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Exchange Rate Policy and the Management of Official and Private Capital Flows in Africa

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Abstract

We focus on the management of highly persistent shocks to aid flows, including PRSP-related increases in net inflows, in three "post-stabilization." African economies with *de jure* flexible exchange rates. Such shocks have beneficent long-run effects, but when currency substitution is high they can produce dramatic macroeconomic management problems in the short run. What is the appropriate mix of money and exchange rate targeting in such cases, and what is the role of temporary sterilization? We analyze these issues in an intertemporal optimizing model that allows a portion of aid to be devoted to reducing the government's seigniorage requirement. This creates a strong link between official aid flows and private capital flows. When the credibility of policymakers' commitment to low inflation is firm, some degree of dirty floating, with little or no sterilization of increases in the monetary base, is the most attractive approach in the short run.

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Contents Page

Tables

I. INTRODUCTION

During the 1990s a number of African central banks succeeded in bringing inflation to relatively low levels while maintaining a market-determined exchange rate. These central banks were generally reluctant to fully subordinate exchange rate targets to monetary targets, however, particularly in the face of large shocks to commodity prices, external aid, or private capital flows. In this paper we focus on the management of highly persistent shocks to aid flows, including PRSP- and HIPC-related increases in net flows.[2] Such shocks have beneficent long-run effects, but when substitutability between domestic and foreign currencies is relatively high they can produce dramatic monetary management problems in the short run. What is the appropriate mix of money and exchange rate targeting in such cases, and the role of temporary sterilization?

A similar question received substantial attention in the wake of large capital inflows to emerging-market economies in the early 1990s. Under the managed exchange rate regimes of the day, these inflows tended to produce rapid monetary expansion. Central banks responded initially by sterilizing a substantial portion of these inflows, using sales of government securities. As the inflows persisted, however, this strategy proved unsustainable (Schadler, et al, 1993). Critics warned that bond sales prevented interest rate differentials from falling, thereby perpetuating the inflows they were designed to neutralize and generating a mounting fiscal burden (Calvo, 1991; Calvo, Leiderman and Reinhart, 1994). Few precise results emerged from this literature, however, and controversy has therefore persisted regarding the efficacy of bond sterilization, the role of foreign exchange sales (i.e., nominal appreciation) in absorbing domestic liquidity, and the relevance of underlying concerns about "overheating" (Frankel, 1997). Moreover, the problem we address has its own distinctive features: the initiating inflows are official rather than private, the officially pronounced nominal anchor is money rather than the exchange rate; and the economies in question are low-income rather than emerging-market economies, with correspondingly less-developed domestic financial markets. The problem therefore requires a fresh analytical treatment, and one that is tailored to the particular circumstances of the countries at hand.

In Section II we set the stage by reviewing recent experience in Uganda, Tanzania and Mozambique. As official inflows into these countries began to increase in the late 1990s, the policy dialogue between their respective central banks and the International Monetary Fund focused increasingly on the appropriate path for domestic liquidity. The Fund consistently favored greater exchange rate flexibility and tighter bounds on liquidity

[2] The Poverty Reduction Strategy Paper (PRSP) articulates a country's medium-term macroeconomic and public expenditure program. In the majority of countries, the PRSP anticipates increased public expenditures financed in part by sustained increases in net aid flows, including from debt relief payments arising from the Heavily Indebted Poor Countries (HIPC) Initiative.

expansion than did the central banks. In practice, the central banks chose to lean heavily against nominal appreciation, retaining a substantial portion of the aid as international reserves and quickly abandoned attempts to manage the liquidity expansion through bond sales. The central message of this paper is that when the credibility of policymakers' commitment to low inflation is firm, a heavily managed float, with little or no sterilization, is indeed the most attractive short-run approach to managing a large and persistent aid inflow.

Since the central bank strategy generates rapid nominal money growth, its appeal must rest on a view that persistent aid inflows generate a large increase in real money demand. While the evidence to date favors such a view (Section II), the literature provides little guidance as to the mechanisms involved or the structural features underlying such a response. In our analytical model, two features of post-stabilization low-income countries prove decisive. The first is that a portion of aid ends up reducing domestic budgetary financing rather than supporting an increase in government spending or a reduction in taxes. In sub-Saharan Africa between 1990 and 2001, for example, 21 cents of the aid dollar substituted, on average, for domestic financing (Appendix Table 1). A persistent aid inflow therefore reduces expected seigniorage and expected inflation, thereby generating a potentially substantial increase in real money demand.

The second decisive feature of our analysis is an active private capital account. While private capital flows have largely been ignored in discussions of aid management, this is no longer appropriate. Foreign-denominated assets constitute an important share of private financial wealth in low-income Africa, and a growing body of evidence suggests that foreign currency competes actively with domestic currency in the countries we are studying (Collier et al, 2002, Asea and Reinhart, 1996 and Bhindra, et al, 1999). Our simulation results suggest that portfolio adjustments already confront central bankers with trade-offs that, while less spectacular than those facing their emerging-market counterparts, hold similar perils for short-term macroeconomic stability. In particular, a fall in expected inflation triggers a portfolio adjustment that even under relatively modest portfolio substitutability generates an outright reduction in desired foreign currency balances. The incipient capital inflow places acute short-run pressure on the foreign exchange market, dramatically undermining the case for a floating exchange rate.

In Sections III-V we develop the core structure of our model and calibrate it to the countries under study. Following Buffie (2003) we use a two-sector perfect-foresight model with imperfect asset substitutability. Aid accrues directly to the public sector, where the bulk of it is spent but a portion may be devoted to reducing the government's seigniorage requirement. To quantify the macroeconomic trade-offs we begin by solving the model under the polar exchange rate arrangements of a pure float (Section VI) and a predetermined crawling peg (Section VII). The long-run response is identical, and we assume throughout the paper that the monetary authority accepts the moderate real appreciation that is required to absorb the long-run spending effect of aid.[3] A comparison of short-run responses, however (Section VIII), generates a result reminiscent of the broader literature on exchange rate regimes: when government spending rises by the full amount of aid, portfolio shifts play a minor role, and we find that floating rates deliver a superior outcome, with near-immediate adjustment to the steady state and little short-run volatility in the real exchange rate or interest rate. When a portion of aid is used to reduce the seigniorage requirement, in contrast, portfolio adjustment plays a major role and the crawling peg delivers greater short-run stability.

A clean float is even more unappealing if domestic wages and prices are downwardly rigid in the short run, because in this case the deflationary impact of nominal appreciation creates a strong bias towards economic contraction (Section VI).[4] The advantages of the crawling peg, however, are not unambiguous: they are bought at the price of an initial burst of inflation, unless—implausibly, in our view—domestic wages and prices are rigid in the upward direction. In Sections IX and X, therefore, we consider alternative strategies for neutralizing these short-run effects, including temporary bond sterilization of foreign exchange intervention and a managed float that targets the new long-run equilibrium real exchange rate. A crawling peg with bond sterilization fails badly, however, generating intolerable increases in interest rates and government debt, as observed in our case studies (Section IX). The managed float, in contrast, finally delivers an unambiguously satisfactory outcome. Section XI concludes the paper with suggested extensions of the analysis.

II. Country Experiences

The experiences of Uganda, Tanzania and Mozambique since the late 1990s illustrate well the policy problems confronting central banks in many low-income countries (see Box 1 and Tables 1 and 2). For at least the previous two decades monetary policy was subordinated to fiscal imperatives, initially to the financing of large (and ultimately unsustainable) fiscal deficits, and since the early 1990s in support of decisive fiscal consolidations which, in turn, ushered in an era of historically low inflation (Honohan and O'Connell (1997)). With each

[3] If the inflow is known to be temporary, it may be welfare-improving for the monetary authority to target the real exchange rate, letting inflation and/or the real interest rate increase in order to prevent "Dutch disease" or other adverse effects of a temporary real appreciation (Prati, Sahay and Tressel, 2003; Calvo, Reinhart and Vegh, 1995). But when the inflow is persistent, there is little to recommend a delayed real exchange rate adjustment. Monetary management should concentrate, instead, on avoiding short-run volatility around the new long-run real exchange rate. A successful monetary response is one that avoids an overshooting of the real exchange rate, a burst of inflation, a slump in real activity, or a run-up in the real exchange rate.

[4] Calvo and Reinhart (2000b) cite debt deflation as a risk in floating exchange rate systems. Our own interpretation emphasizes the traditional demand contraction channel.

country resorting to fiscal rules to manage the growth in domestic credit to government, however, there was little or no role for active monetary policy.

Successful stabilization has been associated with large and persistent increases in aid and private capital flows, most notably into Uganda and Tanzania. Given the priorities embedded in countries' PRSPs, the public expenditure financed by these aid flows has been biased towards nontradables, implying an increase in the governments' net domestic liquidity requirements. In this environment the central banks have wrestled with the problem of how much (if any) of this aid-induced domestic liquidity injection needs to be neutralized, over what time period, and by what means.

Two issues have complicated the question of the required scale of intervention. The first is a lack of clarity on the part of the authorities at to whether concerns about the exchange rate relate more to its volatility than its level (and even whether the argument that monetary policy cannot depreciate the real exchange rate on a permanent basis is fully accepted (Calvo, Reinhart and Végh, 1995)). The second is the absence of a consensus on the likely evolution of the demand for money and hence the sustainable non-inflationary growth in domestic liquidity. As Table 1 indicates, reserve money velocity has declined in all three countries, and in both Uganda and Tanzania inflation has remained low and stable despite bursts of rapid growth in reserve money. In Mozambique, by contrast, a closer—or at least more rapid—link between reserve money and inflation has been evident. The central banks of Uganda and Tanzania, and to a lesser extent the Bank of Mozambique, have argued that the decline in velocity, which was consistently greater than the IMF had projected, reflected two factors: first, that the inflation-induced demonetization of the late 1980s and early 1990s was still in the process of being reversed; and second, that structural reforms had substantially increased permanent income and therefore the demand for money. The contrary view, articulated in IMF staff appraisals but apparently supported by the Ministry of Finance in Uganda, is more pessimistic. According to this view, structural reforms have generated, at best, only a modest increase in money demand, while the history of inflation in these countries has *permanently* increased the elasticity of substitution between domestic and foreign money, reducing the demand for domestic currency at any inflation rate. Hence, while there may have been a structural shift in money demand between the 1980s and 1990s, the case for a further sustained increase in real money demand in the post-stabilization period remains unproven. This pessimism, combined with a view that money supply growth is still taken as a signal of the credibility of government's commitment to fiscal discipline, underpins the 'neutralize at all costs' position that appears to have dominated the IMF's perspective on the limit of monetary policy in these countries in recent years.

