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Monetary Policy Rules for Managing Aid Surges in Africa

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Abstract

Since the turn of the century, aid flows to Africa have increased on average and become more volatile. As a result, policymakers, particularly in *post-stabilization* countries where inflation has only recently been brought under control, have been increasingly preoccupied with how best to deploy the available instruments of monetary policy without yielding on hard-won inflation gains. We use a stochastic simulation model, in which private sector currency substitution effects play a central role, to examine the properties of alternative monetary and fiscal policy strategies in the face of volatile aid flows. We show that simple monetary rules, specifically an (unsterilized) exchange rate crawl and a 'reserve buffer plus float'-under which the authorities set a time-varying reserve target corresponding to the unspent portion of aid financing and allow the exchange rate to float freely once this reserve target is satisfied—have attractive properties relative to a range of alternative strategies including those involving heavy reliance on bond sterilization or a commitment to a 'pure' exchange rate float.

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I. INTRODUCTION

"…even if government's domestic borrowing requirement remains low, a large aid-funded fiscal deficit can destabilize domestic financial markets…. To control the money supply in the face of a steep rise in liquidity arising from fiscal operations, the Central Bank had to step up the issuance of government securities to the domestic financial market….The only alternative sterilization instrument…was larger sales of foreign exchange, but this would have risked destabilizing the exchange rate." [Brownbridge and Tumusiime-Mutebile, 2007].

Monetary management in the face of surging aid flows is a difficult business for African central bankers. Since the turn of the century, aid flows to the continent have, on average, increased in volume and become more volatile.[2] Moreover, inflows been increasingly targeted to general budget support and program assistance rather than to project financing; a larger proportion of aid therefore now passes through the government budget, reinforcing the link between aid and domestic credit creation. As a result, policymakers, particularly in *post-stabilization* countries where inflation has only recently been brought under control, have been increasingly preoccupied with how best to deploy the available instruments of monetary policy without yielding on hard-won inflation gains. Eifert and Gelb (2005) and Foster and Killick (2007) even suggest that, in some instances, concerns with the short-run management of volatile aid inflows have threatened to overshadow broader considerations about the medium-term developmental rationale for aid, with the result that countries may seek to reduce their reliance on aid flows even when the medium-term returns to aid remain high and a number of donors remain committed to increasing their aid budgets in the coming years.

Central bankers' concerns span three main areas. The first is the perennial anxiety about 'Dutch Disease' effects of aid which may draw the authorities into attempts to prevent the temporary (or persistent) appreciation of the real exchange rate in order to forestall perceived losses in competitiveness. The second is the fear of fiscal destabilization. Volatile aid flows may induce public spending that is difficult to retrench when aid inflows recede, increasing the risk that the authorities will fall back on domestic deficit financing thereby jeopardising inflation control. As we discuss in a related paper,(Buffie *et al* 2006b), this risk remains even when governments plan to adjust expenditure in the face of volatile aid flows, but cannot credibly commit to do so.[3] Third, as the quotation from Brownbridge and Tumusiime-Mutebile (2007) at the top of the paper indicates, even when questions of medium-term credibility and competitiveness are not in play policymakers may still believe that large aid inflows force them to steer a course between Scylla and Charybdis; between nominal (and real) exchange rate volatility on the one hand and high and volatile interest rates on the other, which, in turn, raise concerns about private investment, the lending behaviour of the banking system and the quasi-fiscal burden of increased domestic borrowing.

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[2] Gupta, Pattillo, and Wagh (2006), Bulir and Hamann (2006).

[3] Buffie *at al* (2006b).

What central bankers seek in these circumstances are monetary rules that provide guidance on how to navigate these concerns. Specifically, they want answers to a range of questions, including: How aggressively should the authorities seek to manage the path of the nominal exchange rate, if at all? What is the role of foreign reserves as a buffer to smooth the spending response to aid inflows? Should aid-related liquidity growth be sterilized through bond sales? Moreover, how should these considerations be traded off against other concerns that legitimately compete for policymakers' attention, including, about external competitiveness and the development of nascent domestic financial sectors?

By casting the monetary problem in terms of how the volatility of aid flows transmits into volatility in the path of expected future seigniorage, we show that simple monetary rules which stabilize this path for a given aid flow have attractive properties relative to a range of conventional alternative strategies including those involving heavy reliance on bond sterilization or a commitment to a pure exchange rate float. We consider two specific rules which achieve this objective, albeit in different ways. The first, which we refer to as a *reserve buffer plus float,* directly stabilizes the path of seigniorage by synchronizing foreign exchange sales to the growth in liquidity generated by domestic spending out of aid. This entails initially accumulating aid inflows as official foreign exchange reserves and then sterilizing the full domestic currency counterpart of aid-financed non-import spending through foreign exchange sales as it occurs.[4] When aid is the only source of volatility on the budget and there is no recourse to bond financing, the *reserve buffer plus float* is tantamount to targeting base money. The second rule, the *exchange rate crawl*, does not target liquidity growth directly but rather the authorities intervene in the foreign exchange market to keep the nominal exchange rate close to its long-run equilibrium rate of depreciation. In doing so, the authorities respond to the latent pressures coming through the private capital account which, in turn, reflect underlying changes in the demand for and supply of domestic liquidity.

In the face of an aid surge, the *buffer plus float* and *crawl* imply broadly similar patterns of reserve accumulation and exchange rate movements. The difference is operationally significant, however. Under a *crawl*, the central bank targets the nominal exchange rate, without reference to the pattern of government spending and liquidity creation, whereas under the *buffer plus float*, the central bank does not pay direct attention to the nominal exchange rate. Instead it sets a time-varying reserve target that corresponds to aid financing that has not yet been spent, and allows the exchange rate to float freely once this reserve target is satisfied.

[4] Throughout this paper, we model budgetary aid as accruing in the form of dollar deposits owned by the Central Bank. Until aid dollars are sold by the central bank, an aid surge has no impact on seigniorage, because net international reserves and net domestic credit to government change in equal and opposite directions. As aid is spent (increasing the fiscal deficit), the import component of spending continues to leave domestic liquidity unchanged because net international reserves fall by the import component of the rise in the fiscal deficit (while in the background, net domestic credit rises by the same amount). The liquidity injection associated with aid corresponds to the non-import component of aid-financed spending. A *buffer plus float* policy uses foreign exchange sales to sterilize this in full, leaving seigniorage unchanged.

We show that both of these rules are robust to plausible variations in the fiscal response to aid. While there is a strong general presumption that a portion of any large aid surge should be held aside initially rather than being immediately spent, a distinction can be made between responses that reduce the present value of expected future seigniorage and those that alter the pattern of seigniorage over time. We refer to the former, which arises when aid substitutes for domestic deficit financing in support of a fiscal consolidation, as *deficit-reducing* aid. Amongst countries still struggling to bring inflation under control, the return to using some portion of the aid to reduce the present value of the government's domestic financing requirement is likely to be particularly high.[5]

Alternatively the fiscal authorities may primarily (or, indeed, in addition) be concerned to smooth the profile of government expenditure relative to that of aid, thereby altering the timing of a given present value of seigniorage requirements. The desire to delay some portion of aid-financed spending may reflect conventional welfare-based motives for expenditure smoothing, concerns about real exchange rate volatility, or, as we discuss in detail in Buffie *et al* (2006b), a desire to manage credibility in circumstances when donors cannot commit to aid flows on an ongoing basis and where public expenditure is difficult to reverse.

These arguments are illustrated using a stochastic simulation model.[6] The defining feature of our model is a characterization of households' portfolio choices and the financing options facing government that reflects the 'imperfectly open' capital account structures pervasive in much of Sub-Saharan Africa. Thus, the private sector engages in currency substitution but neither it nor the public sector has direct access to world capital markets. Hence, domestic government debt, which is the only marketable debt instrument in the economy, is effectively non-tradable so that domestic interest rates are not tied down by interest parity conditions. The model is calibrated to reflect key structural features of low-income African economies, both *pre-* and *post-stabilization* countries.[7]

For the most part, we adopt a strictly positive analysis geared to characterizing how different policy packages affect the volatility of inflation, real interest rates, output, and the real exchange rate. We therefore eschew an explicit welfare perspective. We show that strategies involving more or less active foreign exchange intervention and reserve buffering designed to smooth the path of domestic deficit financing serve best to moderate short-run macroeconomic volatility, including avoiding excessive real exchange rate volatility.

[5] Retiring privately domestic debt is one way of doing this, but we will focus on reducing the domestic credit requirement, i.e., reducing seigniorage relative to the no-aid counterfactual.

[6] Our model sits alongside and shares similarities with a number of recent papers emanating from the IMF concerned with the same topic including, Arellano *et al* (2005), Berg *et al* (2007), Pratti and Tressel (2006) and Peiris and Saxegaard (forthcoming). Many of the broader issues of the macroeconomic management of aid in low income countries, including the questions of aid absorption and policy responses to the transfer problem in the face of dynamic growth externalities, are also discussed in the collection edited by Isard *et al* (2006).

[7] *Post-stabilization* countries—referred to as *mature stabilizers* by the IMF—are those that have established track records of fiscal discipline and low inflation over a sustained period of time. These include, for example, Tanzania and Uganda since the mid-1990s.

Moreover, our results suggest that for pre-stabilization countries, where the fiscal response to aid typically involves a substantial reduction in domestic deficit financing requirements, the *reserve plus buffer* strategy may be inefficiently tight. In these circumstances, a managed float, with little or no sterilization of increases in the monetary base, better accommodates the increased demand for money associated with declining inflation and delivers a more attractive way of smoothing macroeconomic volatility.

While the paper is entirely focused on the management of aid flows, the close parallels with the management of commodity price volatility should not be overlooked. Similar macroeconomic management concerns preoccupy policymakers in commodity-dependent economies, especially in natural-resource economies where fiscal linkages via the budget mean the transmission channels from external price volatility to the domestic economy closely resemble those operating in the presence of aid volatility. The basic insights from this paper therefore carry over.

The remainder of the paper is structured as follows. In Section 2, we provide some motivation for the formal simulation analysis by establishing the main lines of our argument and presenting some stylized facts which will shape the calibration of the simulation model. Section 3 then describes the structure of the model (although readers interested only in the core message of the paper can easily skip this section), and in Section 4, we specify reaction functions for fiscal and monetary policy. Section 5 presents and discusses the simulation results. Section 6 concludes.

II. Basic Structure and Stylized Facts

We develop the simulation model in detail in the following sections. The central insights from our paper, however, derive directly from the basic accounting identities constraining public sector behaviour and the reaction functions that frame fiscal and monetary policy choices. The first identity is the consolidated budget constraint of the public sector, which we define in nominal terms as

$$\Delta M + \Delta B - \Delta NIR = DF = \text{Fiscal Deficit} - \text{Net Budgetary Aid}, \tag{1}$$

where DF is domestic financing of the consolidated public sector deficit. Equation (1) states that the fiscal deficit net of aid is ultimately financed through some combination of seigniorage (increases in the monetary base, ΔM), domestic borrowing (ΔB), and depletion of official net international reserves $(-\Delta NIR)$.[8] The second identity is the balance of payments, which takes the form

$$-\Delta NIR - \Delta NFA = \text{CA Deficit} - \text{Net Aid}, \tag{2}$$

[8] To keep the exposition simple, we have assumed that no non-grant foreign financing passes through the budget.

where ΔNFA is the change in private net foreign assets and CA is the current account before grants. Net Aid may in practice include flows that do not enter the fiscal accounts. Normalizing the world price of imports to 1 and dividing by the exchange rate E_t, we can express these constraints in terms of imports (the numeraire in our simulation model) as

(3) $$\Delta m_t + t + p_t \Delta b_t - \Delta z_t = d_t - a_t$$

and

(4) $$c_t + \Delta f_t = a_t - \Delta z_t .$$

In these equations, *m*, *b*, *z,* and *f* are the real monetary base, (indexed) government bonds, net international reserves, and private net foreign assets; $t_t = \frac{x_t}{1+x_t} m_{t-1}$ is revenue from the inflation tax (*x* is the rate of depreciation of the nominal exchange rate); *d* and *c* are the fiscal and current account deficits before aid; and *a* is net budgetary aid (here assumed equal here to net aid).

