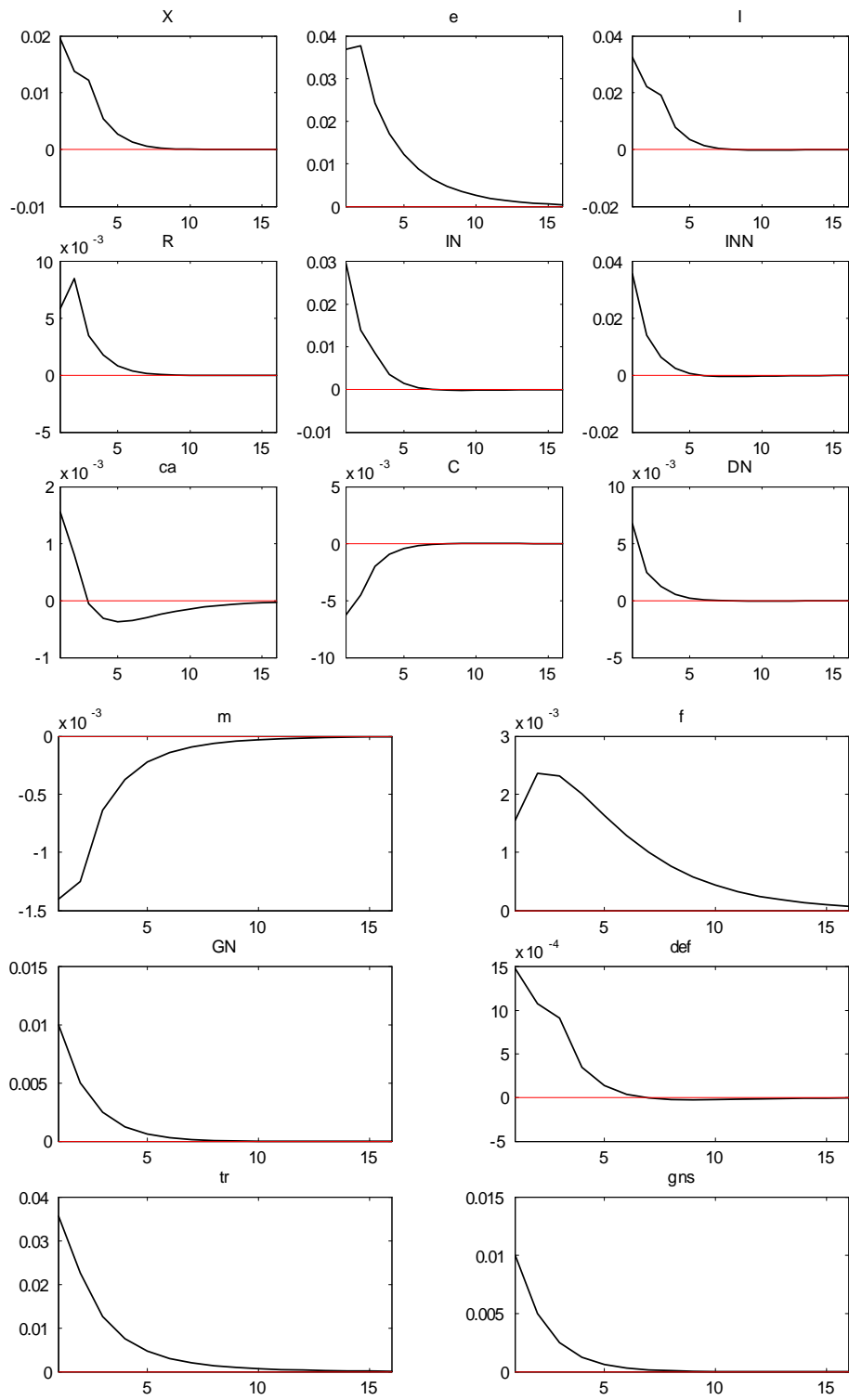
Figure 6: Africa float exchange rate - demand shock