Turning next to the question of how sterilization is to be achieved—via traditional bond sterilization, foreign exchange sales, or delayed fiscal absorption of aid—it would appear the central banks have first and foremost been concerned to avoid excessive nominal and real appreciation. The initial response to inflows in all three countries thus included a sharp accumulation of international reserves, and in Uganda and (especially) Tanzania the central bank intervened in the foreign exchange market to limit the pressure on the nominal exchange rate, in a pattern consistent with the "fear of floating" widely exhibited by countries operating nominally flexible exchange rate regimes (Calvo and Reinhart, 2000a).

To the extent that the underlying anxieties about the exchange rate are articulated, it is the adverse effect on traditional cash-crop exports that appears to have been of prime concern to the central banks. It is much less clear whether their concerns extend to non-traditional exports or the import-substituting sector, as stressed by the Dutch disease literature.

In the context of a reserve money program, this "fear of floating" suggests the use of sterilized intervention, and bond sterilization played a major role in all three countries, at least initially. The thinness of domestic debt markets, however, meant large change in domestic interest rates which in turn, given the short maturity of debt instruments, led to a rapid pass through to debt-servicing costs (Table 2). It appears to have been these mounting fiscal costs of debt service, rather than the impact of high interest rates on credit to the private sector, that constituted the dominant constraint on central banks' willingness to continue bond sterilization, and it was this unwillingness that induced the authorities to switch towards more aggressive foreign exchange sales (in Uganda) and/or allow reserve money growth to exceed its program target (in Tanzania and Mozambique).

III. THE CORE STRUCTURE OF THE MODEL

We work with a simple currency substitution model of a small open economy that produces a nontraded good and a composite traded good. Real output is fixed in both sectors and the world price of the traded good equals unity. The private sector divides its wealth between domestic currency, foreign currency, and government bonds.[5] Notational conventions are as follows: P_n and γ denote the relative price of the nontraded good and its share in aggregate consumption; Q_i is output in sector i; b is the nominal stock of bonds deflated by the price level; and m, F, and E are real money balances, the stock of foreign currency, and aggregate real expenditure measured in dollars (i.e., units of the traded good).

A. Prices

P_n adjusts to clear the goods market in the nontradables sector. This requires

$$D_n(P_n,\ E) = Q_n, \tag{1}$$

where $D(\cdot)$ is the Marshallian demand function for the nontraded good.

[5] The foreign asset could be an interest-earning asset instead of foreign currency. What is critical is that the foreign asset and domestic bonds be imperfect substitutes so that the domestic interest rate is not tied down by the interest-parity condition.

The overall price level P is a geometric weighted average of the prices of the traded and nontraded goods. Since the nominal exchange rate e sets the domestic price of the traded good,[6]

$$P = eP_n^{\gamma}. \tag{2}$$

B. The Private Agent's Optimization Problem

All economic decisions in the private sector are controlled by a representative agent who possesses an instantaneous utility function of the form $V(P_n,\ E) + \phi(mP_n^{-\gamma},\ FP_n^{-\gamma})$. $V(\cdot)$ is a standard indirect utility function that measures utility from goods consumption, while $\phi(\cdot)$ reflects liquidity services generated by holdings of domestic and foreign currency. The private agent chooses $m,\ b,\ F,$ and E to maximize

$$U = \int_0^{\infty}[V(P_n,\ E) + \phi(mP_n^{-\gamma},\ FP_n^{-\gamma})]e^{-\rho t}dt, \tag{3}$$

subject to the wealth constraint

$$A = m + P_n^{\gamma}b + F \tag{4}$$

and the budget constraint

$$\dot{A} = P_n Q_n + Q_T + P_n^{\gamma}g + rP_n^{\gamma}b + (\pi - \chi)P_n^{\gamma}b - \chi m - E, \tag{5}$$

where ρ is the time preference rate; g is real lump-sum transfers; $\chi = \dot{e}/e$ is the rate of currency depreciation; r is the real interest rate; and $\pi = \dot{P}/P$ is the inflation rate. $P_n^{\gamma} = P/e$ multiplies g and b because wealth is measured in dollars but transfers and bonds are indexed to the price level. For the same reason, the artificial capital gains term $(\pi - \chi)P_n^{\gamma}b$ appears in the budget constraint (5).

Let ω be the multiplier attached to the constraint in (5). The necessary conditions for an optimum then consist of

$$V_E = \omega, \tag{6}$$

$$\phi_1 / \omega P_n^{\gamma} = r + \pi, \tag{7}$$

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[6] For small changes, γ can be treated as a constant. In the numerical simulations, γ varies endogenously with P_n (we do not assume Cobb-Douglas preferences).

$$\phi_2 / \omega P_n^{\gamma} = r + \pi - \chi, \tag{8}$$

and the co-state equation

$$\dot{\omega} = \omega(\rho + \chi - r - \pi). \tag{9}$$

Equations (6)-(8) state that the marginal utility of consumption equals the shadow price of wealth and that the marginal rate of substitution between consumption and m or F equals the income foregone from holding that type of money. The co-state equation (9) may look less familiar, but it is nothing more than a standard Euler equation. Differentiate (6) with respect to time and substitute for $\dot{\omega}$. Under the assumption of homothetic preferences, this gives[7]

$$\frac{\dot{E}}{E} = \frac{\tau}{1-\gamma k}(r-\rho), \tag{10}$$

where $\tau \equiv -V_E / V_{EE} E$ is the inter-temporal elasticity of substitution, $k \equiv (\eta + \gamma)^{-1}$, and η is the compensated own-price elasticity of demand.

C. The Public Sector Budget Constraint

Money is injected into the economy whenever the central bank accumulates foreign exchange reserves Z or runs the printing press to finance the fiscal deficit of the central government. For now, we ignore bond sales and open market operations. The *consolidated* public sector budget constraint is thus

$$\dot{m} = P_n^{\gamma}(g + rb) + \dot{Z} - X - \chi m, \tag{11}$$

[7] We have omitted some intermediate steps. The first is $\left(\frac{V_{EP}}{V_{EE} D_n} - \tau\right) \gamma \frac{\dot{P}_n}{P_n} + \frac{\dot{E}}{E} = \tau(r-\rho)$, where $V_{EP} \equiv \partial V_E / \partial P_n$. [Note from (2) that $\pi - \chi = \gamma \dot{P}_n / P_n$.] To get rid of the awkward V_{ij} terms, recall Roy's identity $D_n = -V_P(P_n,\ E)/V_E(P_n,\ E)$. For homothetic preferences, $V_{EP} / V_{EE} D_n = \tau - 1$. We also have from (1) that $dP_n / P_n = kdE / E$. Substituting for $\dot{P}_n / P_n$ and for $V_{EP} / V_{EE} D_n$ produces equation (10) in the text.

where X is the sale of aid dollars net of government imports and interest payments on the public sector foreign debt net.[8]

D. Net Foreign Asset Accumulation and the Balance of Payments

One last equation completes the core structure of the model. Summing the private and public sector budget constraints produces the accounting identity that foreign asset accumulation equals national saving or the current account surplus:

$$\dot{F} + \dot{Z} = P_n Q_n + Q_T + X - E. \tag{12}$$

IV. The Steady-State Outcome

The long-run equilibrium is independent of the exchange rate regime. It is not yet necessary therefore to specify whether the central bank operates a crawling peg, a clean float, or some type of managed float.

Across steady states, $\dot{m} = \dot{F} = \dot{Z} = \dot{E} = 0$. Imposing these conditions leads to

$$r = \rho, \tag{13}$$

$$\chi = \pi, \tag{14}$$

$$E = P_n Q_n + Q_T + X, \tag{15}$$

$$\phi_1 = V_E P_n^{\gamma} (\rho + \pi), \tag{16}$$

$$\phi_2 = V_E P_n^{\gamma} \rho, \tag{17}$$

$$\pi m = P_n^{\gamma} (g + \rho b) - X. \tag{18}$$

Equation (18) says that revenue from the inflation tax equals the fiscal deficit after grants. (Hereafter we use the shorter term fiscal deficit and omit "after grants.") When more aid flows in, X rises and the government increases real transfers to the private sector by $d(P_n^{\gamma} g) = \psi dX$. To obtain concrete results and prepare the model for calibration, we assume $V(\cdot)$ and $\phi(\cdot)$ are nested CES-CRRA functions:

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[8] For simplicity, we ignore interest payments on reserves. This ensures that the long-run impact of aid on real income and the fiscal deficit is independent of the exchange rate regime

$$V(P_n,\ E) = \frac{E^{1-1/\tau}\left(k_o + k_1 P_n^{1-\beta}\right)^{(1-1/\tau)/(\beta-1)}}{1-1/\tau}, \tag{19}$$

$$\phi(\bar{m},\ \bar{F}) = h\frac{\left\{\left[k_2\bar{m}^{(\sigma-1)/\sigma} + k_3\bar{F}^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)}\right\}^{1-1/\tau}}{1-1/\tau}, \tag{20}$$

where h and $k_o - k_4$ are constants, β is the elasticity of substitution between traded and nontraded consumer goods, σ is the elasticity of substitution between domestic and foreign currency, $\bar{m} \equiv mP_n^{-\gamma}$, and $\bar{F} \equiv FP_n^{-\gamma}$. For this utility function, the steady-state effects of aid are given by

$$dE = \frac{dX}{1-\gamma k}, \tag{21}$$

$$\frac{dP_n}{P_n} = \frac{dX}{\eta E}, \tag{22}$$

$$d\pi = -\frac{\pi\mu - \rho s\gamma k + (1-\psi)(1-\gamma k)}{(1-\gamma k)\mu(1-\varepsilon)}\frac{dX}{E}, \tag{23}$$

$$\frac{dm}{m} = \left[\frac{1}{1-\gamma k} + \frac{\varepsilon}{\pi\mu(1-\varepsilon)}\left(\frac{\pi\mu - \rho s\gamma k}{1-\gamma k} + 1 - \psi\right)\right]\frac{dX}{E}, \tag{24}$$

$$\frac{dF}{F} = -\left[\frac{(\sigma-\tau)\theta_m}{i\mu(1-\varepsilon)}\left(\frac{\pi\mu - \rho s\gamma k}{1-\gamma k} + 1 - \psi\right) - \frac{1}{1-\gamma k}\right]\frac{dX}{E}, \tag{25}$$

where

$$\theta_m = \frac{im}{im + \rho F}$$

$$\theta_f = \frac{\rho F}{im + \rho F} = 1 - \theta_m$$

are the shares of liquidity services provided by domestic and foreign currency; $\mu \equiv m/E$; $s \equiv P_n^{\gamma} b/E$; $i = \rho + \pi$ is the nominal interest rate; and $\varepsilon = (\tau\theta_m + \sigma\theta_f)\pi/i$ is the elasticity of money demand with respect to inflation. In the ensuing analysis we assume $\varepsilon < 1$ and $\sigma > \tau$. Neither assumption is particularly restrictive. The first keeps the economy away from the slippery, downward-sloping portion of the seigniorage Laffer curve. (When $\varepsilon > 1$, long-run comparative statics results are perverse and the equilibrium path is indeterminate.) The second implies that lower inflation reduces the demand for foreign currency. Although theory does not guarantee this result, there is not much doubt that it is easier to substitute between the two currencies than to substitute intertemporally in consumption; hence some flight capital comes home when inflation declines.