The right-hand side of (3)—which determines the total change in public sector liabilities or, in the present context, the government's domestic financing requirement—is the province of fiscal policy. Assuming government revenue is constant, the key fiscal choice is how much of the temporary aid inflow to spend in the current period. This choice determines the overall public sector deficit net of aid period-by-period. Monetary policy, in turn, may have important indirect effects on the fiscal position (for example via domestic debt service costs), but its fundamental domain is the *composition* of the left-hand side of (1), taking the right-hand side as given. The monetary authorities' instruments are Δz, which is determined by foreign exchange intervention, and Δb, which is determined through open-market operations. Together these instruments determine the path of Δm_t and t_t given the private sector's demand for money.

To study the monetary and fiscal responses to aid shocks, we start from a steady state in which the fiscal deficit is financed by a combination of aid and the inflation tax, and the current account deficit is fully financed by aid. Writing (3) in terms of deviations from the steady state, the path of seigniorage then satisfies

(5) $$\Delta m_t + t - \bar{t} = (d_t - \bar{d}) - [\Delta z_t - (a_t - \bar{a})] - p_t \Delta b_t .$$

On receipt, any aid that is not immediately self-sterilizing through increased government imports creates an equal and offsetting increase in foreign exchange reserves and net central bank credit to the government. Ignoring self-sterilizing aid, then, domestic liquidity is 'instantaneously' unchanged by the receipt of aid $(d_t - \bar{d} = 0$ and $\Delta z_t = a_t - \bar{a}$ in (5)). Subsequently, however, the government's spending decision $(d_t - \bar{d})$ and the monetary authority's choices regarding reserve accumulation (Δz_t) and bond operations (Δb_t) play central roles in shaping the macroeconomic response to aid. For plausible paths of aid-induced spending, our interest is in finding monetary policy rules that have straightforward

operational features and that deliver acceptable responses of inflation, real exchange rates, and real interest rates to large and temporary shocks to aid.
Tables 1 and 2 provide evidence on the actual responses of fiscal deficits and reserve accumulation to aid surges in Sub-Saharan Africa. In contrast to the appealing benchmark of 'fully spent' and 'fully absorbed' aid (Berg *et al* 2007), aid has rarely increased the fiscal deficit dollar for dollar and has frequently been accompanied by significant official reserve accumulation.[9]

Table 1 reports the average propensity to spend out of aid. Across SSA spending out of aid has averaged about 75 cents on the dollar, although a clear distinction emerges between *pre-stabilization* countries, like Malawi, the Democratic Republic of Congo (until very recently), and Uganda (until the early 1990s), and *post-stabilization* ones such as Tanzania and Uganda since the early 1990s. The markedly lower propensity to spend out of aid amongst the former group is likely to reflect the differential importance attached to inflation stabilization and to institutional reform in the design of monetary and fiscal policy. Pre-stabilization countries face the challenge of establishing credible fiscal discipline, while post-stabilization ones face the more modest challenge of maintaining it. Hence, in pre-stabilization countries, there is a strong presumption that a portion of any major aid inflow will continue to be used to support a reduction in inflation: the fiscal deficit after grants will be allowed to fall so that the domestic financing requirement is reduced. Amongst post-stabilization countries, in contrast, there is no intrinsic need to reduce seigniorage, because inflation is reliably anchored by ongoing fiscal discipline a major aid inflow may or may not end up substituting for domestic deficit financing. The path of domestic financing will therefore be more likely to reflect other considerations, including the government's perception of the permanence of aid and its preferences regarding the relative importance of smoothing government spending and domestic financing.

Table 2 suggests in addition that aid flows in general, and surges in particular, tend to be met by substantial official reserve accumulation. This is particularly strong amongst mature stabilizers, reinforcing the view expressed by Berg *et al* (2007) and Foster and Killick (2006) amongst others that central banks' concerns about nominal and real exchange rate appreciation have drawn them into relatively heavy foreign exchange intervention in the face of aid surges.

In Section 4, we develop a fiscal reaction function that describes the response to aid in terms of *deficit reduction* and *fiscal smoothing* parameters. To characterize monetary policy, we embed the management of aid flows within a broader framework that allows alternative

[9] In this context, spending out of aid is measured by the increase in the fiscal deficit before grants and absorption by the increase in the current account deficit before grants. As argued lucidly by the IMF (2005), the conventional development rationale for aid suggests that aid should be allowed reasonably quickly to produce a dollar-for-dollar increase in the former (to maximize the contribution of aid to public goods and services), and also the latter (to maximize the resource transfer from donors). Our evidence bears directly on fiscal response, which as we show is typically partial. It bears only indirectly on the current account response, because as equation (2) makes clear, this is not a policy variable unless the private capital account is zero, which it decidedly is not, even among low-income African countries.

degrees of commitment to monetary and exchange rate targets. Taking the stochastic aid inflow as given and assuming a small range of alternative fiscal responses, we examine the properties of alternative monetary policy responses in terms of their impact on inflation, the exchange rate, interest rates and the level and composition of private spending and the current account. Throughout, we maintain the assumption that the fiscal authorities move first, and do so in fully credible manner, both in the eyes of the monetary authorities and of the private sector. We briefly consider the issue of the credibility of fiscal policy in the final section.

III. The Simulation Model

A. Basic Design

We work with a simple optimizing two-sector dependent economy model with currency substitution in which both domestic and foreign currencies delivery liquidity services.[10] The representative private agent consumes traded imports and non-traded final goods and accumulates financial wealth in the form of three assets: domestic currency, foreign currency, and government bonds. There are no banks so that money is base money and foreign currency balances are held in non-interest-bearing forms. Capital mobility is imperfect: government bonds, which are indexed to consumer prices, are non-traded while the private agent has no access to foreign bonds. Nonetheless, the private capital account is open so that the private agent can accumulate or decumulate foreign currency through transactions with the central bank or current account surpluses.

Given our focus on the short-run management of the demand side effects of aid surges, the supply side of the model economy has been kept deliberately simple. Thus we assume the economy produces exported and non-tradable goods using sector-specific capital, an intermediate import (oil) and labour, which is intersectorally mobile. The aggregate capital stock is fixed and there is no investment. However, we allow for two adjustment mechanisms on the supply side. In the first, we assume fully flexible prices and wages, so that full employment prevails and the relative supply of exported and non-traded goods is governed by the real exchange rate for exports. We assume a relatively low elasticity of substitution in production, which implies that shocks to sectoral supplies and demands have a relatively strong effect on the real exchange rate.[11] The second adjustment mechanism assumes that non-traded goods prices are sticky so that the output of non-traded goods is demand-determined in the short run. In this case, macroeconomic adjustment can then take place off the production frontier, via booms or recessions in the nontraded goods sector.[12] The

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[10] This money-in-the-utility-function model shares a similar structure with that developed in Buffie (2003) and Buffie *et al* (2004). The stochastic version we develop here is a variant of the model introduced in O'Connell *et al* (2007).

[11] Although the model does not explicitly allow for capital accumulation, the consequences of supply-side adjustment on the real exchange rate can be approximated by assuming a higher inter-sectoral elasticity of substitution than is currently imposed.

simulations reported below focus entirely on this second case; readers are referred to O'Connell *et al* (2007) for a comparison with the flex-price representation of the supply side.

As described above, macroeconomic policy choices are defined through linear policy rules for government and the central bank. Taking the tax structure as given, fiscal policy consists purely of the spending response to the aid shock which determines the path of domestic financing (see equation (2) above), while on the monetary side, two independent rules define how the instruments of indirect monetary control—transactions in foreign exchange and government securities with the private sector—are deployed.

Finally, the model is closed by defining a stochastic process for the external shocks. In this case we limit the sources of external volatility to stochastic shocks in the net aid inflow.[13]

B. Preferences and Aggregate Demand

The representative household maximizes an expected utility function of the form

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

where τ is the inter-temporal elasticity of substitution, $\beta \equiv (1+\rho)^{-1}$ is the discount factor, and the consumption and liquidity aggregates C and L are CES functions of the underlying goods and currencies:

$$C_t \equiv \left(k_N C_{Nt}^{\frac{\alpha-1}{\alpha}} + k_I c_{It}^{\frac{\alpha-1}{\alpha}} \right)^{\frac{\alpha}{\alpha-1}} \qquad L_t \equiv \left\{ k_M \left(\frac{M_t}{P_t} \right)^{\frac{\sigma-1}{\sigma}} + k_F \left(\frac{E_t f_t}{P_t} \right)^{\frac{\sigma-1}{\sigma}} \right\}^{\frac{\sigma}{\sigma-1}}.$$

Here C_{Nt} and c_{It} are consumption of non-traded and imported goods, M_t and f_t are end-of-period holdings of domestic and foreign currency, E_t is the nominal exchange rate in units of local currency per unit of foreign currency, and P is an exact consumption-based price index.[14]

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[12] In the sticky-price version, we assume that labour is sector-specific, so that value-added in the exportables sector is fixed, aside from supply shocks.

[13] This simple one-shock structure is nested within a higher dimension structure in which we allow for the stochastic determination of commodity export prices, non-tradable output (via rainfall volatility) and for volatility in intermediate input prices ('oil shocks'). Given the specific focus on managing aid shocks we suppress these other sources of volatility in this paper.

[14] Given the CES structure for the consumption aggregate, $P_t = \left(k_N^{\alpha} P_{Nt}^{1-\alpha} + k_I^{\alpha} P_{It}^{1-\alpha} \right)^{\frac{1}{1-\alpha}}$.

Households have access to government bonds whose yield is indexed to P so that financial wealth acquired in period *t* is given by $W_t = M_t + P_t b_t^P + E_t f_t$. Using Y to denote the non-interest income of the household sector and TR to denote taxes net of transfers received from the government, the household sector's overall budget constraint in nominal terms 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 $P_t C_t = (P_{Nt} C_{Nt} + P_{It} c_{It})$ and where $R_{t-1} = 1 + r_{t-1}$ is the real interest factor applicable to bonds carried over from period *t*–1. Assuming PPP for traded goods and normalizing the foreign price of importables to 1, we divide by E_t to express this in terms of imports. Using lower-case letters to denote stocks or flows measured in terms of imported goods, this yields

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

where $\Pi_t = 1 + \pi_t = P_t / P_{t-1}$ and $X_t = 1 + x_t = E_t / E_{t-1}$ are the current-period inflation and depreciation factors and $R_{It} = 1 + r_{It} = R_{t-1}\Pi_t / X_t$ is the real interest factor in terms of importables (note that as of period *t*–1, the real yield R_{It} is uncertain even though R_{t-1} is known). The price of the consumption aggregate in terms of imported goods, p_t, is a function of the real exchange rate for imports, $e_t \equiv P_{Nt} / E_t$:

(6) $$p_t \equiv \frac{P_t}{E_t} = \left(k_N^{\alpha} e_t^{1-\alpha} + k_I^{\alpha}\right)^{\frac{1}{1-\alpha}}.$$

Rearranging terms and using $R_{It} = I_t / X_t$ (for $I_t = 1 + i_t = R_{t-1}\Pi_t$) to simplify further, we can write the household sector's budget constraint as

(7) $$\Delta w_t = r_{It} w_{t-1} - \frac{i_t}{1+x_t} m_{t-1} - \frac{i_t - x_t}{1+x_t} f_{t-1} + y_t - tr_t - p_t C_t.$$

The first-order conditions for maximizing utility subject to the sequence of budget constraints include, along with appropriate transversality conditions, the consumption Euler equation