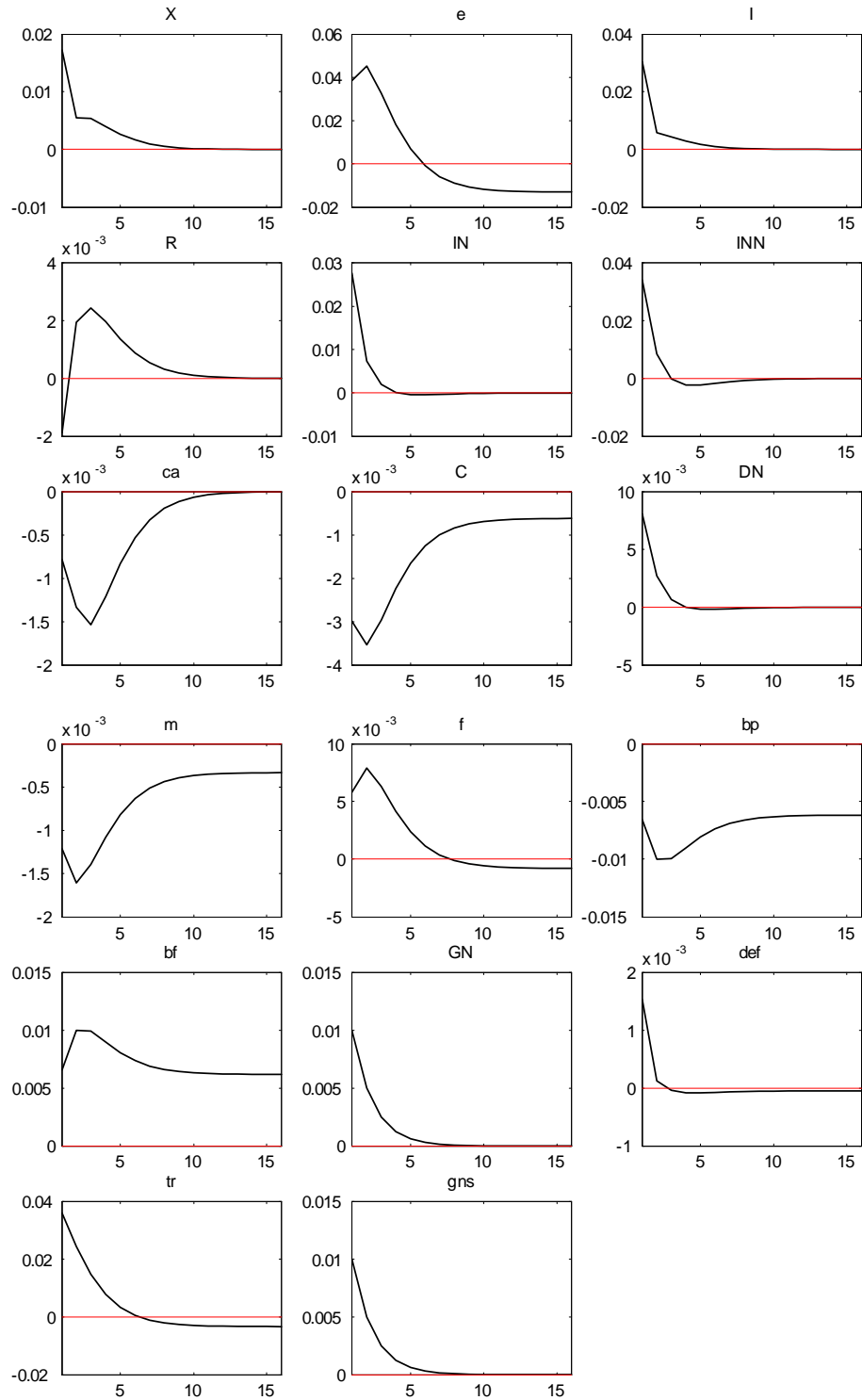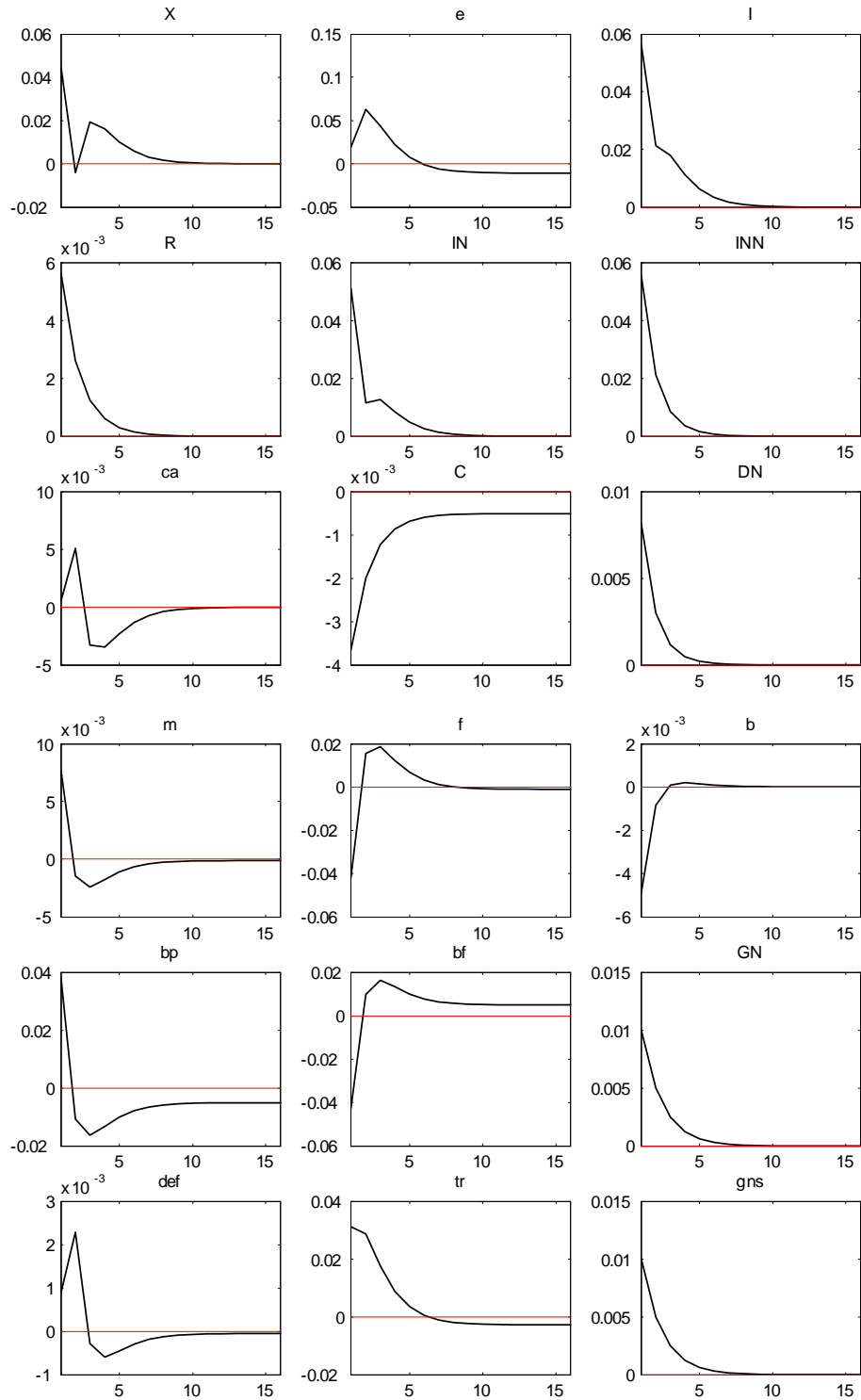Figure 7: Africa float exchange rate with UIP - demand shock