Aid spending drives up the relative price of the nontraded good, but it is not clear what happens to currency demands, the fiscal deficit, or inflation. We distinguish here between aid that is fully spent and aid used partially for deficit reduction (PDR aid). In the case where every dollar of aid is spent ($\psi = 1$), the fiscal deficit worsens because appreciation of the real exchange rate ($P_n \uparrow$) increases the size of the internal debt measured in dollars. But higher spending also strengthens real money demand. Consequently, despite the rise in the fiscal deficit, inflation falls when

$$\pi\mu > \frac{\rho s \gamma}{\eta + \gamma}. \tag{26}$$

The term on the left side is seigniorage expressed as a percentage of national income, a number on the order of .005-.02 in countries experiencing low/moderate inflation. On the right side, real interest payments on the internal debt (ρs) are equally small (in sub-Saharan Africa) while $\gamma/(\eta + \gamma)$ is typically .5-.8 (See the discussion in Section III.A). The sign of $d\pi$ is thus highly uncertain. This is irritating but unimportant; as will become apparent shortly, even large aid inflows do not change the inflation rate by more than half of a percentage point.[9]

PDR aid is different in that $(1-\psi)$ percent of the external inflow is earmarked for reduction of the fiscal deficit. When analyzing this scenario, we assume

$$\psi < 1 - \rho s \gamma / \eta$$

so that the seigniorage requirement does, in fact, decline. This ensures that inflation falls and that the real money supply increases. Private capital flows could go either way since lower inflation and higher consumption spending exert conflicting effects on the demand for foreign currency. Normally, however, the currency substitution effect dominates the outcome. Observe in (25) that $i\mu(1-\varepsilon)/\theta_m = (i\mu + \rho F/E)(1-\varepsilon)$ is the ratio of liquidity services to national income, scaled down by $1-\varepsilon$. The reciprocal of this, which multiplies $\sigma - \tau$, is a huge number. Private capital flows out therefore only when domestic and foreign currencies are extremely weak substitutes. To illustrate, suppose $\tau = \eta = .25$, $\gamma = .50$, $\pi = .15$, $\rho = \mu = F/E = .10$, $s = .15$, $\psi = .75$, and that aid increases by 2 percent of national income. Holdings of foreign currency then decrease as long as σ exceeds .565. And for $\sigma = 1.5$, a value at the low end of empirical estimates, cumulative private inflows are big—2 percent of national income.

[9] This statement assumes that ε is not too close to unity. Near the top of the seigniorage Laffer curve, small variations in the fiscal deficit have large effects on the inflation rate.

V. Flexible Exchange Rates

On paper, flexible exchange rates and strict targeting of the money supply are the norm in sub-Saharan Africa. But the commitment to money-based stabilization and market-determined exchange rates is far from absolute, especially in periods of adjustment to large external shocks. Many countries have responded to large aid inflows by shifting to managed floats and partly accommodating monetary policy.

The decision about how much to manage the exchange rate is a decision about how much to move in the direction of a fixed exchange rate. Most of the information relevant to this decision is contained in the outcomes at the endpoints of the policy spectrum. Accordingly, we start by investigating the polar cases of a pure float and a crawling peg.

In a pure float the central bank never intervenes in the foreign exchange market. With $\dot{Z}=0$, the Euler equation

$$\dot{E}=\frac{\tau E}{1-\gamma k}(r-\rho), \tag{10}$$

$$\dot{m}=P_n^{\gamma}(g+rb)-X-\chi m \tag{11'}$$

and

$$\dot{F}=P_n Q_n+Q_T+X-E \tag{12'}$$

comprise a 3x3 dynamic system in which F is predetermined while m and E are jump variables. To solve the system, we need to figure out how r and χ vary with m, F, and E. [Equation (11) already relates P_n to E.] Working toward this end, note from (1), (2) and (10) that

$$\dot{P}/P=\pi=\chi+\frac{\gamma k\tau}{1-\gamma k}(r-\rho). \tag{27}$$

Equations (7), (8), and (27) can be solved for π, χ, and r. The solutions for r and χ are

$$dr=n_2\hat{m}-n_3\hat{F}+n_4\hat{E}, \tag{28}$$

$$d\chi=n_8\hat{F}-n_9\hat{m}+(\pi/\tau)\hat{E} \tag{29}$$

where

$$n_1 = \frac{\gamma k \tau}{1-\gamma k} > 0,$$
$$n_2 = \frac{\rho(\tau-\sigma)\theta_m}{\tau\sigma(1+n_1)} < 0,$$
$$n_3 = \frac{\rho(\tau\theta_m + \sigma\theta_f)}{\tau\sigma(1+n_1)} > 0,$$
$$n_4 = \rho / \tau(1+n_1) > 0,$$
$$n_8 = \frac{\rho}{\sigma} + \frac{\pi(\tau-\sigma)\theta_f}{\tau\sigma} ?\, 0,$$
$$n_9 = \frac{\rho}{\sigma} + \frac{\pi(\tau\theta_f + \sigma\theta_m)}{\tau\sigma} > 0.$$

The requisite machinery is now in place. Linearizing (10), (11'), and (12') around the steady state (m^*, F^*, E^*) produces

$$\begin{bmatrix} \dot{m} \\ \dot{F} \\ \dot{E} \end{bmatrix} = \begin{bmatrix} c_1 & -c_2 & c_3 \\ 0 & 0 & \gamma k - 1 \\ c_4 & -c_5 & c_6 \end{bmatrix} \begin{bmatrix} m - m^* \\ F - F^* \\ E - E^* \end{bmatrix}, \tag{30}$$

where

$$c_1 = sn_2 / \mu + n_9 - \pi,$$
$$c_2 = (P_n^\gamma b / F) n_3 + (m / F) n_8,$$
$$c_3 = s(\gamma k + n_4) - \pi\mu / \tau,$$
$$c_4 = \tau n_2 / \mu(1-\gamma k),$$
$$c_5 = \tau n_3 /(1-\gamma k) F / E,$$
$$c_6 = \tau n_4 /(1-\gamma k).$$

The system is saddlepoint stable.[10] On the unique path that converges to the stationary equilibrium,

$$m(t) - m_o = m^* - m_o - \frac{R_1}{R_2}(F^* - F_o)e^{\lambda_3 t}, \tag{31}$$
$$F(t) - F_o = (F^* - F_o)(1 - e^{\lambda_3 t}), \tag{32}$$

$$E(t) - E_o = E^* - E_o - \frac{F^* - F_o}{R_2} e^{\lambda_3 t}, \tag{33}$$

[10] Saddlepoint stability requires $c_2 c_4 - c_1 c_5 < 0$, which holds for $\varepsilon < 1$.

where

$$R_1 = \frac{\lambda_3 - c_6 + c_5 R_2}{c_4} ? 0,$$

$$R_2 = \frac{\gamma k - 1}{\lambda_3} > 0,$$

and λ_3 is the system's negative eigenvalue.

When all aid is spent the new steady state is very close to the old steady state. While this does not preclude interesting dynamics, we have yet to discover a case (based on sensible parameter values) where inflation, the real exchange rate, or any other variable changes much on the transition path. The results are boring even by the standards of flex-price, full-employment macromodels.

Which is not true, however, of scenarios that link aid to deficit reduction. As shown earlier, in the PDR-aid scenario inflation and holdings of foreign currency decrease significantly across steady states. This imparts quantitative heft to the dynamics and pins down the qualitative properties of the transition path. Several results follow directly from the private sector's desire to run down its stock of foreign currency: at t = 0 expenditure increases *more* than aid ($E(0) > E^*$), the current account worsens, and the real exchange rate ($1/P_n$) *overshoots* its steady-state level [$P_n(0) > P_n^*$]. Furthermore, since $\dot{E},\ \dot{F} < 0$, $\forall t$, the real interest rate is continuously lower

$$r(t) = \rho - \lambda_3 \frac{1-\gamma k}{\tau} \frac{F^* - F_o}{ER_2} e^{\lambda_3 t} < \rho \qquad (34)$$

and the current account (CA) deficit does not disappear until capital inflows cease

$$CA(t) = \dot{F}(t) = -\lambda_3 (F^* - F_o) e^{\lambda_3 t} < 0. \qquad (35)$$

Consider next the impact on the path of inflation. The surge in consumption spending might seem to be a source of trouble in the short run. But this is not the case. It is easy to demonstrate that when the private sector attempts to sell foreign currency at $t = 0$ the nominal exchange rate appreciates and the price level (P) and the inflation rate ($\dot{P}/P$) jump downward. Recall that the nominal money supply is predetermined. Thus

$$\frac{e(0) - e_o}{e_o} = -\frac{m(0) - m_o}{m_o}$$
$$= -\frac{m^* - m_o}{m_o} + \frac{R_1 (F^* - F_o)}{R_2 m_o}.$$

After substituting for $m^* - m_o$ and $F^* - F_o$, this becomes

$$\frac{e(0)-e_o}{e_o} = -\left\{ \frac{R_2\sigma}{(\sigma-\tau)\theta_m(1-\gamma k)} + \frac{\lambda_3 - c_6}{c_4}\frac{F}{m}\underbrace{\left[\frac{(\sigma-\tau)\theta_m K}{i\mu(1-\varepsilon)} - \frac{1}{1-\gamma k}\right]}_{\text{Positive for } F^* < F_o} \right\} \frac{dX}{ER_2} < 0, \tag{36}$$

where

$$K = \frac{\pi\mu - \rho s \gamma k}{1-\gamma k} + 1 - \psi > 0.$$

The solution for the jump in the price level is obtained from (2), (11), (33), and (36):

$$\frac{P(0)-P_o}{P_o} = \frac{e(0)-e_o}{e_o} + \gamma k \frac{E(0)-E_o}{E_o}$$

$$\Rightarrow \frac{P(0)-P_o}{P_o} = -\left\{ \frac{R_2}{1-\gamma k}\underbrace{\left[\frac{\sigma}{(\sigma-\tau)\theta_m} - \gamma k\right]}_{\text{Positive for } \sigma>\tau} + \frac{F}{E}\underbrace{\left[\frac{(\sigma-\tau)\theta_m K}{i\mu(1-\varepsilon)} - \frac{1}{1-\gamma k}\right]}_{\text{Positive for } F^* > F_o} \times \left[\frac{\lambda_3}{c_4\mu} + \underbrace{\frac{\sigma}{(\sigma-\tau)\theta_m} - \gamma k}_{\text{Positive for } \sigma>\tau}\right] \right\} \frac{dX}{ER_2} < 0. \tag{37}$$

Finally, equation (27) and the first-order conditions (7) and (8) yield

$$\frac{k_2}{k_3}\left(\frac{m}{F}\right)^{-1/\sigma} = \frac{r+\pi}{r(1+n_1)-\rho n_1}.$$

m/F rises and r falls, so π must decrease at $t = 0$. This guarantees continuously lower inflation on the transition path to the new steady state.[11]

[11] After jumping at $t = 0$, the path of π is continuous, with $\dot{\pi} = h(F^* - F_o)$. For $h > 0$, $\dot{\pi} < 0$. When $h < 0$, $\dot{\pi} > 0$, implying that π approaches its steady-state level from below.