(8) $$C_t^{-\tau^{-1}} = \beta E_t\left[\frac{R_{I,t+1} p_t}{p_{t+1}} C_{t+1}^{-\tau^{-1}}\right] = \beta R_t E_t C_{t+1}^{-\tau^{-1}}$$

along with the following currency demand conditions

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

and

$$\left(\frac{f_t}{p_t}\right)^{-\frac{1}{\sigma}} = \left(\frac{1}{hk_F}\right) L_t^{\left(\frac{\sigma-\tau}{\sigma\tau}\right)} \beta E_t\left[\frac{i_{t+1}-x_{t+1}}{1+\pi_{t+1}} C_{t+1}^{-\tau^{-1}}\right]. \tag{10}$$

Given the central role that portfolio behaviour plays in our analysis, it is convenient to examine the properties of the currency demand function in a little more detail. By linearizing (9) and (10) around the steady state, so that $\tilde{m}_t$ and $\tilde{f}_t$ denote log deviations from the steady state, we can express the relative demand for domestic and foreign currencies as

$$\frac{\tilde{m}_t}{\tilde{f}_t} = \phi_0 - \phi_i \cdot {}_t i_t + \phi_x \cdot (i_t - {}_t x_{t+1}),$$

where $\phi_i = \sigma / \bar{i} > 0$ and $\phi_x = \sigma/(\bar{i} - \bar{x}) > 0$. Here i_t is the nominal interest rate on government securities and ${}_t x_{t+1}$ is the expected rate of depreciation of the local currency between periods *t* and *t*+1,[15] and $\bar{i}$ is the steady-state value of the interest rate. Relative currency demand thus depends on the relative opportunity cost of holding domestic or foreign currency, i_t and $i_t - {}_t x_{t+1}$ respectively, rather than government bonds. The sensitivity of relative currency demand to these opportunity costs is an increasing function of the elasticity of currency substitution.

The demand for domestic currency, in turn, is given by

$$\log \tilde{M}_t - \log \tilde{P}_t = \eta_0 - \eta_i \cdot i_t + \eta_x \cdot {}_t(i_t - {}_t x_{t+1}) + \log \tilde{C}_t,$$

where $\tilde{C}_t$ is (the log deviation from steady state of)total spending by the private sector. The semi-elasticities of domestic currency demand are given by $\eta_i = [\tau + (1-v)(\sigma - \tau)]\bar{i}^{-1} > 0$ and $\eta_x = (1-v)(\sigma-\tau)/(\bar{i} - \bar{x}) > 0$, where *v* is the steady-state share of domestic currency in liquidity services, $\bar{i} = \rho + \bar{\pi}$ is the nominal interest rate and ρ the rate of time preference. The steady-state inflation elasticity of the demand for domestic money is defined as

$$\varepsilon = \bar{\pi} \cdot \eta_i = [\tau + (1-v)(\sigma-\tau)](\bar{\pi} / \bar{i}). \tag{11}$$

For any positive steady-state inflation rate, this is a small number when the currency substitution and inter-temporal substitution elasticities are the same ($\sigma = \tau$). But, as noted

[15] Expected depreciation is ${}_t x_{t+1} \equiv ({}_t E_{t+1} - E_t)/E_t$.

below, most evidence suggests that $\sigma >> \tau$ so that empirically realistic calibrations can easily generate large elasticities.
The portfolio behaviour described in these equations has conventional properties. First, the demands for both currencies are unit-elastic with respect to spending on goods and services. Second, holding the nominal interest rate constant, an increase in expected depreciation $({}_t x_{t+1})$ shifts desired portfolios in favour of foreign currency. As long as $\sigma > \tau$, this is accomplished partly through an absolute reduction in the real demand for domestic currency. Finally, a rise in the domestic interest rate reduces the real demand for domestic currency, as long as steady-state inflation is not too high.[16]

The parameters σ and τ therefore play a critical role in governing the behaviour of the private sector. On their own, higher degrees of substitutability (σ) tend to provoke larger portfolio reallocations and therefore greater pressures on the nominal exchange rate in response to shocks. A higher value of the inter-temporal elasticity of substitution (τ), other things equal, tends to produce greater volatility in consumption and the current account and less volatility in the real interest rate. In this paper, we set $\sigma = 2$ and $\tau = 0.50$ which correspond to mid-range values from the limited empirical evidence of these parameters.[17] Combined with initial steady state values of π, i, and v, these values imply steady state inflation elasticities of the demand for money of 0.53 for mature stabilizers and 0.62 for high-inflation, low-credibility countries (see Table 3a).

C. Aggregate Supply

For given fixed capital endowments, aggregate domestic output is defined in terms of a constant elasticity of transformation aggregator over exportable and non-tradable production

$$\bar{Q} = \left[\delta Q_N{}^{(1+\eta)/\eta} + (1-\delta) Q_X{}^{(1+\eta)/\eta} \right]^{\eta/(1+\eta)} \tag{12}$$

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[16] When steady-state inflation is zero, steady-state nominal depreciation, $\bar{x}$, must also be zero, and the impact of higher nominal interest rates is negative, because $\eta_x - \eta_i = -\tau / \bar{i}$. This effect can be reversed when steady-state inflation is positive, if there is a high degree of portfolio substitution $(\sigma >> \tau)$. Holding expected depreciation constant, a rise in the nominal interest rate *increases* the relative demand for domestic currency as long as steady-state inflation is positive. This effect emerges because a higher nominal interest rate, given a fixed, positive rate of expected depreciation, reduces the *relative* opportunity cost of domestic currency, $i_t / (i_t - {}_t x_{t+1})$.

[17] There are no reliable direct estimates for the elasticity of substitution between domestic and foreign money for any African countries. Estimates for Latin America generate numbers in the range 0.75 to as much as 7, although the top-end estimates appear extremely large (e.g. Ramirez-Rojas (1985), Giovannini and Turtleboom (1994)). Hence our choice of 2.0. There is a stronger degree of consensus concerning the value of inter-temporal elasticity of substitution (see, for example Agenor and Montiel, 1999). However, in view of the uncertainty on these key parameter values we re-run the simulations under lower values of both parameters (i.e. $\sigma = 0.75$ and $\tau = 0.25$). These simulations are available on request. Changing these parameters alters the model properties in intuitive ways but do not substantially alter our central insights.

where η is the elasticity of transformation in output. Measured in importables, full-employment GDP is given as:

(13)
$$y = e\left(1-\omega_N\left(\frac{p^0}{e}\right)\right)Q_N + p_X\left(1-\omega_X\left(\frac{p^0}{p_X}\right)\right)Q_X$$

for sectoral supply functions Q_N and Q_X, where p_X is the world price of the exportable in terms of the importable (the barter terms of trade), p^o the world oil price and ω_N and ω_X the cost share of intermediate inputs in gross costs in the non-tradable and tradable sectors respectively.

While our PPP assumption rules out sticky prices for exports, the assumption of flexible domestic prices is less appealing for nontraded goods. To accommodate the possibility of price stickiness, we allow for Calvo (1983) pricing in the non-tradable goods market. Assuming that an individual firm's opportunity to change its price arrives as a Poisson process with parameter λ, the price level chosen by adjusting firms in period *t* satisfies

$$\log P_{Nt}^A = [1-(1-\lambda)\Gamma]\log P_{Nt}^* + (1-\lambda)\Gamma E_t \log P_{N,t+1}^A.$$

where $\log P_{N,t+k}^*$ is the target (log) price in *t+k,* and Γ the discount factor. Since a proportion λ of (the large number of) firms ends up changing prices in period *t*, the aggregate price level for nontraded goods satisfies $\log P_{Nt} = \lambda \log P_{Nt}^A + (1-\lambda)\log P_{N,t-1}$. In the meantime, the actual output of nontraded goods is demand determined. We model the optimal price as a function of the aggregate price level and the gap between the output of nontraded goods and their supply at full employment. Thus

$$\log P_{Nt}^* = \log P_{Nt} + \zeta \cdot \left[\frac{C_{Nt}(e, C_t) + G_{Nt} - \varphi_{Nt} Q_N(e_{Xt})}{\varphi_{Nt} Q_N(e_{Xt})}\right], \qquad \zeta > 0.$$

These three equations yield the sector-specific Phillips Curve

(14)
$$\log P_{Nt} - \log P_{N,t-1} = \Gamma E_t[\log P_{N,t+1} - \log P_{Nt}] + \psi \cdot \left[\frac{C_{Nt}(e_t, C_t) + G_{Nt} - \varphi_{Nt} Q_N(e_{Xt})}{\varphi_{Nt} Q_N(e_{Xt})}\right],$$

where $\psi \equiv \frac{\zeta\lambda}{1-\lambda}[1-(1-\lambda)\Gamma] > 0$. High values of ψ imply greater price flexibility, and as $\psi \to \infty$ equation (14) approaches the flexible-price market-clearing condition in the nontraded goods market, $\varphi_{Nt} Q_N(e_{Xt}) = C_{Nt}(e_t, C_t) + G_{Nt}$. To ensure that the Natural Rate Hypothesis holds, we impose $\Gamma = 1$.

D. The Public Sector

The central bank's balance sheet, in nominal terms, reads $\Delta M_t = E_t \Delta z_t + P_t \Delta b_t^C$, where z denotes official international reserves and b^C government securities held by the central bank. Assuming the central bank transfers its operating surplus to government, the government budget constraint takes the form

$$P_t(\Delta b_t^P + \Delta b_t^C) = P_{Nt}G_{Nt} + E_t g_{It} + P_t r_{t-1} b_{t-1}^P - TR_t - E_t a_t,$$

where we are assuming no interest on reserves and no foreign debt accumulation, and where a is foreign aid net of interest payments on any existing foreign debt of the public sector. The consolidated public sector budget constraint is therefore

$$M_t + P_t b_t^P - E_t z_t = M_{t-1} + P_t R_{t-1} b_{t-1}^P - E_t z_{t-1} + P_{Nt} G_{Nt} + E_t g_{It} - TR_t - E_t a_t$$

or, in terms of importables,

(3') $$\Delta m_t + p_t \Delta b_t^P - \Delta z_t = d_t - a_t - \frac{x_t}{1+x_t} m_{t-1},$$

where the fiscal deficit is defined as $d_t \equiv g_t - t_t + p_t r_{t-1} b_{t-1}^P$. Equation (3') is of course identical to equation (3) of Section 2; it can be combined with the household sector's flow budget constraint (7) to yield a version of equation (4), the current account identity:

(4') $$\Delta f_t + \Delta z_t = y_t - g_t - p_t C_t + a_t.$$

E. External Shocks

The economy is subject to a stochastic sequence for external aid flows, represented by $v_t = [\log a_t - \log \bar{a}]$ which follows a stationary AR(*1*) process for given steady-state mean value of aid, $\bar{a}$. Thus

(15) $$v_t = \alpha_1 v_{t-1} + \varepsilon_{vt}, \qquad E_t \varepsilon_{vt} \varepsilon'_{vt} = \sigma_a^2.$$

ε_{vt} is serially uncorrelated, and the root of the lag polynomial is stable. Parameterization of (15) is based on a cross-country VAR analysis.[18] In this paper we limit ourselves to a single characterization of the aid process in which aid shocks are scaled to an equivalent of 2 percent of GDP and follow a first-order AR process with an autoregressive parameter of 0.50.

[18] This VAR analysis is described in detail in O'Connell *et al* (2007).

IV. Fiscal and Monetary Policy

To complete the model, we require a description of how fiscal and monetary policies respond to aid. On the fiscal side, our focus is on the financing implications of fiscal policy, and, in particular, on the consequences of deficit reduction or delayed expenditure out of aid. We therefore adopt a simple structure in which domestic revenue takes the form of lump-sum taxes and government spending takes the form of transfers to the private sector.[19] Taxes are held constant throughout so that aid shocks constitute the only source of revenue volatility.