Figure 8: Africa float exchange rate with UIP and Taylor rule - demand shock
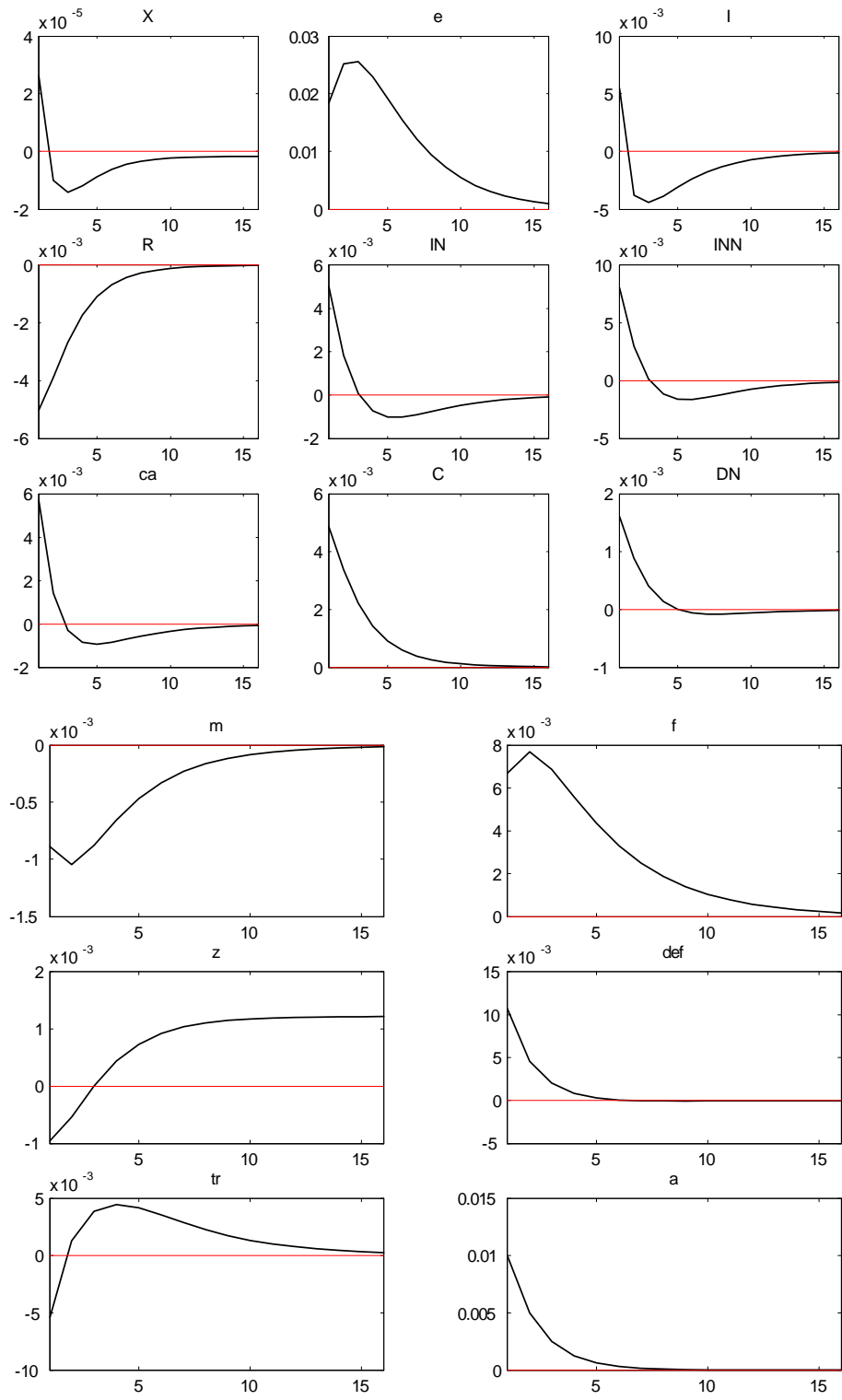