A. Numerical Results: How Big Are the Effects?

To calibrate the model we chose units so that $P_{no} = E_o = 1$ and set

$$m_o = .08,\ \ b_o = .09,\ \ \pi_o = .10,\ \ \gamma_o = .50,\ \ X_o = .10,$$
$$\beta = .50,\ \ \sigma = .75 - 3,\ \ \rho = .10,\ \ \tau = .25 - .50,\ \ F_o = .12.$$

The numbers assigned to m_o, π_o, b_o, γ_o, and X_o are rough averages of the values observed in Uganda, Mozambique, and Tanzania in the period 1999-2001 (see Table 3). We chose average values mainly to save space; the results do not change much when the model is calibrated separately to the data for each country. With respect to the other choices:

- *Elasticity of substitution in consumption between traded and nontraded consumer goods* (β). Fixing β at .50 implies that the compensated elasticity of demand for the nontraded good is .25 initially. This agrees with the finding in empirical studies that compensated elasticities of demand tend to be small at high levels of aggregation.[12]

- *Elasticity of substitution between domestic and foreign currency* (σ). There are no reliable estimates of σ for the countries in our sample or any other country in Africa. For Latin America the numbers range from 1.5 to 7 (Ramirez-Rojas, 1985; Marquez, 1987; Giovannini and Turtleboom, 1994; Kamin and Ericcson, 1993). Not trusting the high-end estimates (7??) and allowing for the possibility that the elasticity of substitution could be lower than the low-end of the Latin American range, we decided to let σ vary from .75 to 3.

- *Time preference rate* (ρ). The time preference rate is 10 percent because the real interest rate on government debt—fixed by ρ across steady states—seems to be high in the countries we study.

- *Elasticity of inter-temporal substitution* (τ). Most estimates for developing countries place τ between .20 and .50. (See Agenor and Montiel, 1999, Table 10.1.) We settled therefore on .25 and .50 as the low and high values for the inter-temporal elasticity of substitution. Occasionally, we also report results for the intermediate case of $\tau = .35$.[13]

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[12] See Lluch et al. (1977, chapter 3), Deaton and Muellbauer (1980, p.71), Blundell (1988, p.35), and Blundell, Pashardes, and Weber (1993, Table 3b, p.581).

[13] .25 is the point estimate for τ for Tanzania in Ogaki, Ostry, and Reinhart (1996). .50 is slightly below their average point estimate (.57-.60) for middle-income countries.

- *Ratio of foreign currency to national income* (F_o). Foreign currency deposits in the domestic banking sector range from 45-200 percent of reserve money in Mozambique, Uganda, and Tanzania.[14] This suggests $F_o = .086$, but the true value is higher because a good deal of foreign currency is held outside of the domestic banking system. We arbitrarily set F_o at .12. This is in line with dollarization ratios in other parts of the Third World.[15]

B. All Aid Is Spent

Table 4 shows how inflation, the real interest rate, the real exchange rate (RER), and the current account (CA) evolve during the first five years of the adjustment process in the case where all aid is spent.[16] The numbers in parentheses in the cells for π at $t = 0$ and $t = 1$ state the initial percentage jump in the price level and the cumulative percentage increase in the price level over the first year (i.e., the real world definition of annual inflation).[17] In the column at the far right, Long Run refers to the steady-state outcome.

The results echo our earlier complaint that the dynamics are short-lived and uninteresting. The change in the current account is trivial, and most of the long-run appreciation of the real exchange rate is accomplished in a single downward jump of the nominal exchange rate at $t = 0$. In the first panel the real interest rate jumps initially to 11 percent. This is mildly exciting, but it is not repeated elsewhere in the table—in the other seven panels r increases only one- to five-tenths of a percentage point. The most notable conclusion is that aid spending does *not* temporarily exacerbate inflationary pressures. Quite the contrary: thanks to sharp appreciation of the nominal exchange rate, the price level decreases 1.6-6.4 percent on impact and inflation declines in the first year from 10 percent to 2.8-8.6 percent.

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[14] Evidence from Uganda, Tanzania, Mozambique and elsewhere (e.g., IMF staff appraisals for Zambia and Ghana) indicate that the overwhelming proportion of foreign currency deposits in the domestic banking system are held by domestic residents.

[15] See Kamin and Ericsson (1993), Savastano (1996), and Balino, Bennett, and Borensztein (1999).

[16] The paths for π, r, RER, and CA in Table 4 and all subsequent tables were generated by substituting the linearized solutions for the variables in the core dynamic system (E, m, and F in the present case) into the static nonlinear model. This retains more of the nonlinear structure of the model and thereby reduces linearization error (Novales et al., 1999).

[17] Due to continuous-time compounding, the increase in the price level over the calendar year is greater than 10 percent when $\dot{P}/P = \pi = .10$ (i.e., $e^{.10} - 1 = .105$). The figure reported for inflation in the first year is the constant level of inflation that produces the same increase in the price level at $t = 1$ as in the model.

C. Partial Deficit Reduction (PDR) Aid

In the simulations for PDR aid (Table 5) we treat ψ as a policy variable. A value of .75 is consistent with African data for the 1990s (see Appendix Table 1) and implies—given an aid increase of 2 percent of national income—a decline in the fiscal deficit of roughly half a percentage point of national income. This reduces the steady-state inflation rate to 2.1-3.3 percent. Cumulative private capital inflows range from 0 to 6.6 percent of national income.

What happens on the way to the long-run equilibrium depends mainly on the currency substitution parameter σ. For $\sigma = .75$ private capital inflows are small and the economy moves quickly to the vicinity of the new steady state. But when $\sigma = 2-3$ the ride is a bit wild. Consumption spending strongly overshoots its steady-state level; as a result, the real exchange rate appreciates 14-20 percent in the short run and the current account deficit, *inclusive of aid*, jumps to 1.8-3.5 percent of national income. There are also pronounced fluctuations in π and r in the runs where $\tau = .25$. The real interest rate decreases 1.8-2.2 percentage points at $t = 0$; it rises steadily thereafter but is still 1.3-1.7 percentage points lower at $t = 2$. Because of the temporary decrease in the real interest rate, the fiscal deficit and inflation also overshoot their steady-state levels.

We have saved the bad news for the end. Unfortunately, the results presume far too much flexibility of nominal prices. Consider how the economy adjusts in the short run. According to our model, the nominal exchange rate appreciates 24-55 percent at $t = 0$ to forestall incipient capital inflows (F is predetermined). Since the real exchange rate appreciates "only" 8-20 percent, the nominal price in the nontradables sector has to immediately fall 16-44 percent to keep demand equal to supply. This strains belief to say the least. But if nominal price adjustment is incomplete the economy slides into a recession—probably a deep recession given the magnitude of nominal appreciation at $t = 0$. The real message of Table 5 is that a pure float is impractical when the foreign exchange market has to absorb large private capital inflows.

VI. A Crawling Peg

Under a crawling peg, the money supply adjusts endogenously through the capital account to satisfy money demand. But while domestic currency can be swapped for foreign currency at the central bank, the total dollar value of currency holdings is predetermined. Thus $J \equiv m + F$ is the state variable in the dynamic system defined by (10)-(12). To bring J into view, add (11) and (12). This gives

$$\dot{J} = P_n^{\gamma}(g + rb) + P_n Q_n + Q_T - E - \chi m. \tag{38}$$

To tie down the dynamics, we assume the government lowers the rate of currency depreciation χ to its new steady-state level at the same time it increases transfers. Hence the inputs needed to solve (10) and (38) are limited to the reduced forms that show how r and m vary with J and E on the transition path. These are buried in (7) and (8). Substitute for π from (27) and replace F with $J-m$. Routine algebra then delivers[18]

$$dm = n_{11}dJ + n_{12}dE, \tag{39}$$

$$dr = -\frac{n14}{F}\left(dJ - \frac{J}{E}dE\right), \tag{40}$$

where

$$\begin{aligned}
n_{11} &= \frac{m}{F\Delta}[\tau\rho + \pi\theta_f(\tau-\sigma)],\\
n_{12} &= \sigma\pi\mu/\Delta,\\
n_{14} &= \rho i/\Delta(1+n_1),\\
\Delta &= \tau[\theta_f i + \theta_m\rho(2+\rho\theta_m/i\theta_f)] + \sigma\theta_m\pi^2/i.
\end{aligned}$$

Linearizing (10) and (38) and exploiting the information in (39)-(40) leads to

$$\begin{bmatrix}\dot{J}\\ \dot{E}\end{bmatrix} = \begin{bmatrix}-n_{16} & n_{17}\\ -n_{18} & n_{18}\end{bmatrix}\begin{bmatrix}J-J^*\\ E-E^*\end{bmatrix}, \tag{41}$$

where

$$\begin{aligned}
n_{16} &= (P_n^{\gamma}b/F)n_{14} + \pi n_{11},\\
n_{17} &= \gamma k(1+\rho s) + (P_n^{\gamma}b/FE)n_{14}J - \pi n_{12} - 1,\\
n_{18} &= \tau n_{14}/(1-\gamma k).
\end{aligned}$$

[18] Since they will shortly be used in linearizing (12) and (38), the solutions in (39) and (40) are evaluated at the stationary equilibrium.

Under the weak restriction $\eta > \rho s \gamma$, the steady state is a saddle point and the solutions for J and E read[19]

$$J(t) - J_o = (J^* - J_o)(1 - e^{\lambda_2 t}), \tag{42}$$

$$E(t) - E_o = E^* - E_o - (J^* - J_o) R_3 e^{\lambda_2 t}, \tag{43}$$

where λ_2 is the system's negative eigenvalue and

$$R_3 = \frac{n_{18}}{n_{18}(J/E) - \lambda_2 (F/E)} > 0.$$

To locate the position of J^*, add the solutions for m^* and F^* in (24) and (25):

$$J^* - J_o = \frac{J}{E}(E^* - E_o) - \frac{m}{i\rho}[\tau\rho + \pi\theta_f(\tau - \sigma)](\pi^* - \pi_o). \tag{44}$$

Higher spending increases total currency demand proportionately, but the impact of lower inflation depends on initial conditions (π_o, θ_f) and the relative magnitudes of the substitution parameters σ and τ.