Fiscal behaviour is then governed by two decisions determining the level and timing of spending out of aid. First a portion δ of aid may be devoted to *deficit reduction*. Hence for a given aid surge, an amount $\delta(a_t - \overline{a})$ is used to substitute for domestic deficit financing (seigniorage or domestic debt) and $(1-\delta)(a_t - \overline{a})$ is spent. Based on the evidence from Table 1, we assume $\delta = 0$ or $\delta = 0.25$. Second, given this planned spending out of aid, the fiscal authorities may choose to alter the path of spending relative to that of the aid inflow so as to extend the duration of public expenditure out of temporary aid beyond that of the aid itself. To track spending carried over to future periods, we introduced an 'aid account', denoted *W*. In steady state, all aid is spent so that the aid account has a zero balance. Outside of the steady state, the government spends a constant fraction $(1-\mu)$ of the balance in the aid account each period; the remaining fraction μ is devoted to *smoothing*. Denoting W_t the end-of-period balance in the aid account, the fiscal deficit in period *t* is given by

$$d_t - \overline{d} = (1-\mu)\left[(1-\delta)(a_t - \overline{a}) + W_{t-1}\right] \tag{16}$$

The implied equation of motion for *W* is

$$W_t = W_{t-1} + (1-\delta)(a_t - \overline{a}) - (d_t - \overline{d}) = \mu[(1-\delta)(a_t - \overline{a}) + W_{t-1}].$$

Clearly, for $\mu = 0$, the aid account remains at zero and the profile of expenditure matches that of aid net. Higher value of μ attenuate the path of expenditure relative to aid. Given the value of the autoregressive parameter for the aid process of 0.50, the half-life of the aid shock is one year, with 94 percent of the aid received within four years. With an expenditure smoothing parameter of $\mu = 0.5$, the half-life of aid-induced spending is double that of aid and only 81 percent of the aid is spent within four years. A value of $\mu = 0.25$ would increase the half-life of spending to almost four years, with only 56 percent of the shock spent by year four. In our simulations we fix $\mu = 0.5$.

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[19] In this paper we assume that spending takes the form of transfers to the private sector, rather than direct purchases of goods and services. In other versions of the model we allow for the authorities to alter the composition of public expenditure at the margin between tradable and non-tradable consumption (see O'Connell *et al* 2007). Earlier work using this model suggests that plausible changes in expenditure composition at the margin generate modest (and intuitive) differences in volatilities in the real exchange rate and the real interest rate. We lose relatively little, therefore, by excluding this additional policy choice here.

Monetary policy is our central focus and our treatment is correspondingly more detailed. The instruments of monetary policy are transactions in foreign exchange and government securities with the private sector.[20] To characterize reserve management, we begin with the simplest reaction function that accommodates alternative degrees of commitment to a fixed rate of crawl: $\Delta z_t = -\alpha_1(x_t - \bar{x}),$ for $\alpha_1 \geq 0$ (e.g., Obstfeld and Rogoff 1996, pp. 657-8). To this, we add a fixed long-run reserve target $\bar{z},$ in order to preserve the stationary structure of the analysis; and—possibly—a time-varying reserve target that is tied to the pattern of fiscal spending out of aid. Reserve policy is therefore given by

$$\text{(17)} \qquad \frac{\Delta z_t}{\bar{z}} = -\alpha_1 \frac{x_t - \bar{x}}{\bar{x}} - \alpha_2 \frac{z_{t-1} - \bar{z}}{\bar{z}} + \alpha_3 \frac{(a_t - \bar{a}) - \gamma \cdot (d_t - \bar{d})}{\bar{z}},$$

where $\alpha_1 \geq 0,$ $\alpha_2 > 0,$ $\alpha_3 \in \{0,1\},$ and $0 \leq \gamma \leq 1.$ Here $\bar{x}$ is the steady-state rate of depreciation, which is tied down by the long-run inflation rate, and $\bar{z}$ is the steady-state level of reserves.

The parameter α_1 governs the degree of commitment to the steady-state rate of crawl. As $\alpha_1 \to \infty$ the regime approaches a predetermined *crawl* in which $x_t = \bar{x}$ on a continuous basis. Lower values of α_1 represent looser commitments to the reference rate of crawl, and for $\alpha_1 = 0$ the exchange rate floats: central bank intervention, if any, is independent of movements in the nominal exchange rate.[21] In the floating case, all foreign exchange available to the economy is immediately priced in a competitive foreign exchange market and either added to private foreign currency holdings or absorbed through an increased current account deficit.

We will refer to the combination of $\alpha_1 = 0$ and $\alpha_3 = 0$ as a *pure float*: this is the textbook case in which the monetary authority not only ignores the exchange rate but also keeps international reserves unchanged in the face of shocks. The final term in (17), however, allows the central bank to tie foreign exchange sales directly to the path of aid-induced government spending. A policy of $\alpha_1 = 0,$ $\alpha_3 = 1$ and $\gamma = 1$ corresponds to what we call a *buffer plus float*. This approach is simple and intuitive: the central bank sells aid dollars in the precise amount required to finance aid-induced spending as it occurs, but floats with respect to all other shocks.[22] In a *buffer plus float*, any aid that is not spent in the current

[20] With no banking system in model, there is no role for reserve requirements or deposit placement policies in the central bank's toolkit.

[21] Equation (17) can be adapted to accommodate a real rather than a nominal exchange rate target; in Section 5.4 we do this by replacing the exchange rate term $(x_t - \bar{x})$ with $(e_t - \bar{e})$, where *e* denotes the real exchange rate.

[22] Note that the import component of aid-induced spending (zero in our runs) is self-sterilizing. It generates no increase in the monetary base because government deposits decline (and net domestic credit rises) as reserves decline.

period is retained as reserves. Of course, if $\delta = \mu = 0$ so that aid is always spent immediately, there is no operational difference between a *buffer plus float* and a *pure float*. In the presence of deficit-reduction or expenditure-smoothing components, however, a *buffer plus float* involves a period of potentially substantial reserve accumulation during an aid boom.

The results to follow can be foreshadowed by reference to the consolidated budget constraint and the implications of monetary policy for the path of seigniorage. To do this recall equation (5)

$$(5) \qquad \Delta m_t + t - \bar{t} = (d_t - \bar{d}) + [\Delta z_t - (a_t - \bar{a})] - p_t \Delta b_t .$$

In a moment we will discuss the potential role of bond operations, but for now we set $\Delta b = 0$. A few observations are immediately apparent. First, if the fiscal authorities spend aid as it is received, so that $(d_t - \bar{d}) = (a_t - \bar{a})$, the first-order impact of a *pure float*, which entails $\Delta z_t = 0$, is to stabilize the time path of required seigniorage. With the right hand-side of (5) equal to zero, such a policy is therefore likely to have at most a very modest impact on expected inflation; any temporary real appreciation generated by the spending impact of aid is likely to be accomplished mainly by a mild nominal appreciation. More surprisingly, perhaps, the same logic suggests that there will be relatively little to differentiate even an aggressive crawl from a pure float. The reason is simple: if a policy that holds reserves unchanged produces only a small impact on the rate of crawl, a policy that uses intervention to *target* a limited impact on the crawl is likely to generate a similar path for reserves and other macroeconomic variables. Our simulations confirm this intuition.

It is clear from equation (3), however, that the story is likely to change substantially if there is a deficit-reduction or smoothing component to the fiscal response. A pure float now produces a first-order decline in seigniorage—a monetary contraction—at the outset of an aid boom, and with this, at least a transitory reduction in expected inflation, the strength of which will clearly depend on the elasticity of domestic money demand with respect to expected inflation. The impact on inflation, in turn, induces portfolio substitution in favour of the domestic currency, bringing the private capital account into play and placing potentially acute pressure on the nominal exchange rate. A *pure float* now performs very badly, producing an overshooting appreciation at the outset of an aid boom and an increase in the volatility of key variables by comparison with a crawl. A *crawl* does well in absolute as well as relative terms: as we will see, adjustment is smooth and volatility is low.

We noted earlier that a *pure float* and a *buffer plus float* were operationally equivalent when aid is fully spent. The structure of equation (3) suggests that when aid is only partially spent, a *buffer plus float* may sharply out-perform a *pure float*. The reason is straightforward: the *buffer plus float* stabilizes seigniorage, and thereby expected inflation. By doing so it contains portfolio pressures and limits nominal exchange rate movements to the mild adjustments associated with real exchange rate responses to aid. Our simulations confirm this intuition as well. As we will see, a *crawl* does even better under these circumstances; but the two are not very far apart and the operational simplicity of the buffer plus float is appealing.

The decision between these alternatives is therefore likely to come down considerations unrelated to aid management.
To complete the description of monetary policy we turn briefly to bond operations. The conventional role of bond operations is to offset the net impact of domestic credit creation or foreign exchange intervention on the monetary base. The reaction function

$$p_t \Delta b_t = \beta_1 (d_t - a_t - \bar{t}) + \beta_2 \Delta z_t - \beta_3 (b_{t-1} - \bar{b})$$

accommodates this role, where $\beta_3 > 0$ allows for a gradual return of bond holdings to a long-run level.[23] For $\beta_1 > 0,$ bond operations offset a portion of the difference between the government's domestic borrowing requirement and the steady-state inflation tax; for $\beta_2 > 0$ they offset a portion of the impact of reserve accumulation on the monetary base. With $\beta_1 = \beta_2 = 1,$ the impact of bond operations is to stabilize seigniorage over time, at a level equal to the steady-state inflation tax.[24]

In a *buffer plus float*, $\gamma = 1$ in equation (16) and the impact of aid-induced spending on domestic liquidity is fully offset through the sale of aid dollars. This task could in principle be accomplished through bond sales, however—or, as advocated by Berg *et al* (2007), through a '50,50' approach that allocates half of the task of liquidity management to forex sales and half to bond sales. Generalizing to a $[\gamma, 1-\gamma]$ split and gearing bond operations to actual foreign exchange intervention (rather than to reserve accumulation) gives us a bond reaction function of the form

(18) $$p_t \Delta b_t = \beta_1 (1-\gamma)(d_t - \bar{d}) + \beta_2 [\Delta z_t - (a_t - \bar{a})] - \beta_3 (b_{t-1} - \bar{b}).$$

With $\beta_1 = \beta_2 = \gamma = 1,$ bond operations have the conventional role of targeting money growth. In what follows we restrict ourselves to the case in which $\beta_2 = 0,$ so that the role for bond sales is simply to offset a fixed portion of the domestic liquidity expansion produced by aid. When $\gamma = 1$, foreign exchange sales take the full brunt of liquidity control, as in the *pure float* and *buffer plus float* approaches described above; for $0 < \gamma < 1$ the burden is shared. In the simulations reported below, we examine the specific case where $\gamma = 0.50$.

Both foreign exchange operations and bond operations are unwound over time, at rates determined by α_2 and β_3. Since private foreign currency holdings return to a steady-state level over time, the long-run reserve target implies that aid is ultimately fully absorbed in

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[23] Ensuring that bonds held by the private sector return to their steady-state level means in turn that interest payments and the fiscal deficit are unchanged in the long run. This is required by consistency with the long-run inflation target.

[24] The dynamics of bond sterilization are of course not as simple as portrayed here since the path of the fiscal deficit, d_t is itself a function of the interest burden on domestic debt. The simulation model used in the next section fully reflects this quasi-fiscal effect.

current account deficits, regardless of the time pattern of aid-induced public spending and the other parameters of the monetary policy reaction functions. In the simulations reported below, we assume a relatively slow rate of adjustment, setting $\alpha_2 = \beta_3 = 0.05$ throughout.