Figure 9: Africa fixed exchange rate - aid shock
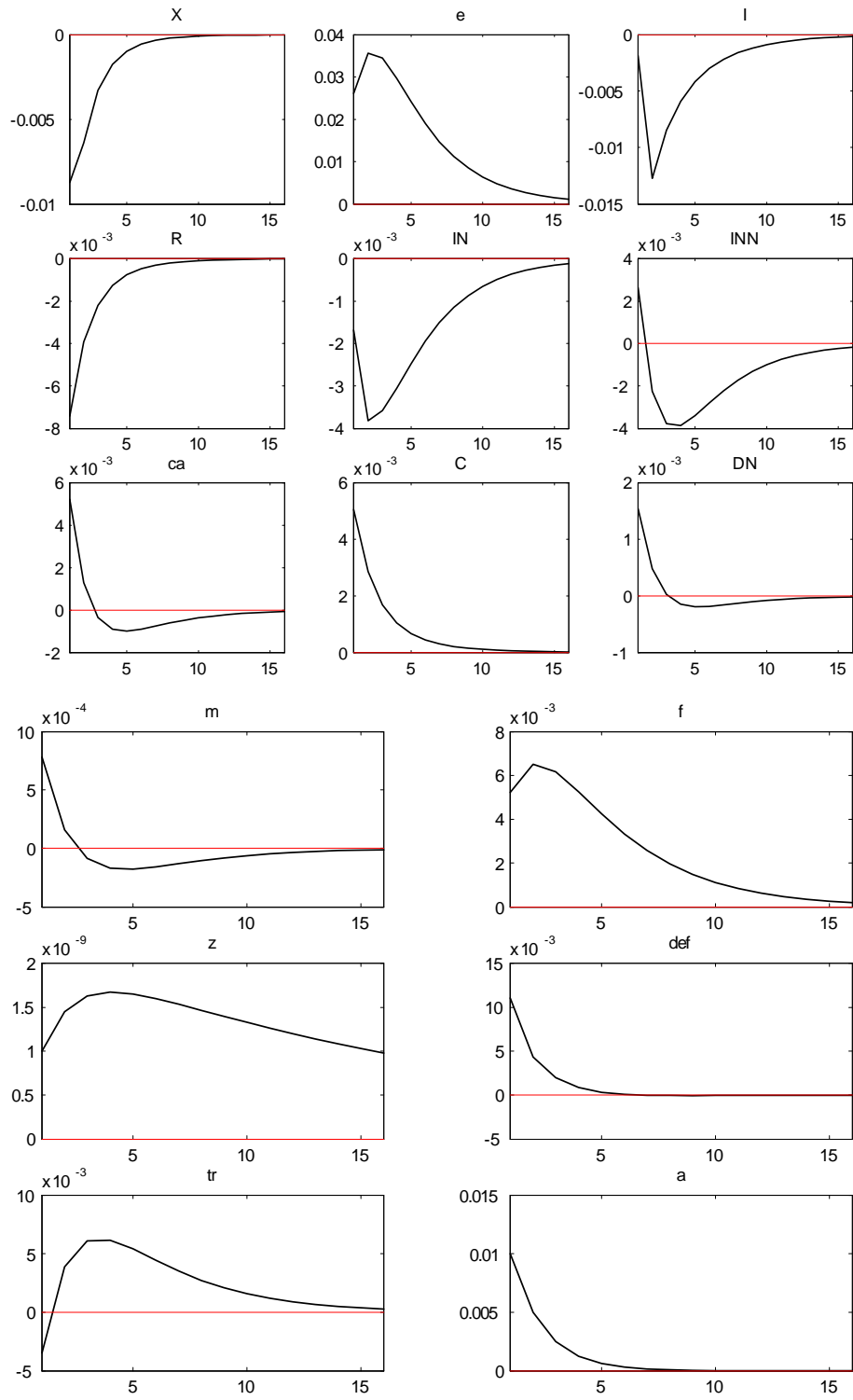