A. All Aid Is Spent

We do not have much to report in Table 6. The macroeconomic effects are still small and generally uninteresting. The choice of exchange rate regime is not, however, unimportant. In a crawling peg the nominal exchange rate is predetermined. Consequently, appreciation of

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[19] The steady state is a saddle point if $n_{17} - n_{16} J/E < 0$, or $\gamma\rho s - \eta - (\eta + \gamma)(n_{12} + n_{11} J/E) < 0$. Since

$$n_{12} + n_{11} J/E = \frac{\mu}{\Delta}\left[\frac{J}{F}\tau(\rho + \pi\theta_f) + \sigma\pi(1 - \underbrace{\theta_f J/F}_{<1})\right] > 0,$$

the second and third terms in the stability condition are negative. The first term is positive, however, because the feedback effects between changes in expenditure, the real exchange rate, and the real interest payments on the internal debt are mutually reinforcing. This is a nuisance, not a serious problem. Instability is a threat only if η is unusually small and variations in the real exchange rate unrealistically large. Even in the extreme case where $\gamma = .80$ and real interest payments on the internal debt are 10 percent of national income, $\eta > .10$ ensures stability.

the real exchange rate at $t=0$ occurs through a large increase in the nominal price of the nontraded good. Purists may argue that this is not inflation but rather a change in a relative price. Be that as it may, the nasty spike in the CPI (P rises 2.9-3.3 percent at $t=0$) is something most policy makers would prefer to avoid.[20] We return to this point later in Sections VIII and IX.

B. PDR Aid

PDR aid has potentially strong effects on private capital flows and total currency demand.

$$\sigma > \tau(1+\rho/\pi\theta_f) + \frac{i\rho(1-\varepsilon)}{\pi\theta_f K(1-\gamma k)}\frac{J}{E}, \tag{45}$$

For total currency demand declines in the long run. The paths for expenditure, the real exchange rate, the current account, and the real interest rate are then qualitatively the same as the paths in a pure float. The item missing from the list is the impact effect on the price level. Once again, the big increase in spending at $t=0$ triggers large jumps in the nominal price of the nontraded good and the CPI. Nor is the effect small: under the weaker condition

$$\sigma > \tau(1+\rho/\pi\theta_f),$$

the spike in the price level is *larger* than in the case where 100 percent of the aid is spent.

The dynamics are quite different when the condition in (45) does not hold: expenditure and the real exchange rate undershoot their steady-state levels, the real interest rate rises, and the current account registers surpluses instead of deficits. Moreover, expenditure may *decrease* initially, causing the real exchange rate to depreciate and the price level to jump downward at $t=0$. The result is odd but it cannot be ruled out by plausible parameter values. When the inequality sign in (45) is reversed the private sector saves more in order to build up total currency holdings ($J^* > J_o$). If

$$\sigma < \tau(1+\rho/\pi\theta_f) + \frac{i\rho(1-R_3J/E)}{K(1-\gamma k)R_3\pi\theta_f}, \tag{46}$$

[20] Aid is funneled to the private sector through lump-sum transfers. Since $\gamma_o = .50$, approximately half of the extra aid money is spent on nontraded goods. If aid financed some project that involved a larger component of nontradables spending, the initial increase in the price level would be greater. When all aid is spent on nontraded goods, for example, the upward jump in P at $t=0$ is about twice as large as in Table 6.

the stimulus to saving is so great that spending and disposable income move in opposite directions in the short run.[21]

C. Numerical Results

How does switching from a pure float to a crawling peg affect the paths of key macroeconomic variables? We should be able to say a lot about this *without* taking a stand on the condition in (45). In a pure float, spot appreciation of the nominal exchange rate at $t = 0$ confers a large wealth gain on the private sector ($m + F \uparrow$ on impact) while also exerting strong downward pressure on the price level. No similar effects operate in a crawling peg. Thus intuition suggests that in comparisons of the two systems a crawling peg buys greater stability of the real exchange rate and smaller current account deficits (or possibly current account surpluses) at the price of higher inflation and higher real interest rates. But if these results are obvious they are not easy to prove. The problem is that the negative eigenvalue governing the saddle path in the flexible rate system is the root of a cubic equation. The solutions in (31)-(33) are not, therefore, as simple as they look—the expression for λ_3 takes up several pages.

Since a proper analytical proof is out of reach, we settle for the next best thing: evidence from numerical simulations. Compare the numbers in Table 7 with those in Table 5. In Table 5 inflation and the real exchange rate overshoot their steady-state levels, the real interest rate decreases, and the current account worsens. All of this turns around in Table 7: the real interest rate rises, the current account improves, and inflation and the real exchange rate undershoot, approaching their steady-state levels from above.[22] At higher values of σ and π_o the qualitative properties of the transition paths are frequently the same (apart from the initial jump in the price level) as in a float. We carried out thirty simulations for this part of the parameter space ($\sigma = 3 - 5$, $\pi_o = .10 - .50$, $s = .10 - .25$, $m_o = .05 - .08$, $F_o = .08 - .16$). The results proved perfectly robust. Under a crawling peg, inflation and the real interest rate always decreased less, the real exchange rate always appreciated less, and the current account deficit was always smaller.

Two other results merit comment. First, the increase in the real interest rate is small in most cases. For $\tau = .25$ and $\sigma = .75$, the rate jumps initially to 12 percent; in every other case, the increase is less than a percentage point. Second, inflationary pressures are confined to the spike in the price level at $t = 0$. Although the spike is large (P jumps 2.5-4.3 percent), the path of the CPI drops below the pre-aid path within 3-7 months and the inflation rate for the first year decreases from 10 percent to 5.2-6.4 percent.

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[21] The condition in (46) is compatible with private capital inflows ($F^* < F_o$).

[22] The results are not quite uniform. In the panel for $\tau = .25$ and $\sigma = 3$, the real interest rate decreases two-tenths of a percentage point at $t = 0$ and inflation barely overshoots its steady-state level.

VII. Sticky Prices

There is some unfinished business connected with the analysis of PDR aid in a pure float. Turn back to Table 5. The numbers look nice but they rely on extreme downward price flexibility to preserve full employment when the nominal exchange rate appreciates 24-55 percent in the short run. We conjectured that real output would decrease sharply if, instead, nominal prices were sticky downward. This needs to be confirmed before drawing any conclusions about the efficacy of managing aid flows in flexible vs. fixed exchange rate systems.

We introduce sticky prices à la Calvo and Végh (1993). The price of the traded good is set by the exchange rate but firms in the nontradables sector adjust prices only when they receive a random "price-change signal". Firms that receive a signal choose a new price by forecasting the future paths of the price level and excess demand.[23] Price adjustment is thus forward-looking. Calvo (1983) shows that when the price-change signal obeys a Poisson process

$$\dot{P}_n = (\pi_n - \chi)P_n \tag{47}$$

$$\dot{\pi}_n = -\delta[D_n(P_n,\ E) - \bar{Q}_n],\quad \delta > 0, \tag{48}$$

where $\bar{Q}_n$ denotes notional output (i.e., the level of output associated with a normal capacity utilization rate). Equation (47) follows from the fact that, at any given point in time, the nominal price of the nontraded good is fixed by past price quotations. (More precisely, at any time *t* the set of firms that adjust their prices is of measure zero.) Equation (48) is a higher-order Phillips Curve. It says that the *change* in π_n, the inflation rate in the nontradable sector, is a decreasing function of excess demand. The parameter δ is larger the shorter the length of the average price quote.

Sticky prices add two variables to the dynamic systems analyzed earlier. In a pure float, both π_n and P_n are jump variables.[24] Under a crawling peg, π_n is a jump variable but P_n is predetermined. Nontradables output is demand determined in both exchange rate regimes.

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[23] Forecasts are mathematically correct and weighted by the probability the price quote will be in force at time t.

[24] To solve the floating rate model, real money balances measured in units of the nontraded good has to be introduced as a state variable.

A. PDR Aid in a Pure Float

The row for Q_n in Table 8 tracks the path of $[Q_n(t) - Q_{no}]/Q_{no}$, the percentage difference between nontradables output at time t and its pre-aid level.[25] Although the compensated elasticity of demand is only .25, substitution toward traded goods—induced by appreciation of the nominal exchange rate—easily dominates the expansionary income effect of higher aid flows. Consequently, Q_n declines in every case. When $\sigma = 2 - 3$, the recession in the nontradables sector is protracted and severe as large private capital inflows force the nominal exchange rate to appreciate 29-37 percent at $t = 0$. For $\sigma = .75$, capital inflows and nominal appreciation are comparatively modest; nevertheless, Q_n falls 4-7 percent on impact and is 1.4-2 percent lower at $t = 1$.

Recession is not the only problem policy makers face. The real exchange rate overshoots its steady-state level much more than in the flexprice model, especially in the runs for $\sigma = 2 - 3$. Moreover, the impact on the real interest rate changes dramatically. When prices are flexible, the real interest rate decreases temporarily from 10 percent to
7.8-9.3 percent. With sticky prices, the rate jumps to 18-35 percent in the first year. This is a natural byproduct of the transitory recession: r is higher on the transition path because aggregate consumption spending rises over time as demand and output recover in the nontradables sector.

The adverse impact on the real interest rate is important, for it implies that the simulation results underestimate the real output losses from floating. Our model assumes constant output in the tradables sector. But if a higher return on treasury bills increases the cost of working capital or depresses investment spending, then tradables production will contract and the demand curve in the nontradables sector will shift further to the left. In a more elaborate model that captured these linkages, the recession would be deeper and more persistent than in Table 9.

B. PDR Aid in a Crawling Peg

The results for a crawling peg in Table 9 are what policy makers dream about. Inflation decreases smoothly without an initial spike in the price level. The current account records a small surplus and the real exchange rate moves toward its long-run equilibrium value in a gradual, orderly manner. For a couple of years, the economy also enjoys higher output and lower real interest rates (apart from the second panel, where r increases slightly). What makes everything work is that the budget-support component of aid effectively finances a perfectly credible exchange-rate-based stabilization. The small exchange rate based stabilization component (1/4 of the total aid package) ensures that inflation decreases monotonically even though real spending rises 2.2-3.4 percent in the short run.

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[25] We assume fast price adjustment: $\omega = 5$ in Tables 8 and 9.

Does this mean that a crawling peg with fully accommodating monetary policy solves all macroeconomic problems in the case of PDR aid? Probably not. Few macroeconomists have trouble with the notion that prices are sticky downward. But are prices sticky upward as well? For reasons that are hard to justify, we suspect that price adjustment is asymmetric in sub-Saharan Africa and that the flexprice specification is correct for many branches of the nontradables sector (e.g., the informal sector) when nominal price increases are required to clear the market. The pure flexprice model of sections I-IV may exaggerate the initial upward jump in the CPI, but the sticky-price model is overly optimistic in assuming the problem away. Doubtless the truth lies somewhere in between.