A. Model Calibration

To solve and simulate this model, we calibrate it to the initial conditions of two archetype economies (*pre-stabilization* and *post-stabilization*) which we define on the basis of the evidence from Section 2. The full set of calibration parameters is reported in Table 3a and the variables to be tracked in the simulations in Table 3b. Our archetype economies differ in only two respects. First, the initial (steady state) inflation is assumed to be 25 percent per annum in pre-stabilization countries and 10 percent in mature stabilizers, and second, initial (steady state) debt is set to 20 percent of GDP in pre-stabilization countries and 9 percent in mature stabilizers. As can be seen from equation (11) the higher steady-state inflation (and nominal interest rate) in pre-stabilization countries translates into a higher steady-state inflation elasticity of demand for domestic money. In all other respects, both economies are assumed to be the same. Thus, for example, the degree of dollarization is assumed not to differ systematically between pre-stabilization countries and mature stabilizers. Moreover, we assume that both types of economy are subject to the same pattern of aid shocks.

V. Results

We now turn to the simulation results which describe the macroeconomic behaviour of the economy under alternative monetary policy rules in response to a temporary aid inflow given different assumptions about the fiscal response. In Tables 4 and 5, we first consider the performance of the three monetary policy rules introduced earlier when the total volume of spending out of aid is varied. In Table 4, spending follows aid dollar-for-dollar so that the total domestic financing requirement is fully insulated from the direct effects of the aid inflow, although some volatility in domestic financing may remain as a result of volatility in domestic revenue and other components in the budget induced by movements in prices, interest rates and the exchange rate. In Table 5, public spending increases by less than the full amount of the aid inflow. Letting δ denote the proportion of the inflow devoted to deficit-reduction, public spending adjusts by $(1-\delta)$ of the aid shock, and the remainder, $\delta(a_t - \overline{a})$, is passed on to the monetary authorities in the form of a reduction in domestic credit growth: based on evidence suggested in Section 2, we assume $\delta = 0.25$. In Table 6, we broaden the range of instruments to introduce partial *bond sterilization* under which the authorities choose to sterilize a portion of the liquidity injection associated with aid-financed spending using bond sales and a portion using foreign exchange sales. In Table 7, we consider the case where the authorities use nominal exchange rate policy to explicitly target the *real* exchange rate to prevent the equilibrium real appreciation that accompanies an aid boom, and finally, in Table 8, we briefly examine the 'fiscal smoothing' case where the authorities pursue an independent reserve management strategy aimed at extending the duration of public expenditure relative to that of the aid surge.

Although relevant for some countries and episodes, we do not report in detail the results for the case in which an aid inflow produces a public spending increase but where the monetary authority, having initially accumulated the full amount of the aid inflow as reserves neither runs these down nor attempts to sterilize the liquidity injection through bond sales. This case, which, drawing directly on the earlier literature on the use of counterpart funds arsing from the sale of commodity aid (for example Roemer, 1989), we refer to as the *counterpart fallacy*, corresponds directly to a deficit financed expansion in public expenditure.[25] Not surprisingly in these circumstances, inflation immediately surges, the nominal exchange rate depreciates sharply and creates a sharp demand-switching boom in the non-traded goods sector which, in turn, generates a substantial temporary current account surplus as the private sector seeks to smooth the temporary increase in its disposable income. However, this outcome has nothing directly to do with aid: what has occurred is simply a large, temporary, money-financed increase in the fiscal deficit whose macroeconomic consequences are largely well understood.

In each table, we report the simulated impulse response functions (IRFs) of real and monetary variables in response to a positive shock to aid of 2 percent of GDP, around its steady state mean value of 10 percent of GDP. Given our focus on policy responses to well-defined discrete events (i.e. positive aid surges), we emphasize the IRFs. However the final column of each table also reports the theoretical standard deviations of the endogenous variables given the specification of the stochastic process for aid. We limit the presentation of the results to a core set of variables as listed in Table 3b.[26]

We contrast the behaviour of pre- and post-stabilization countries. In the interest of space, however, we limit the results to the case where we assume some price stickiness in non-tradable price adjustments. With minor exceptions, mentioned as we present the results, the qualitative insights of our analysis are not radically altered if we assume that prices are fully flexible.[27]

A. All Aid Is Spent

When the fiscal authorities spend all the aid inflow as it is received, domestic financing is fully and continuously insulated. Full spending implies there is no distinction between a *pure float* and a *buffer plus float* in this case. Both, however, entail a different path for the nominal exchange rate and aggregate prices compared to the *crawl*, at least in the short run, even though macroeconomic outcomes are similar in the two cases and most importantly, are largely benign. The only significant difference is how the initial real exchange rate appreciation associated with the aid inflow is effected: an initial inflationary spike is required under the crawl whereas under a float the initial adjustment is mildly deflationary as the

[25] Berg *et al* (2007) refers to this as a case of 'spend and don't absorb' although strictly this refers only to the public sector response to the aid inflow: the extent to which absorption changes in these circumstances depends on the evolution of the private capital account.

[26] All the simulations presented here are generated by the Dynare-Matlab routines (Julliard 1996) using a first-order Taylor approximation to the nonlinear model around the non-stochastic steady state

[27] The full set of simulation results for the flex-price case is available on request from the authors.

nominal exchange rate appreciates. In neither case are the effects large. While the crawl delivers marginally less volatility for both inflation and the real exchange rate, and marginally more current account volatility, the differences between these polar approaches to exchange rate policy are second-order, particularly for the post-stabilization countries. When all aid is spent, little happens to the exchange rate in the float case: the real appreciation is relatively modest (just over 2 percent over the first three years in response to a 2 percent of GDP aid inflow), and it is accomplished with relatively little volatility in the nominal exchange rate. Even a tight crawl therefore requires little net foreign exchange accumulation, implying that in both cases the bulk of the aid is sold—and absorbed—roughly as rapidly as it is spent. These features carry over to the case of pre-stabilization countries although, as a result of the higher inflation elasticity of the demand for money, the IRFs and volatilities are magnified, and the differences between the monetary rules larger, compared to the post-stabilization results.

B. Aid Not Fully Spent

Matters are rather different when aid is not fully spent but is used to provide an element of fiscal stabilization. Partial spending removes the previous insulation provided to domestic financing and thereby confronts the monetary authorities with the explicit challenge of how to manage the alteration to the path of domestic financing. In this case the *buffer plus float* rule is no longer equivalent to a pure float. Although it is doubtful that any country pursues a pure float, in the strict sense that the aid inflow is met with absolutely no change in official reserves, it is important to understand the consequences of adopting such a rule, if only to shed light on why the *buffer plus float* delivers the outcomes it does. Hence we start with the *pure float* which is illustrated in panel 1 of Tables 5a and 5b respectively. By setting $\Delta z = 0$ (and assuming for the moment that the authorities do not engage in bond sterilization) the pure float implies that the contraction in the fiscal deficit after net budgetary aid is fully met by a contraction in the government's seigniorage requirement for a given stock of domestic debt. The consequences are dramatic, even for the post-stabilization countries: the nominal exchange rate appreciates by around 14 percent on impact (compared to an appreciation of around 2.4 percent in the corresponding no-deficit reduction case reported in Table 4), and the real rate appreciates by 6.5 percent (again compared to 2.4 percent). These powerful price effects induce a contraction in non-tradable output of 1.6 percent on impact compared to an *increase* of around 0.8 percent in Table 4. What has happened here is that the reduction in expected inflation as a result of the fiscal adjustment shifts the private sector's asset portfolio in favour of domestic money: given the contraction in the supply of domestic money and the fact that the authorities are not intervening in the foreign exchange market, this requires the nominal exchange rate to overshoot in the short run to restore portfolio equilibrium. Since the nominal appreciation is much larger than the real appreciation required to absorb the aid inflow, non-tradable prices must fall sharply. If, as we assume here, there is a measure of price stickiness, a sharp recession in the non-tradable goods sector ensues.

Against this counterfactual, strategies that *ex post* align absorption more closely to spending and hence smooth the path for seigniorage can substantially close off this source of macroeconomic volatility. Both the *crawl* (Panel 2) and a *buffer plus float* (Panel 3) do rather well in these circumstances. In both cases, but particularly under the crawl, the disruptive volatility in inflation and the real exchange rate are greatly reduced. The sharp deflationary impact under the pure float is substantially eliminated, with prices falling by 4 percent under the *buffer plus float* and virtually not at all under the *crawl,* compared to a 10 percent fall under the *pure float.* By the same token, the impact real exchange rate appreciation is pegged back to around 1.5 percent under the *crawl* and 3.3 percent under the *buffer plus float* compared to 6.5 percent under a *pure float* and the strong recessionary pressures on nontraded output are completely eliminated.

Although the pattern of reserve accumulation is broadly similar under the *crawl* and *buffer plus float*, as are the macroeconomic outcomes, these two approaches are not the same. Moreover, the differences between them emerge much more forcefully in pre-stabilization settings where, as Table 1 suggests, the fiscal authorities are more likely to direct a proportion of aid towards deficit reduction. As Table 5b shows, the *crawl* contributes to a much smoother adjustment path in response to the aid surge than does the *buffer plus float*. Here, the central bank's tight crawl aligns movements in the nominal exchange rate much more closely to the modest real exchange rate adjustment required to absorb the aid inflow, while the (unsterilized) liquidity injection arising from reserve accumulation ensures that the latent contraction in the domestic money supply observed under the float is forestalled. Instead, the increased demand for liquidity as a result of the decline the seigniorage requirement is accommodated without requiring a sharp price adjustment so that the economy responds to the aid inflow with virtually stable prices. Domestic output is hardly affected and total private spending follows a smoother path. As with the post-stabilization case, this 'crawl-with-no-bond-sterilization' strategy appears to deliver an extremely attractive response to a temporary aid inflow.

The *buffer plus float* strategy goes some way to delivering this same outcome, although much less successfully in the pre-stabilization case compared to the post-stabilization calibration. The high nominal volatility seen in Panel 1 is still avoided, but the adjustment trajectory entails much more nominal and real exchange rate movement in the short run, a much smaller reduction in volatility and much stronger private capital inflows than are observed under a *crawl*. The reason is that the *buffer plus float* involves reserve accumulation with respect to the unspent portion of aid only—thereby stabilizing seigniorage (assuming no change in domestic borrowing)—but maintains a free float with respect to absorption of the spent portion of the aid and all other shocks. This rule, in effect, serves to efficiently match the *supply* of domestic liquidity but does not fully accommodate changes in the *demand* for domestic liquidity arising from the fall in expected inflation. By contrast, under a crawl, the central bank stands ready to exchange however much domestic for foreign currency is required at the prevailing (targeted) exchange rate: hence the higher official reserve accumulation. Given the higher elasticity of demand for money with respect to expected inflation in the pre-stabilization calibration, this difference in the degree of intervention is magnified and with it the difference in performance of the two strategies. Put simply, as the inflation elasticity of the demand for money rises, the *buffer plus float* does less well in aligning the demand and supply of domestic liquidity compared to the float.

C. Bond Sterilization

The *crawl* and *buffer plus float* policies in Tables 4 and 5 each end up allocating 100 percent of the burden of liquidity control to foreign exchange sales. Macroeconomic adjustment is smooth, suggesting that there is no obvious case for shifting some of stabilization burden to bond operations. This impression is confirmed in Table 6 where we examine the case where the domestic currency value of aid spending is matched in equal amounts by sales of foreign exchange and government securities. Compared with either the *buffer plus float* or the *crawl*, however, this rule does relatively poorly. When aid is fully spent, bond sterilization contributes to a steady depreciation in the nominal exchange rate and persistent domestic inflation. When aid is partly used for deficit reduction, we already know that a pure float performs poorly so that by comparison the mixed sterilization rule appears to perform well. But a closer look at the simulations suggests that the rule is dominated by the *crawl* and *buffer plus float* and in one respect in particular. Compared with both, the path for the real interest rate under *bond sterilization* is substantially higher than under the counterfactuals considered in Table 5. This is driven by the quasi-fiscal effects which figure prominently in the determining the path of domestic deficit financing. With domestic debt a state variable in this system, domestic interest costs rise sharply relative to the no bond sterilization case beyond the first period and hence reverse the tendency for expected inflation to decline as would otherwise be the case(see the memo items to Table 6). As we have stressed above, the aid inflow is deflationary, especially if there is a deficit-reduction component, so that there is no intrinsic inflationary problem associated with the growth of liquidity; indeed, as the distinction between the *crawl* and the *buffer plus float* highlights, the problem may be the reverse. Ironically, therefore, a strategy such as that expressed by Brownbridge and Tumusiime-Mutubile at the start of this paper, which is built around a narrow focus on nominal liquidity growth, may prompt the authorities into using bond sterilization at exactly the time when a liquidity injection rather than a withdrawal is required.