Figure 10: Africa float exchange rate - aid shock

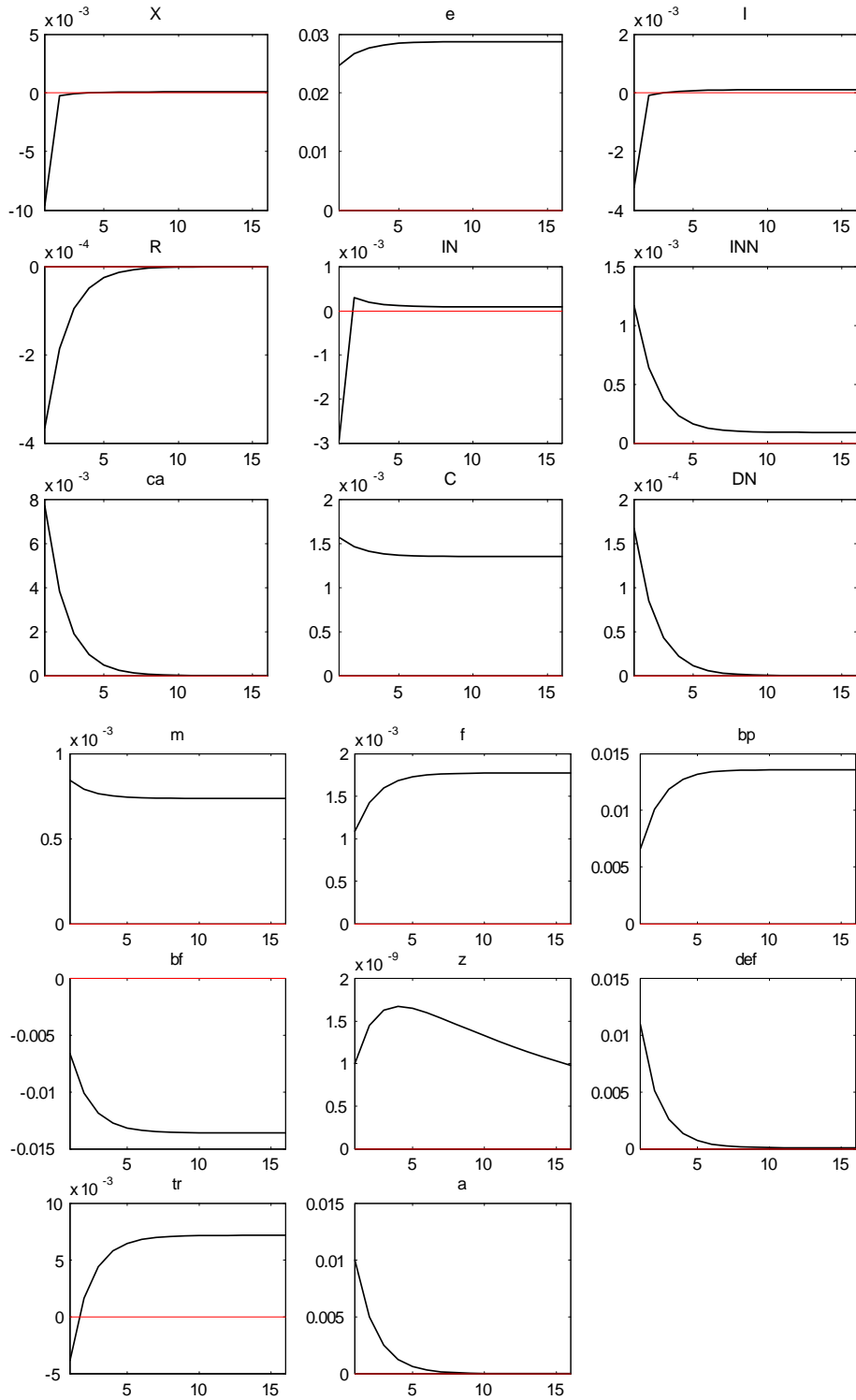Figure 11: Africa float exchange rate with UIP - aid shock

Figure 12: Africa float exchange rate with UIP and Taylor rule - aid shock