VIII. Policy Implications

The preceding analysis yields some useful guidelines for policy. Our strongest conclusion is that a pure float is the best way to absorb aid that will be entirely spent. Adjustment is quick in both a float and a crawling peg, with 80-90 percent of total appreciation of the real exchange rate being concentrated in the short run. What differs is the type of nominal price adjustment paired with real appreciation. Under a crawling peg, real appreciation takes the form of a sharp increase in the nominal price of the nontraded good and a spike in the CPI. In a float, by contrast, spot appreciation of the nominal exchange rate reconciles higher spending and appreciation of the real exchange rate with a large decrease in the price level. Crucially, nominal appreciation is not so large as to require significant deflation in the nontradables sector: in Table 4 the overall price level decreases 1.6-6.4 percent, but the nominal price of the nontraded good rises or is unchanged in four cases and decreases 1.7-2.9 percent in the other two cases ($\tau = .25 - .50$ and $\sigma = 3$).[26]

Absorption of PDR aid presents more difficulties. PDR aid uses part of the external windfall to reduce the fiscal deficit and the equilibrium inflation rate. So far so good. But expectations of lower inflation elicit large private capital inflows. This complicates macroeconomic management because staying out of the foreign exchange market is no longer a genuine option: central banks that rely on a pure float passively acquiesce to (i) stupendous appreciation of the nominal exchange rate, (ii) lower employment in both the tradables and nontradables sectors (assuming wages and prices are not exceptionally flexible downward), (iii) overshooting of the real exchange rate, and (iv) large current account deficits. A crawling peg eliminates the threat of a harsh recession and secures greater stability of the real exchange rate but leaves the government with the problem of negotiating an initial big spike in the CPI. Surprisingly, the initial jump in the price level may be higher than when all aid is spent even though inflation decreases more in the long run.

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[26] In the two cases where nontradables demand decreases, output would fall if prices were sticky downward. The reduction in output, however, is very small. In the worst case where $\tau = .50$ and $\sigma = 3$, Q_n falls only .5 percent in the first year.

Summing up, in the case of PDR aid, neither a crawling peg nor a pure float produces fully acceptable results. We move on therefore to the analysis of alternative policy strategies. In Section IX the central bank temporarily sterilizes capital inflows; in Section X it operates a dirty float, intervening in the foreign exchange market to prevent extreme fluctuations in the nominal exchange rate.

IX. Temporary Sterilization

The price level jumps when aid flows increase and the central bank maintains a crawling peg. Since inflation decreases rapidly after the initial spike in the CPI, temporary sterilization comes to mind as a strategy for smoothing the paths of money growth and the price level. To fix ideas, suppose the government sells bonds as needed to stabilize the price level at $t = 0$ and then redeems the debt in future periods. That is

$$\dot{b} = -\alpha[b(t) - b_o], \tag{49}$$

and hence

$$b(t) = b_o + [b(0) - b_o]e^{-\alpha t}. \tag{50}$$

Initial bond sales are $b(0) - b_o$ and the parameter α determines how fast the debt is paid off. The steady state is unchanged—b eventually returns to b_o.

Temporary sterilization alters only one equation in the model. The public sector budget constraint is now

$$\dot{m} + P_n^{\gamma}\dot{b} = P_n^{\gamma}(g + rb) + X + \dot{Z} - \chi m, \tag{11'}$$

so (38) changes to

$$\dot{J} = P_n^{\gamma}(g + rb) + P_n^{\gamma}\alpha(b - b_o) + P_n Q_n + Q_T - E - \chi m. \tag{38'}$$

Proceeding as before yields

$$J(t) - J_o = J^* - J_o + h_2 e^{\lambda_2 t} + [b(0) - b_o]R_4 e^{-\alpha t}, \tag{51}$$

$$E(t) - E_o = E^* - E_o + h_2 R_3 e^{\lambda_2 t} + [b(0) - b_o]R_5 e^{-\alpha t}, \tag{52}$$

where

$R_4 = (\alpha + \rho)(n_{18}J / F + \alpha) / H,$

$R_5 = (\alpha + \rho)n_{18}E / FH,$

$H = \alpha^2 + \alpha(n_{18}J / F - n_{16}) + \dfrac{n_{18}}{F}(n_{17}E - n_{16}J).$

At $t = 0$, J jumps downward by the same amount as b jumps upward. Thus

$$h_2 = J_o - J^* - [b(0) - b_o](1 + R_4)$$

and

$$E(t) - E_o = E^* - E_o + R_3(J^* - J_o)e^{\lambda_2 t} + [b(0) - b_o][R_5 e^{-\alpha t} - R_2(1 + R_4)e^{\lambda_2 t}]. \quad (53)$$

The path of the price level is continuous (i.e., free of spikes) only if $E(0) = E_o$. Enforcing this condition gives the solution for initial bond sales:

$$b(0) - b_o = -\frac{E^* - E_o + R_3(J^* - J_o)}{R_5 - R_2(1 + R_4)}. \quad (54)$$

Tables 10 and 11 show the outcome when 80 percent of the newly issued debt is redeemed over ten years ($\alpha = .161$).[27] A quick scan of the results reveals plusses and minuses. On the plus side, temporary sterilization does a nice job of smoothing the path of the price level. The inflation rate drops to 4.9-6.5 percent at $t = 0$ and then declines monotonically toward its steady-state level. This is accomplished, to repeat, without a prefatory spike in the CPI. Compared to the no-sterilization case, inflation is 1-2 percentage points lower in the first year and slightly higher in subsequent years. Preferences decide which path is superior. That said, we suspect most policy makers would opt for the smooth, spike-free path proffered by temporary sterilization.

The drawbacks of the policy concern the impact on the real interest rate and the size of the bond sales needed to prevent the price level from jumping. In the runs for $\tau = .50$ the real interest rate fluctuates between twelve and sixteen percent in the first year. This is not too worrisome, but when $\tau = .25 - .35$ the rate vaults to 21-36 percent and takes two full years to fall back to 12 percent. It is also disturbing that so much debt has to be sold so quickly. The policy rule in (48) is partly to blame as it forces all bond sales to occur at $t = 0$. A fair interpretation of the results, however, is that smoothing the path of the price level requires the central bank to increase the internal debt by 4-6 percent of GDP in the span of six months or less. This is probably the outer limit of what is feasible in Africa's thin bond markets. It is easy to understand therefore why most governments have employed a mix of sterilization and foreign exchange sales to counteract the short-run inflationary pressures created by high aid flows.

In passing we should remark on something that is not a problem, or at least not as much of a problem as the literature on sterilization contends. Schadler et al. (1993), Calvo, Leiderman, and Reinhart (1994), and others have asserted that sterilization is self-defeating because bond sales push up the real interest rate and thereby attract the capital inflows they

[27] Paying off the debt more quickly results in higher real interest rates.

are trying to neutralize. In our model, this argument is substantially but not completely correct. Observe in Tables 10 and 11 that high real interest rates are associated with *massive* overshooting of private capital inflows and fairly large offset coefficients (for $\sigma = .75 - 2$).[28] Certainly this is not to the liking of the central bank. Sterilization works by reducing liquidity and raising the real interest rate to a level that induces the private agent to hold expenditure constant at $t = 0$. At the margin, the withdrawal of one dollar of domestic currency from circulation reduces liquidity services by i dollars (20 cents worth in Table 10). When the private agent exchanges foreign for domestic currency at the central bank, π dollars of the cut in liquidity services is restored, leaving a net loss of r dollars. This is only 50 percent of the decrease in liquidity services achieved from selling bonds for domestic currency [$r/i = \rho/(\rho+\pi) = .50$ for differential changes]. Thus capital inflows make it harder but not impossible for the central bank to control liquidity. Monetary policy *can* be used to smooth the path of the CPI, huge capital inflows notwithstanding. The critical question is: when does it become too costly to do so? Our own view is that the cost is acceptable when $\tau = .50$ and the real interest rate temporarily increases 3-5 percentage points more than in the no-sterilization case. But for $\tau = .25 - .35$ it is a hard call; since high treasury bill rates are not of concern *per se*, a lot depends on the structure of financial markets and the extent to which sterilization affects the cost of credit for private firms.[29]

X. A Managed Float

> *" . . . the question of the appropriate exchange rate regime for African countries remains open. None of these countries has a `pure' floating exchange rate, opting instead for the common intermediate case of a `managed' float . . . " (Leape, 1999, pp.126-127)*

The preceding results for PDR aid shed light on why most countries prefer managed floats to either a pure float or a crawling peg. Policy is too passive in a pure float: while inflation decreases strongly, the nominal exchange rate is allowed to appreciate to the point where output contracts in the nontradables sector. A crawling peg errs in the opposite direction, imperiling a different target: when the government commits to a fixed path for the exchange rate it throws away the policy instrument that is most effective in combating the

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[28] Interestingly, numerous empirical estimates find offset coefficients close to those in Table 11. See Agenor and Montiel (1999, p.204).

[29] High treasury bill rates are usually a concern because they threaten fiscal stability. In the case at hand, however, the increase in the fiscal deficit (relative to the no-sterilization path) is temporary and does not prevent inflation from decreasing monotonically. The remark about the structure of financial markets is motivated by the fact that sometimes changes in the treasury bill rate do not have a perceptible impact on bank loan rates.

short-run inflationary pressures created by higher aid spending and accompanying private capital inflows. Nor does more active monetary policy resolve the targets-instruments problem. A crawling peg combined with temporary sterilization *does* deliver continuously lower inflation; but, as we have just seen, this often produces very high real interest rates and may require bond sales on a scale that is not feasible.

A managed float gives policy makers the freedom to find the middle ground between too much and too little intervention. The right amount of intervention depends, of course, on the weights attached to the targets for output, inflation, the real exchange rate, and the real interest rate. Rather than derive a complicated intervention rule by optimizing over a quadratic objective function that incorporates all of these targets, we assume the central bank sells/buys foreign currency whenever the real exchange rate ($1/P_n$) is above/below its long-run equilibrium level:

$$\dot{Z} = \Omega \frac{P_n - P_n^*}{P_n}, \quad \Omega > 0. \tag{55}$$

Equation (55) relates the *flow* accumulation of reserves to deviations of the real exchange rate from its target value. In addition, Z may jump at $t = 0$. The initial purchase of reserves and Ω are chosen jointly to ensure that the existing nominal price of the nontraded good clears the market at $t = 0$. The intervention strategy, in other words, is to let the exchange rate appreciate enough to reduce inflation but not so much as to drive the nontradables sector into a recession. Other targets do not influence the intervention rule; it turns out, however, that the rule postulated here also greatly reduces volatility of the real exchange rate and the real interest rate.

Table 12 shows the outcome when the initial stock of reserves is 5 percent of GNP. At long last, we have something that can be pronounced an unqualified success. In contrast to the polar exchange rate regimes, the managed float reduces inflation immediately without any adverse side-effects on output, the current account balance, or the real exchange rate. The one minor blemish in the results is that the real interest rate initially jumps to 12-13 percent in three cases.