D. Real Exchange Rate Targeting

We have seen that when all aid is spent, a surge in aid generates a modest and ultimately transitory real appreciation. Conventional theory suggests that, for a given long-run inflation target, monetary policy by itself can influence the real exchange rate only on a temporary basis (Calvo, Reinhart and Végh 1995).[28] However, political concerns or considerations over the efficiency costs of short-run real exchange rate volatility may nonetheless draw the monetary authority into attempting to resist any tendency for the real exchange rate to appreciate. Table 7 reports the results for the case where the authorities explicitly target the real exchange rate at its initial (steady-state) equilibrium level.[29] Table 7(a), which illustrates the case where aid is fully spent, suggests that in this case aggressive real exchange rate targeting creates much higher inflation than under either a float or a nominal exchange rate target (see Table 4(a)). This arises from the authorities' reaction to the incipient real

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[28] Moreover, since our model is free of Dutch-disease distortions, adjustment costs or distributional concerns we do not have a welfare rationale for resisting an equilibrium real appreciation, and as we pointed out earlier, monetary instruments are unlikely to be first-best for such purposes in any case.

[29] In terms of the model outlined in Section 3, real exchange rate targeting is implemented by substituting equation (18') for equation (18). For the sake of comparison we assume that the authorities' commitment to the real exchange rate target, as summarized by the parameters, z_1 and z_3, is the same as for the nominal exchange rate target.

appreciation which now generates more aggressive reserve accumulation beyond the impact effect, in order to enforce a sufficiently strong nominal depreciation to neutralize the increase in the prices of nontraded goods; with non-tradable price inflation and the nominal exchange rate depreciation moving in the same direction, aggregate inflation increases by more than before.

Given higher inflation, therefore, substantial real benefits—such as dynamic productivity gains not modelled here -- would have to accrue to a more depreciated real exchange rate to justify the use of monetary policy in this mode. However, were the source of such benefits to be identified, policy discussion should focus first on the appropriate division of labour between monetary and fiscal policy, since fiscal instruments (including those that directly or indirectly influence the supply-side impact of aid) may well be first-best.

While these results suggest caution in using monetary policy alone to resist an equilibrium real appreciation when aid is fully spent, there may be greater scope for policies designed to prevent unnecessary overshooting of the real exchange rate when aid is only partially spent (Table 7b). Our earlier results showed the relative attractiveness, in this context, of an aggressive crawl or (somewhat less so) a *buffer plus float* policy, in preventing the severe short-run real appreciation associated with a *pure float*. A real exchange rate target pursues this objective directly and, not surprisingly, it generates most of the advantages of the *crawl* and *buffer plus float* alternatives. Reserve-accumulation is substantial, and inflation is higher than in the *pure float* counterfactual; but since *disinflation* was a source of macroeconomic volatility in the *pure float*, the real exchange rate target represents a substantial improvement.

These simulations suggest that the case for real exchange rate targeting depends not just on an assessment of the welfare effects of real appreciation and the likely persistence of aid, but crucially also on the nature of the fiscal response. Specifically, they imply there may be more scope for policies that smooth real exchange rate movements by avoiding sharp short-run volatility in the nominal exchange rate than those that seek to target some reference (and possibly non-equilibrium) level of competitiveness. Moreover, while sterilized intervention is feasible given imperfect asset substitutability, the results from Section 4.3 suggest that using bond operations to maintain a money anchor during the intervention phase would produce high real interest rates and—given a mounting interest burden—few gains on the inflation front.

E. Smoothing Public Expenditure

We close this section by briefly considering the case where the fiscal authorities operate an ‘aid account’ in order to stretch aid-funded public spending over a longer horizon than the aid shock, possibly in response to conventional smoothing considerations or to avoid placing excessive pressure on the absorptive capacity of the public sector. As before, we focus on the characteristics of monetary responses given the fiscal stance. For each reported simulation, we also assume that the fiscal authorities apply the smoothing rule defined by (3) with $\mu = 0.5$, which approximately doubles the half-life of the expenditure response relative to that of the aid shock. In addition to the variables reported earlier, Table 8 also records the IRFs and volatility for the government discretionary expenditure (denoted s) and the change in the ‘aid account’ (dW). Again in the interest of space we limit our attention to the post-stabilization calibration only; the results for each panel are directly comparable to corresponding panels in Tables 4(a) and 5(a).

Three key features emerge from Table 8. First, the volatility of total spending is reduced, regardless of the monetary policy response; this is unsurprising given that public spending in these simulations consists entirely of a transfer to the private sector. Second, however, although fiscal smoothing does not alter the total volume of spending out of aid, only its timing, the operation of 'aid account' removes the previous insulation of domestic liquidity afforded by the pure float when aid is fully spent. Hence, although the aid shock is smoothed, inflation and exchange rate volatility is higher under a float than in the case where there is no fiscal smoothing. The reverse is true under the crawl where volatility is marginally reduced relative to the no fiscal-smoothing case. This result is consistent with our earlier discussion of the distinction between the float and the crawl when domestic financing is not fully insulated, even though for the calibration considered here, the differences are not substantial. Third, as is shown in Table 8(b) however, when some of the aid is used for deficit reduction, an aggressive crawl remains much the most effective way of minimizing macroeconomic volatility, even when the fiscal authorities act to smooth spending out of the aid inflow. In other words, the same argument applies: regardless of the fiscal motive for expenditure smoothing, monetary policy is at its most efficient when it serves to appropriately align the supply and demand for domestic liquidity.

These simulations assume coordinated fiscal and monetary policies. If the monetary authorities do not internalize the actions of the fiscal authorities, however, but instead seek to maintain a float with respect to the entire aid inflow, in effect acting to 'unwind' the reserve accumulation by the fiscal authorities' actions, the outcome is highly unstable and reminiscent of the '*float plus dr'* case reported in Table 5. We do not report this case here, but as in the '*float plus dr*' case, the aid flow is 'over absorbed' by the public sector at the margin, accentuating the nominal exchange rate appreciation as the private sector seeks to adjusts its asset portfolio and, to the extent that this puts downward pressure on nontraded goods prices, raising the risk of a short-run recession in the nontraded goods sector.

VI. Conclusions and Extensions

We argued at the beginning of this paper that central bankers in Africa face substantial problems in managing aid surges. In practice, many central banks appear to have adopted strategies involving substantial intervention and reserve accumulation in response to aid surges, accompanied in many cases by fairly aggressive bond sterilization. The simulations presented in this paper suggest that this pattern of foreign exchange intervention is consistent with efficient monetary policy responses to substantial aid volatility, particularly in circumstances where countries continue to use part of the aid inflow for inflation stabilization purposes. The case for bond sterilization is less well grounded.

Our simulations suggest that efficient monetary management of aid inflows centres on the extent to which it can successfully align the path of domestic deficit financing with the demand for domestic base money. This requirement reflects the central role we ascribe to private sector portfolio behaviour in such countries, and as such takes on particular importance when fiscal decisions lead to sharp changes in seigniorage requirements. Thus when aid is fully spent as it is received, domestic financing needs are perturbed very little with the consequence that macroeconomic adjustment to a temporary aid surge is smooth and the choice of nominal anchor makes relatively little difference to the adjustment path. The aid surge facilitates higher private consumption and entails a modest appreciation of both the real and nominal exchange rate. Under a float this appreciation ensures that the aid inflow is mildly deflationary; under a crawl a modest initial inflation is required to effect the appreciation. If, however, aid is used partly to reduce the domestic financing requirement, consequent portfolio adjustment effects now play a potentially important role in the macroeconomic dynamics. In the extreme case—in which the monetary authorities accumulate no additional reserves, even though the public spending impact of aid is less than dollar-for-dollar—required seigniorage falls sharply, producing an overshooting real appreciation as the private sector substitutes out of foreign currency and into domestic currency. This in turn increases inflation volatility as well as promoting recessionary pressures in the short-run. Realignment of absorption with spending in these circumstances, either through a crawl, in which the sales of aid dollars are endogenous to actual exchange rate movements, or a *buffer plus float* rule, which ties the reserve target to the fiscal absorption of aid, significantly reduces macroeconomic volatility. For the parameterizations considered here, the distinction between the *crawl* and *buffer plus float* is relatively modest for mature post-stabilization economies. For 'pre-stabilization' settings where the inflation elasticity of the demand for money is higher, efficient responses to the fall in velocity associated with an aid-supported inflation stabilization appear to require greater intervention than provided by the *buffer plus float* so as to match the rise in domestic money demand. In these circumstances, the superiority of the *crawl* in reducing nominal and real volatility on the adjustment path is decisive. This general feature will also be a feature of the optimal response to an aid surge is when the authorities seek to smooth the path of public expenditure for purely fiscal reasons.

In reality, however, the superiority of the *crawl* over the *buffer plus float* may need to be set against other considerations weighing in favour of more market-based exchange rate arrangements. Thus a *buffer plus float* may be better aligned with broader policy objectives aimed at supporting financial sector development or, indeed, laying the foundations for a more explicit inflation targeting regime, while nonetheless providing a substantial degree of intervention in response to aid inflows.

Our simulations also suggest that, contrary to much popular thinking, aggressive bond sterilization does not have a central role to play in the efficient management of aid surges, at least in those circumstances where aid inflows do not trigger a generalized loss of fiscal control. There may, of course, be circumstances where fiscal control is less assured or where foreign exchange markets are perceived to be too shallow or otherwise distorted such as to limit the scope for intervention, in which case bond sterilization may constitute one component of a stabilization strategy.

We close with two important caveats. First, our analysis ascribes a central role to the private sector's portfolio behaviour as a potential source of macroeconomic volatility. Clearly, if portfolio effects are weak, the distinction between alternative policy rules diminishes. However, as capital market integration increases, either formally or informally, portfolio effects of the kinds emphasised here are likely to increase rather than decreases in importance. Second, in this paper we have abstracted entirely from issues of either donor or government credibility. Aid flows are uncertain but the stochastic process is common knowledge. Moreover, we assume that government expenditure plans are fully and credibly tied to the aid inflows, given (equally credible) deficit reduction or other fiscal smoothing choices. In reality, however, donors cannot commit to enhanced aid flows on an ongoing basis, nor can recipient governments commit to fully and instantly adjust domestic spending to realized aid flows when the latter decline. These realities increase the likelihood that the private sector will face a temporary surge in domestic financing requirements. In a related paper (Buffie *et al* 2006b), we examine how these private sector perceptions of fiscal stability may also shape the appropriate monetary response to aid. In that paper we argue that faced with credibility issues of this kind, a full 'absorb and spend' policy is potentially destabilizing since it provides no buffer against the expected future seigniorage requirements of government. By contrast, a strategy embodying some near-term fiscal restraint, combined with either a temporary accumulation of reserves or a temporary buyback of domestic debt, is a necessary component of a successful strategy until it becomes clear that the scaling up of aid flows is permanent.