The upshot of all this is that the optimal exchange rate regime lies close to the crawling peg end of the policy spectrum. To quantify the meaning of "close", consider the paths of the exchange rate and reserves associated with the policy rule in Table 12. Appreciation of the nominal exchange rate at $t = 0$ is 3-9 percent vs. 24-55 percent in a pure float. Cumulative reserve purchases are 42-96 percent as large as in a crawling peg, with the figure exceeding 70 percent when $\sigma = 2 - 3$. (The figure in parentheses in the row for Z is the stock of reserves in a crawling peg.) Note, however, that the managed float entails greater reserve purchases at $t = 0$ in the runs for $\tau = .50$. This makes an odd impression. Shouldn't a managed float involve less, not more, intervention than a crawling peg? Ceteris paribus, the answer is yes. But other things are not equal in Tables 7 and 12. For $\tau = .50$, inflation and the rate of currency depreciation χ decrease more in the short run when the government operates a managed float instead of a crawling peg.[30] This leads to larger capital inflows and greater reserve accumulation in the short run even though appreciation of the nominal exchange rate bears some of the burden of adjustment. When the central bank intervenes only at $t = 0$ (i.e., $\Omega = 0$), initial reserve purchases decrease 8-29 percent but are still a bit larger than in a crawling peg. (See the panels for $\tau = .50$ in Table 13.)

XI. Concluding Remarks

We have shown that the dynamic response to persistent official capital flows is linked to the degree of financing support they provide and the strength of private portfolio substitution. When these take even rather ordinary values by the standards of three post-stabilization African economies, portfolio adjustments dominate the short-run dynamics and produce some distinctly unpleasant trade-offs. A pure float, in particular, performs very poorly. Portfolio pressures produce a nominal appreciation that is an order of magnitude larger than the required real appreciation, and unless the prices of nontraded goods are perfectly flexible, the real exchange rate overshoots and substitution effects produce a potentially deep recession in the nontraded sector. A crawling peg does better, but at the cost of a short-run spike in inflation, and one that can be contained through bond sterilization only at the cost of a rapidly rising interest burden. In our preferred "managed float" scenario, the central bank uses unsterilized foreign exchange intervention to target the modest real appreciation that is needed to absorb the aid inflow. Real interest rates stay low and macroeconomic adjustment is rapid. Our analysis suggests that African central banks have been correct to intervene substantially in the face of the recent increases in aid, and to discount the argument that rapid domestic liquidity expansion necessarily calls for a combination of bond sterilization and cleaner floating.[31]

[30] In a crawling peg, χ is constant and equal to the steady-state inflation rate. In Table 10, $\chi = -.013$, 0, and .007 at $t = 0$ in the runs where $\tau = .50$ and $\sigma = .75$, 2, and 3, respectively.

[31] We have assumed throughout that the government's anti-inflation commitment is fully credible. The absence of credibility, however, does not undermine the analysis of the paper. In the context of our model, the counterpart to low credibility would be that the private sector's demand for domestic balances would respond less to the decline in anticipated seigniorage requirements, and hence private capital inflows would be correspondingly lower. With private capital flows subdued in this way, the short-run inflation spike under a crawling peg is moderated. Low credibility, therefore, serves to lower the elasticity of demand for domestic money and in doing so strengthens the case for a crawling peg.

We close with some thoughts about two extensions of the analysis that would shed light on the robustness of our conclusions in a broader policy context.[32] The first concerns aid flows that support public investment. We have equated aid with transfer payments to the "poor" (i.e., the representative agent). It is also desirable to investigate the repercussions of aid that finances rehabilitation of social and physical infrastructure. This type of aid brings many new effects into play. If productive capacity increases proportionately in the tradables and nontradables sectors, then appreciation of the real exchange rate will be strictly temporary. Furthermore, if private capital and infrastructure are complements, aid may produce large multiplier effects and a nontrivial increase in tax revenue in the long run.[33] The complications that were confined here to PDR aid would then materialize in the case where all aid is spent. Related to this, we conjecture that productive aid—aid that has a strong positive impact on permanent income and the equilibrium private capital stock—will elicit immediate, large increases in private consumption and investment. This pushes the "optimal" managed float more in the direction of the middle ground between a fixed exchange rate and a pure float. How much more is not clear absent careful analysis. For what it is worth, our expectation is that the macroeconomic trade-offs associated with aid and the right policy intervention *are* sensitive to the type of aid.

The second extension acknowledges that African central banks have to worry about more than just aid shocks when deciding on the appropriate exchange rate regime. We are currently working on a stationary, discrete-time version of our model in which aid shocks compete with other important shocks for policymakers' attention and some portion of aid may in fact represent a response to other shocks (e.g., to the terms of trade). We look for desirable intervention and sterilization rules, given a plausible loss function and the observed distribution of shocks and aid. This approach links the analysis in the current paper with the growing literature on monetary policy rules in the open economy (e.g., Svensson, 2000). The conclusions we have emphasized here—including the merits of dirty floating and the limited

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[32] For a couple of reasons, we do not consider the assumption that aid is permanent to be especially limiting. First, empirical measures of aid generally show strong persistence in African countries. Even after removing a linear trend, for example, the variance of variables like real aid per capita or the aid-to-GNP ratio tends to be dominated by low-frequency components. [Thus while Bulir and Hamann (2001) emphasize the volatility of aid, their analysis applies to the short-run "cycle"—i.e., the component that remains after using the Hodrick-Prescott filter to remove a slow-moving nonlinear "trend". The trend itself shows very substantial persistence, even when applied to linearly detrended aid series.] Second, intuition suggests that temporary aid inflows will produce results qualitatively similar to but quantitatively weaker than in the case of permanent aid flows. (The present model applies, of course, if the government converts temporary aid into permanent aid by spending only its annuity value.)

[33] Theory suggests that the crowding-in effect on private investment could be quite strong. See Buffie (1995).

role for bond sterilization—seem likely to survive if the environment is dominated by autonomous and reasonably persistent changes in aid. What remains to be seen is whether these conclusions constitute a serious challenge, under more general circumstances, to rules that incorporate greater exchange rate flexibility and/or more aggressive bond operations.

Box 1: Monetary and Exchange Rate Policy in Uganda, Tanzania and Mozambique 1999-2002.[1]

Since the mid-1990s, Uganda, Tanzania and Mozambique have enjoyed rapid economic growth based around broad overall macroeconomic stability and structural reforms that have included exchange rate unification and the *de facto* liberalization of the capital account; each now classifies itself as operating a floating exchange rate regime. All three have seen inflation drop sharply compared to levels experienced in the early 1990s.[2] Three key characteristics have helped shaped the countries' current policy choices: low levels of domestic debt and thin domestic debt markets; low domestic monetization; and widespread currency substitution. At the end of the 1990s, on the eve of the episodes we examine here, domestic debt averaged between 2 and 4 percent of GDP, reflecting in part the legacy of high inflation and administered interest rates on nominal debt and, more recently, a sequence of domestic budget surpluses. Moreover, markets in government debt are relatively new and dominated by short-dated instruments. Hence, changes in domestic public borrowing, which would otherwise be considered modest relative to the size of the fiscal deficit or GDP, end up being large relative to the domestic bond market and entail correspondingly large movements in domestic interest rates.

Money demand in all three countries is also low and appears to be strongly influenced by currency substitution. Reserve money averages little more than 4 percent of GDP, and narrow money 10 percent. By contrast, foreign currency constitutes a large and rising share of private sector money. Foreign currency deposits account for between one quarter (Uganda and Tanzania) and one half (Mozambique) of total deposits of the banking sector, and an unknown volume of foreign currency circulates in parallel with domestic currency outside the banking sector. Consistent with the broader literature on Africa, it would appear that although some of this stock is accounted for by 'passive' resident donor mission, embassy and NGO accounts, a substantial portion is actively managed as part of the private sector's wealth.[3]

Uganda

The recent surge in aid flows into Uganda, which began around 2000, occurred against the background of a slump in world coffee prices. Reflecting concerns about this sector, the initial response by the Bank of Uganda (BoU) was to accumulate foreign exchange reserves in order to forestall any exchange rate appreciation arising from increased aid-financed public expenditure on non-tradables. Given the constraints of the program negotiated with the IMF—which envisaged only a modest growth in reserve money—the BoU therefore initially attempted to sterilize the domestic liquidity injection through domestic debt sales. Large relative to the initial size of the domestic debt, this intervention in the domestic debt market precipitated a rapid increase in the debt stock, interest rates, and debt service costs (since with a short average maturity the debt stock was turned-over and re-priced rapidly). So swift was this increase that the BoU abandoned its bond-sterilization strategy in early 2001 but without any offsetting change in its stance on the exchange rate. As a result, reserve money grew rapidly and by mid-2001 it was around 10 percent above its program target. Under pressure from the IMF and the Ministry of Finance, the BoU reverted to a sterilization strategy that relied more heavily on foreign exchange sales. With export earnings weakening and slower than anticipated implementation of public expenditure at the time, the nominal exchange rate did not in fact appreciate in response to BoU intervention (although the nominal and real exchange rates were arguably still more appreciated that the Bank would have wished at the time). Throughout this whole episode and despite the significant monetary overhang relative to the program, underlying nonfood inflation remained low and consistent with the BoU's inflation target.

Tanzania

Tanzania's experience is similar to that of Uganda although perhaps more dramatic. Following a sequence of successful ESAF/PRGF arrangements through the late 1990s, tensions began to emerge in mid-1999 as aid and private capital flows increased. As in Uganda, the Bank of Tanzania (BoT) sought to resist the pressure on the exchange rate by targeting the nominal exchange rate which, despite the surge in inflows, remained virtually constant against the US dollar for almost two years (mid-1999 to April 2001).[4] Sterilization of the shilling counterpart of these aid flows was initially achieved through domestic debt sales. As it happened, the start of this period coincided with a temporary shortfall in tax revenues which the authorities chose to fund through domestic debt sales, so that part of the surge in domestic borrowing and the rise in interest rates at this time reflected conventional deficit-financing requirements.[5] However, during the final quarter of 1999 and well into 2000, by which time the funding crisis had receded, BoT continued to rely on debt sales to sterilize the shilling counterpart to the aid inflow. By mid-2000 concerns about rising interest costs saw the Bank scale its intervention in the domestic debt market. With both of the conventional instruments for neutralizing domestic liquidity pinned down, reserve money grew rapidly and quickly broached the ceiling implied by the targets for net international reserves (NIR) and net domestic assets (NDA) defined under the PRGF. Since 2001 the IMF has argued for a significantly tighter monetary stance, and secured the agreement of the Bank of Tanzania to supplement the existing performance criteria with an explicit program benchmark for reserve money growth in the 2002/03 PRGF arrangement. However, as in Uganda, despite the volatility in interest rates and the excess growth in reserve money, inflation has remained low and stable.