TABLES

Table 1. Mean Share of Aid Spent by Country Group

	1990-2004	1990-97	1998-2004
		All aid changes	
SSA	77	76	78
Mature stabilizers	79	77	79
High inflation	72	73	72
Low inflation	79	77	79
		Positive aid changes	
SSA	76	76	76
Mature stabilizers	78	74	78
High inflation	65	62	69
Low inflation	78	80	78

Source: IMF African Department

Table 2. Mean NFA Accumulation and Aid Inflows

	1990-97		1998-2004	
	Full sample			
	Impact	Long-run	Inpact	Long-run
SSA [non-CFA]	0.00	-0.04	0.00	0.00
Mature stabilizers	0.24	0.28	0.30	0.26
	Large aid changes			
SSA [non-CFA]	0.00	0.01	0.01	0.04
Mature stabilizers	0.22	0.25	0.34	0.27
Aid surges			0.38	0.74

Source: IMF Africa Department
Note: a large aid increase is one of at least two percent of GDP. An aid surge is when this higher level is sustained for at least two years.

Table 3a. Pre-Stabilization and Mature Stabilizers calibration values

Parameter	'Mature stabilizers''	'Pre-stabilization'
Intertemporal elasticity, τ	0.50	0.50
Currency substitution elasticity, σ	2.00	2.00
Elasticity of production substitution, *nu*	0.10	0.10
Foreign currency holdings, percent of GDP (*f*)	0.12	0.12
Domestic currency holdings, percent of GDP (*m*)	0.08	0.08
Private holdings of government securities, percent of GDP (*b*)	0.09	0.20
Net official reserves, percent of GDP (*z*)	0.04	0.04
Inflation rate, π (percent)	0.10	0.25
Government spending; percent of GDP (*s*)	0.25	0.25
Aid (aid shock), both percent of GDP (*a*)	0.10 (0.02)	0.10 (0.02)
Deficit reduction share *dr* (δ)	0.25	0.25
Fiscal smoothing parameter (μ)	0.50	0.50
Implied values:		
Nominal interest rate (*i*)	0.210	0.375
Steady-state inflation elasticity of money demand	0.53	0.62

Table 3b. Definition and Scaling of Variables in Simulation Runs

Variable	*Definition*	*Scaling of IRs and Standard Deviations*
In	Inflation rate = π	percentage points from SS
NER	Nominal exchange rate	"
RER	Real exchange rate for imports $= EP_I / P_N$	"
RIR	Real interest rate	"
Ca	Current account surplus including grants	percentage points of GDP from SS
DN	Output of nontraded goods	percent deviation from SS
C	Private consumption	"
Dz	Change in central bank international reserves	"
Db	Change in privately-held government debt	"
Mg	Growth in nominal domestic money stock	"
A	Aid	percentage points of GDP from SS
S	Government discretionary spending	"
dW	Change in aid account	"

.

Table 4. Aid Fully Spent

Variable	0	1	2	3	4	5	15	Stdev
				Horizon [years]				
				Aid Inflow [percent of GDP]				
A	2.000	1.000	0.500	0.250	0.125	0.063	0.001	
				4(a): Post-Stabilization Countries				
				1. Buffer+Float				
In	-1.131	-1.179	-1.258	-1.004	-0.723	-0.494	-0.004	2.491
NER	-2.436	-1.226	-1.056	-0.720	-0.466	-0.295	-0.002	3.071
RER	-2.372	-2.458	-2.090	-1.575	-1.107	-0.745	-0.007	4.549
RIR	-1.571	-1.296	-0.847	-0.528	-0.325	-0.199	-0.001	2.305
ca	0.725	0.051	-0.143	-0.170	-0.144	-0.107	-0.001	0.787
DN	0.785	0.197	-0.104	-0.184	-0.173	-0.135	-0.002	0.874
C	2.306	1.592	1.003	0.618	0.378	0.230	0.001	3.077
dz	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
mg	-0.075	-2.118	-1.704	-1.091	-0.696	-0.406	-0.003	3.084
				2. Crawl				
In	1.089	0.046	-0.311	-0.369	-0.320	-0.246	-0.027	1.324
NER	0.245	-0.139	-0.188	-0.158	-0.119	-0.088	-0.026	0.524
RER	-1.534	-1.870	-1.646	-1.261	-0.897	-0.609	-0.008	3.406
RIR	-1.371	-1.159	-0.812	-0.531	-0.336	-0.209	-0.001	2.085
ca	0.863	0.127	-0.108	-0.154	-0.136	-0.103	-0.002	0.914
DN	1.023	0.400	0.088	-0.036	-0.069	-0.066	-0.001	1.109
C	2.159	1.536	1.009	0.639	0.398	0.245	0.003	2.949
dz	-3.338	2.062	2.625	2.088	1.455	0.954	1.410	5.507
mg	-1.179	-0.281	0.285	0.355	0.289	0.203	-0.002	1.809
				4(b): Pre-Stabilization Countries				
				1. Buffer+Float				
In	-4.475	-5.261	-1.987	-3.170	-0.782	-1.754	-0.152	8.186
NER	-5.98	-6.077	-0.951	-3.364	-0.062	-1.918	-0.234	9.575
RER	-2.410	-3.716	-2.059	-2.370	-1.019	-1.281	-0.079	5.742
RIR	-2.800	0.085	-1.587	0.359	-0.955	0.391	0.113	3.540
ca	0.714	0.201	-0.180	-0.118	-0.207	-0.089	0.005	0.821
DN	0.781	-0.752	-0.025	-0.713	-0.019	-0.465	-0.053	1.436
C	2.322	1.049	1.087	0.366	0.529	0.096	-0.025	2.866
dz	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
mg	-0.820	-10.416	0.231	-5.663	1.354	-3.366	-0.500	12.999
				2. Crawl				
In	1.103	-0.075	-0.412	-0.458	-0.400	-0.319	-0.057	1.602
NER	0.304	-0.311	-0.322	-0.265	-0.205	-0.157	-0.054	1.015
RER	-1.278	-1.655	-1.512	-1.203	-0.890	-0.631	-0.013	3.106
RIR	-1.170	-0.947	-0.678	-0.462	-0.309	-0.203	-0.003	1.763
ca	1.012	0.229	-0.058	-0.138	-0.139	-0.114	-0.004	1.070
DN	0.921	0.351	0.079	-0.029	-0.060	-0.060	-0.002	0.995
C	1.887	1.355	0.924	0.616	0.406	0.266	0.005	2.630
dz	-3.652	3.610	3.860	2.971	2.103	1.429	2.479	7.779
mg	-2.022	-0.552	0.136	0.295	0.277	0.210	-0.047	2.281

Source: WIDER_sticky_p_JAN07.mod

Notes
[1] An increase in NER and RER denotes a depreciation in the nominal and real exchange rates respectively.
[2] See Tables 3a and 3b for parameter settings.
[3] For float, z1=0; for crawl, z1=15 and z2=0.95.
[4] dr=0.00.
[5] since mu=0, dW=0.

Table 5. Deficit-Reducing Aid

Variable	Horizon 0	1	2	3	4	5	15	Stdev
				Aid Inflow [percent of GDP]				
a	2.000	1.000	0.500	0.250	0.125	0.063	0.001	

5(a) : Post-Stabilization Countries

Panel 1: Pure Float

Variable	0	1	2	3	4	5	15	Stdev
In	-10.465	-2.983	-2.206	-1.478	-0.956	-0.608	-0.005	11.269
NER	-14.056	-1.737	-1.479	-0.951	-0.582	-0.352	-0.002	14.290
RER	-6.529	-4.264	-2.941	-1.984	-1.303	-0.839	0.006	8.733
RIR	-0.396	-0.960	-0.709	-0.462	-0.291	-0.181	-0.001	1.390
Ca	0.759	0.031	-0.155	-0.174	-0.145	-0.107	-0.001	0.821
DN	-1.591	-0.778	-0.559	-0.405	-0.281	-0.188	-0.002	1.937
C	1.494	1.314	0.877	0.555	0.345	0.213	0.001	2.286
dz	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
mg	-7.749	-4.395	-3.191	-1.877	-1.065	-0.603	-0.003	9.733

Panel 2: Crawl

Variable	0	1	2	3	4	5	15	Stdev
In	-0.016	-0.420	-0.518	-0.467	-0.379	-0.296	-0.098	1.596
NER	-0.824	-0.518	-0.379	-0.275	-0.207	-0.165	-0.096	1.679
RER	-1.471	-1.648	-1.394	-1.045	-0.734	-0.496	-0.014	2.984
RIR	-1.121	-0.878	-0.605	-0.396	-0.251	-0.157	-0.001	1.629
ca	1.098	0.322	0.029	-0.063	-0.078	-0.068	-0.004	1.154
DN	0.670	0.202	0.000	-0.066	-0.074	-0.062	-0.001	0.713
C	1.668	1.158	0.759	0.484	0.304	0.190	0.007	2.256
dz	11.243	6.498	4.276	2.655	1.506	0.933	0.643	14.107
mg	-0.675	-1.210	-0.352	-0.061	0.013	0.011	-0.096	1.899

Panel 3: Buffer+ Float

Variable	0	1	2	3	4	5	15	Stdev
In	-4.199	-2.128	-2.097	-1.791	-1.488	-1.242	-0.496	6.401
NER	-5.993	-1.772	-1.790	-1.494	-1.244	-1.061	-0.492	7.347
RER	-3.262	-2.616	-2.058	-1.518	-1.074	-0.746	-0.070	5.132
RIR	-1.041	-1.072	-0.718	-0.449	-0.276	-0.169	-0.003	1.753
ca	0.871	0.146	-0.080	-0.133	-0.125	-0.102	-0.014	0.920
DN	0.047	-0.048	-0.189	-0.214	-0.186	-0.144	-0.016	0.413
C	1.835	1.362	0.875	0.548	0.344	0.219	0.017	2.549
dz	12.500	5.625	2.129	0.545	-0.263	-0.641	-7.760	14.265
mg	-0.343	-2.145	-2.340	-1.919	-1.568	-1.321	-0.607	5.333

Table 5. Deficit—Reducing Aid [contd]

Variable	Horizon 0	1	2	3	4	5	15	Stdev
	Aid Inflow [percent of GDP]							
a	2.000	1.000	0.500	0.250	0.125	0.063	0.001	
	5(b) : Pre-Stabilization Countries							
	Panel 1: Pure Float							
In	-13.436	-6.132	-4.219	-2.776	-1.885	-1.207	-0.012	15.805
NER	-17.218	-5.212	-3.442	-2.133	-1.441	-0.870	-0.005	18.533
RER	-6.051	-4.579	-3.336	-2.307	-1.597	-1.059	-0.013	8.866
RIR	-0.938	-0.767	-0.499	-0.390	-0.229	-0.185	-0.006	1.406
ca	0.791	0.112	-0.121	-0.180	-0.163	-0.132	-0.003	0.864
DN	-1.377	-1.087	-0.834	-0.577	-0.415	-0.269	-0.003	2.101
C	1.511	1.084	0.736	0.509	0.332	0.228	0.004	2.111
dz	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
mg	-10.311	-8.547	-5.233	-2.957	-1.936	-1.061	0.003	14.874
	Panel 2: Crawl							
In	-0.047	-0.610	-0.647	-0.566	-0.462	-0.369	-0.133	2.264
NER	-0.804	-0.771	-0.533	-0.386	-0.293	-0.234	-0.130	2.314
RER	-1.212	-1.470	-1.289	-1.000	-0.729	-0.513	-0.017	2.709
RIR	-0.967	-0.707	-0.498	-0.341	-0.230	-0.153	-0.002	1.376
Ca	1.220	0.404	0.070	-0.051	-0.081	-0.076	-0.005	1.297
DN	0.613	0.165	-0.007	-0.061	-0.067	-0.057	-0.001	0.647
C	1.453	1.013	0.692	0.465	0.310	0.206	0.008	2.002
Dz	9.650	8.768	5.480	3.432	2.145	1.333	-0.065	14.851
Mg	-1.753	-1.182	-0.372	-0.069	0.017	0.018	-0.126	2.839
	Panel 3: Buffer+ Float							
In	-6.446	-5.966	-3.404	-4.040	-2.182	-2.737	-0.927	11.795
NER	-8.118	-6.401	-2.556	-4.094	-1.523	-2.811	-0.982	12.694
RER	-2.675	-3.370	-2.013	-2.099	-1.045	-1.162	-0.136	5.519
RIR	-2.237	-0.095	-1.222	0.194	-0.716	0.252	0.079	2.761
va	0.855	0.272	-0.095	-0.092	-0.171	-0.091	-0.010	0.943
DN	0.401	-0.677	-0.140	-0.606	-0.094	-0.395	-0.059	1.135
C	1.974	0.957	0.914	0.359	0.447	0.121	-0.003	2.467
fz	12.500	5.625	2.219	0.545	-0.263	-0.641	-0.643	14.265
mg	-1.206	-9.519	-1.819	-5.851	-0.744	-3.974	-1.250	13.246

Notes: see Table 4.
Except **[4]** dr=0.25.

Table 6. Mixed Foreign Exchange and Bond Sterilization
A [50:50] Rule

	Horizon							
Variable	**0**	**1**	**2**	**3**	**4**	**5**	**15**	**Stdev**
				Aid Inflow [percent of GDP]				
a	2.000	1.000	0.500	0.250	0.125	0.063	0.001	
				Post-Stabilization Countries				
				1. All Aid Spent with [50:50] Sterilization Rule				
In	12.805	4.624	4.195	3.795	3.501	3.275	1.933	18.357
NER	15.227	3.014	3.631	3.555	3.394	3.230	1.939	19.639
RER	4.404	1.477	0.451	0.015	-0.179	-0.262	-0.209	4.792
RIR	-1.072	-0.058	0.014	-0.006	-0.021	-0.028	-0.021	1.080
ca	1.978	0.962	0.389	0.100	-0.040	-0.105	-0.106	2.297
DN	2.494	0.887	0.435	0.256	0.173	0.130	0.058	2.720
C	0.831	0.344	0.317	0.324	0.321	0.311	0.189	1.461
dz	25.000	11.250	4.438	1.091	-0.526	-1.281	-1.286	28.531
db	11.111	5.000	1.972	0.485	-0.234	-0.569	-6.898	12.681
Memo items								
Dint (%GDP)	-0.218	0.129	0.184	0.184	0.176	0.168	0.101	0.675
Table 4a [Buffer plus Float]								
RIR	-1.571	-1.296	-0.847	-0.528	-0.325	-0.199	-0.001	2.305
Dint (%GDP)	0.117	-0.126	-0.124	-0.092	-0.064	-0.042	-0.000	0.246
				2 Partial Deficit Reduction with [50:50] Sterilization Rule				
In	-0.014	1.370	1.883	2.121	2.212	2.220	1.449	8.529
NER	-0.809	1.443	2.036	2.255	2.313	2.292	1.454	8.740
RER	-1.447	-1.313	-1.035	-0.791	-0.608	-0.477	-0.159	2.635
RIR	-0.022	-0.031	-0.064	-0.070	-0.063	-0.053	-0.016	0.163
ca	1.699	0.714	0.244	0.028	-0.067	-0.105	-0.079	1.906
DN	-0.309	-0.261	-0.155	-0.075	-0.022	0.011	0.043	0.482
C	0.387	0.377	0.363	0.334	0.302	0.274	0.142	1.118
dz	18.750	8.438	3.328	0.818	-0.395	-0.961	-0.965	21.398
db	8.333	3.750	1.480	0.363	-0.175	-0.428	-5.173	7.258
Memo items								
Dint (%GDP)	-0.072	0.073	0.098	0.109	0.113	0.114	0.076	0.450
Table 5a [Buffer plus Float]								
RIR	-1.041	-1.072	-0.718	-0.449	-0.276	-0.169	-0.003	1.753
Dint (%GDP)	0.161	-0.111	-0.112	-0.082	-0.056	-0.036	-0.000	0.251

Notes: see Table 4.

Table 7. Targeting the Real Exchange Rate

Variable	Horizon 0	1	2	3	4	5	15	Stdev
				Aid Inflow [percent of GDP]				
a	2.000	1.000	0.500	0.250	0.125	0.063	0.001	
				7(a): Aid Fully Spent				
In	6.560	2.798	1.775	0.961	0.411	0.058	-0.436	7.853
NER	6.899	2.219	1.696	1.002	0.475	0.115	-0.435	7.945
RER	0.617	-0.435	-0.579	-0.504	-0.389	-0.285	-0.052	1.253
RIR	-1.001	-0.837	-0.706	-0.526	-0.364	-0.241	-0.002	1.645
ca	1.174	0.299	-0.035	-0.128	-0.132	-0.109	-0.015	1.239
DN	1.709	0.915	0.561	0.344	0.208	0.124	-0.004	2.064
C	1.876	1.421	1.041	0.720	0.481	0.315	0.023	2.750
dz	-9.257	6.988	8.793	7.241	5.140	3.334	-0.432	17.703
mg	-4.502	3.870	4.877	3.828	2.583	1.560	-0.182	9.515
				7(b): Aid Partially Spent (dr=0.25)				
In	3.182	1.524	0.839	0.275	-0.116	-0.370	-0.675	5.452
NER	2.999	1.298	0.873	0.355	-0.041	-0.313	-0.674	5.277
RER	-0.332	-0.742	-0.679	-0.534	-0.399	-0.294	-0.079	1.403
RIR	-0.660	-0.647	-0.557	-0.417	-0.289	-0.192	-0.003	1.218
ca	1.300	0.406	0.049	-0.071	-0.096	-0.088	-0.022	1.381
DN	0.971	0.567	0.366	0.232	0.142	0.085	-0.007	1.219
C	1.438	1.138	0.844	0.591	0.401	0.270	0.034	2.181
dz	4.987	10.876	9.397	6.750	4.379	2.595	-0.688	17.902
mg	-3.839	2.513	3.202	2.522	1.578	0.792	-0.725	7.671

Notes: see Table 4.

Table 8. Fiscal Smoothing in Post-Stabilization Economies

	Horizon							
Variable	**0**	**1**	**2**	**3**	**4**	**5**	**15**	**Stdev**
				Aid Inflow [percent of GDP]				
a	2.000	1.000	0.500	0.250	0.125	0.063	0.001	
				Table 8(a): Aid Fully Spent [dr=0.0]				
				1. Float with fiscal smoothing [c.f. Table 4(a) panel 1]				
In	-2.527	2.190	1.715	0.971	0.442	0.141	-0.008	3.912
NER	-4.604	3.004	2.105	1.171	0.586	0.264	-0.003	6.037
RER	-3.776	-2.296	-1.588	-1.225	-0.963	-0.739	-0.013	5.061
RIR	1.438	0.018	-0.575	-0.644	-0.529	-0.384	-0.003	1.833
ca	1.390	0.207	-0.238	-0.335	-0.302	-0.233	-0.003	1.530
DN	-1.098	0.030	0.334	0.284	0.168	0.076	-0.003	1.197
C	0.634	1.287	1.296	1.034	0.742	0.501	0.004	2.405
dz	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
s	1.000	1.000	0.750	0.500	0.312	0.187	0.000	1.721
dW	25.000	0.000	-6.250	-6.250	-4.688	-3.125	-0.011	27.217
				2. Crawl with fiscal smoothing [c.f. Table 4(a) panel 2]				
In	-0.574	0.225	0.249	0.115	-0.002	-0.067	-0.014	0.707
NER	-1.666	0.192	0.398	0.299	0.177	0.091	-0.009	1.765
RER	-1.986	-2.045	-1.773	-1.438	-1.112	-0.826	-0.013	3.990
RIR	-0.107	-0.307	-0.497	-0.509	-0.427	-0.322	-0.004	0.995
ca	1.235	0.252	-0.160	-0.276	-0.266	-0.214	-0.003	1.361
DN	0.157	0.095	0.101	0.067	0.026	-0.004	-0.002	0.226
C	1.284	1.235	1.096	0.870	0.638	0.444	0.005	2.427
dz	22.717	-3.754	-6.378	-4.705	-2.810	-1.494	0.003	24.571
s	1.000	1.000	0.750	0.500	0.312	0.187	0.000	1.721
dW	25.000	0.000	-6.250	-6.250	-4.688	-3.125	-0.011	27.217

Table 8. Fiscal Smoothing in Post-Stabilization Economies [contd]

	Horizon							
Variable	**0**	**1**	**2**	**3**	**4**	**5**	**15**	**Stdev**
				Aid Inflow [Percent of GDP]				
a	2.000	1.000	0.500	0.250	0.125	0.063	0.001	
				Table 8(b): Aid Not Fully Spent, Sticky Prices with dr=0.25				
				1. Float with fiscal smoothing [c.f. Table 5(a) panel 1]				
In	-11.512	-0.456	0.023	0.003	-0.082	-0.131	-0.007	11.525
NER	-15.682	1.436	0.891	0.467	0.207	0.067	-0.003	15.781
RER	-7.581	-4.143	-2.565	-1.721	-1.196	-0.835	-0.012	9.323
RIR	1.861	0.026	-0.505	-0.549	-0.444	-0.320	-0.003	2.098
ca	1.258	0.148	-0.226	-0.299	-0.263	-0.201	-0.002	1.375
DN	-3.003	-0.903	-0.231	-0.054	-0.025	-0.029	-0.002	3.145
C	0.239	1.085	1.097	0.867	0.618	0.416	0.003	1.966
dz	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
s	0.750	0.750	0.562	0.375	0.234	0.141	0.000	1.291
dW	18.750	-0.000	-4.688	-4.688	-3.516	-2.344	-0.008	20.412
				2. Crawl with fiscal smoothing [c.f. Table 5(a) panel 2]				
In	-1.263	-0.286	-0.098	-0.104	-0.140	-0.161	-0.087	1.730
NER	-2.258	-0.269	0.061	0.067	0.015	-0.031	-0.084	2.520
RER	-1.809	-1.779	-1.490	-1.178	-0.896	-0.659	-0.018	3.423
RIR	-0.173	-0.239	-0.369	-0.379	-0.320	-0.242	-0.003	0.762
ca	1.377	0.416	-0.009	-0.155	-0.176	-0.151	-0.005	1.474
DN	0.021	-0.027	0.011	0.012	-0.002	-0.015	-0.002	0.058
C	1.012	0.933	0.824	0.657	0.484	0.339	0.008	1.858
dz	30.784	2.135	-2.476	-2.440	-1.603	-0.902	-0.068	31.128
s	0.750	0.750	0.562	0.375	0.234	0.141	0.000	1.291
dW	18.750	0.000	-4.688	-4.688	-3.516	-2.344	-0.008	20.412
				3. Buffer+ Float with fiscal smoothing [c.f. Table 5(a) panel 3]				
In	-4.567	-1.585	-1.709	-1.606	-1.419	-1.219	-0.418	6.198
NER	-6.344	-1.121	-1.479	-1.400	-1.225	-1.050	-0.413	7.318
RER	-3.231	-2.387	-1.968	-1.592	-1.238	-0.930	-0.066	5.095
RIR	0.076	-0.536	-0.571	-0.469	-0.348	-0.244	-0.004	1.033
ca	1.180	0.234	-0.118	-0.215	-0.211	-0.174	-0.013	1.273
DN	-0.446	-0.065	-0.077	-0.120	-0.135	-0.128	-0.015	0.539
C	1.180	1.215	0.971	0.712	0.499	0.341	0.016	2.188
dz	31.250	4.688	-3.359	-4.754	-4.126	-3.138	-0.545	32.797
s	0.750	0.750	0.562	0.375	0.234	0.141	0.000	1.291
dW	18.750	0.000	-4.688	-4.688	-3.516	-2.344	-0.008	20.412

Notes: see Table 4.
[1] smoothing parameter = 0.50.

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