Mozambique

In many respects, the experience of Mozambique is rather different from that of Uganda or Tanzania. One important difference is that the surge in private capital flows preceded the resurgence of official aid flows. The Bank of Mozambique's (BoM) initial response to the growth in private flows, from 1998 to roughly the end of 1999, was conventional. Although BoM did not appear to explicitly target the nominal and real exchange rate, it did allow its net international reserves to rise rapidly, so that over this period reserve coverage increased from 3.5 to 6.5 months of (a rising volume of) imports. This increase was offset by a fiscal sterilization—government deposits with BoM rose sharply and NDA fell one-for-one with the rise in NIR. Reserve money growth was thus almost entirely capped, with higher real money balances accommodated through an increase in the broad money multiplier and a steady rise in the share of foreign currency deposits—on which the domestic reserve requirement was zero at the time—in total private sector money balances.

By late 1999 and into 2000 reserve money growth began to exceed its program targets, even though these had been revised upwards to accommodate the effects of the floods of 2000. By this stage aid flows had increased to finance non-tradable PRSP-related public expenditure, and the previously tight fiscal stance had been loosened somewhat. Although the BoM was not attempting to offset an appreciation in the exchange rate, it was reluctant to use its instrument aggressively to control the growth in reserve money, arguing instead that the observed growth was non-inflationary and reflected an underlying recovery in money demand. Initial sterilization efforts through the debt market were therefore relatively mild, and only in response to significant encouragement from the IMF and a sharp increase in inflation in the second half of 2001, did the BoM adopt more aggressive open market operations.

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[1] These narratives are based on government documents, IMF Staff Reports and Program review documents and discussions with Fund staff. All interpretations of the evidence are our own.
[2] Inflation reached 250 percent per annum in Uganda in the late 1980s and over 60 percent per annum in Tanzania and Mozambique in the early 1990s.
[3] See, for example, the literature on private capital flows by Asea and Reinhart (1996), Bhindra et al (1999), Collier et al (2002), and Fedderke and Liu (2002) on private capital flows and the empirical work by, among others, Fielding (1994), Adam (1999), Henstridge (1999) and Nachega (2001) which finds significant currency-substitution effects on the demand for domestic monetary aggregates.
[4] However, given the sharp depreciation of the South African rand over this period, Tanzania's trade-weighted exchange rate appreciated over this period.
[5] This shortfall, which had been anticipated from early in 1999, reflected over-optimistic forecasts of revenue following tax reform measures implemented in 1989/99.

Table 1. Output, Aid, Inflation and Reserve Money in Uganda, Tanzania, and Mozambique

Calendar Year	Real GDP Growth (In percent)	Net Aid Inflow (Percent of GDP)	CPI Inflation (In percent)	Reserve Money Velocity (1997=1.00)
		Tanzania		
1997	3.5	3.1	15.4	1.00
1998	3.7	4.0	11.2	1.01
1999	3.5	4.5	7.0	0.92
2000	4.9	6.0	5.5	0.93
2001	5.7	5.0	4.9	0.98
2002	6.2	5.9	4.4	0.91
2003(proj)		6.4		
		Uganda		
1997	5.0	8.3	8.4	1.00
1998	4.5	7.9	-1.9	0.85
1999	8.0	7.9	9.3	0.88
2000	5.0	9.2	3.3	0.78
2001	5.5	11.7	-3.3	0.70
2002	6.6	12.5	-0.5	0.64
2003(proj)		10.5		
		Mozambique		
1997	11.2	14.8	6.9	1.00
1998	12.0	12.7	-1.1	1.15
1999	7.5	13.5	6.1	1.12
2000	1.5	14.4	11.6	1.01
2001	13.0	15.2	22.0	0.91
2002	7.7	15.4	9.1	0.90

Sources: IFS and IMF Staff Reports.

Table 2. Bond Sterilization Episodes in Uganda, Tanzania and Mozambique
(In percent)

	Before	**Active OMO**	**After**
Tanzania			
91 day yield	7.3	13.9	4.6
Ex post real yield	-1.1	6.9	-0.5
Uganda			
91 day yield	7.1	13.8	6.7
Ex post real yield	-2.2	9.6	4.1
Mozambique			
91 day yield	12.6	22.9	n.a
Ex post real yield	1.8	10.4	n.a

Sources: IFS and IMF Staff Reports.

Notes: Active OMOs: Tanzania, July 1999—April 2000; Uganda, December 1999—July 2001; Mozambique, July 2000 onwards. “Before” refers to six months before the Active OMO period and “After” to the full period following Active OMOs.

Table 3. Recent Values for Reserve Money, Inflation, Domestic Debt, Share of Nontradables in Aggregate Consumption, Net Aid Transfers, and Foreign Currency Holdings in Uganda, Tanzania, and Mozambique

	Uganda	***Tanzania***	***Mozambique***
Reserve money 1/ (average, 1999-2001)	0.055	0.096	0.077
Inflation 2/ (range, 1998-2002)	0.05-0.10	0.05-0.10	0.10-0.15
Nontradables share in consumption (2001) 3/	0.51		
Net aid transfers 4/			
2000	0.09	0.06	0.144
2001	0.12	0.05	0.152
Foreign currency deposits 1/			
2000	0.049	0.045	0.13
2001	0.041	-	0.16

1/ Expressed as a percentage of private consumption.
2/ Nonfood inflation rate.
3/ Source: Adam and Bevan (2003). Half of food consumption is assumed to be nontradable.
4/ Expressed as a percentage of GDP.

Table 4. Transition Path in a Flexible Exchange Rate System When Aid Increases by 2 percent of GNP and all of the Additional Aid is Spent

τ = .25 and σ = .75							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.103 (-.016)	.101 (.086)	.10	.099	.099	.098	.098
r	.109	.105	.103	.102	.101	.101	.10
RER	.94	.93	.93	.93	.93	.93	.92
CA[1]	.004	.002	.001	.001	0	0	0
τ = .50 and σ = .75							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.098 (-.017)	.098 (.081)	.098	.098	.098	.098	.098
r	.104	.102	.101	.101	.10	.10	.10
RER	.94	.93	.93	.93	.93	.93	.92
CA	.004	.002	.001	.001	0	0	0
τ = .25 and σ = 2							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.102 (-.033)	.10 (.067)	.099	.098	.098	.098	.097
r	.105	.103	.102	.101	.101	.10	.10
RER	.93	.93	.93	.93	.93	.93	.92
CA	.002	.002	.001	.001	0	0	0
τ = .50 and σ = 2							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long run
π	.099 (-.037)	.098 (.061)	.098	.097	.097	.097	.097
r	.102	.101	.101	.101	.10	.10	.10
RER	.93	.93	.93	.93	.93	.93	.92
CA	.002	.001	.001	.001	0	0	0
	τ = .25 and σ = 3						
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.098 (-.052)	.097 (.043)	.096	.096	.096	.096	.095
r	.102	.101	.101	.101	.10	.10	.10
RER	.93	.93	.93	.93	.93	.93	.92
CA	.001	.001	0	0	0	0	0
τ = .50 and σ = 3							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.095 (-.064)	.095 (.028)	.094	.094	.094	.094	.094
r	.101	.10	.10	.10	.10	.10	.10
RER	.93	.93	.93	.93	.93	.93	.92
CA	.001	0	0	0	0	0	0

1/ Ratio of the current account balance to national income inclusive of aid.

Table 5. Transition Path in a Flexible Exchange Rate System When Aid Increases by 2 percent of GNP and 75 percent of the Additional Aid is Spent

τ = .25 and σ = .75							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.031 (-.20)	.032	.032	.032	.033	.033	.033
r	.093	.096	.098	.099	.099	.10	.10
RER	.91	.92	.92	.92	.92	.92	.92
CA	-.003	-.002	-.001	-.001	0	0	0
τ = .50 and σ = .75							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.031 (-.24)	.031	.031	.031	.031	.031	.031
r	.10	.10	.10	.10	.10	.10	.10
RER	.92	.92	.92	.92	.92	.92	.92
CA	0	0	0	0	0	0	0
τ = .25 and σ = 2							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	0 (-.37)	.013	.019	.022	.024	.025	.026
r	.078	.082	.087	.092	.095	.097	.10
RER	.84	.88	.90	.91	.92	.92	.92
CA	-.022	-.013	-.007	-.004	-.002	-.001	0
τ = .50 and σ = 2							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.014 (-.42)	.019	.021	.023	.023	.024	.024
r	.092	.093	.095	.097	.098	.099	.10
RER	.86	.88	.90	.91	.92	.92	.92
CA	-.018	-.011	-.006	-.004	-.002	-.001	0
τ = .25 and σ = 3							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	-.023 (-.45)	-.001	.011	.017	.020	.021	.023
r	.082	.079	.083	.088	.093	.096	.10
RER	.80	.85	.88	.90	.91	.92	.92
CA	-.035	-.020	-.011	-.006	-.003	-.002	0
τ = .50 and σ = 3							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	-.004 (-.50)	.008	.015	.018	.019	.020	.021
r	.095	.092	.093	.095	.097	.098	.10
RER	.81	.86	.88	.90	.91	.92	.92
CA	-.031	-.018	-.011	-.006	-.004	-.002	0

Table 6. Transition Path in a Crawling Peg when Aid Increases by 2 percent of GNP and all of the Additional Aid is Spent

	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
τ = .25 and σ = .75							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.104 (.029)	.102 (.132)	.10	.099	.099	.099	.098
r	.113	.107	.104	.102	.101	.101	.10
RER	.94	.94	.93	.93	.93	.93	.92
CA	.005	.003	.002	.001	.001	0	0
τ = .50 and σ = .75							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.103 (.029)	.101 (.131)	.10	.099	.099	.098	.098
r	.106	.103	.102	.101	.101	.101	.10
RER	.94	.94	.93	.93	.93	.93	.92
CA	.005	.003	.002	.001	.001	0	0
τ = .25 and σ = 2							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.101 (.031)	.10 (.131)	.099	.098	.098	.098	.097
r	.110	.106	.103	.102	.101	.101	.10
RER	.94	.94	.93	.93	.93	.93	.92
CA	.004	.003	.002	.001	.001	0	0
τ = .50 and σ = 2							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.101 (.031)	.099 (.130)	.099	.098	.097	.097	.097
r	.105	.103	.102	.101	.101	.10	.10
RER	.94	.94	.93	.93	.93	.93	.92
CA	.005	.003	.002	.001	.001	.001	0
	τ = .25 and σ = 3						
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.098 (.033)	.097 (.130)	.097	.096	.096	.096	.095
r	.107	.104	.103	.102	.101	.101	.10
RER	.94	.93	.93	.93	.93	.93	.92
CA	.004	.002	.002	.001	.001	0	0
τ = .50 and σ = 3							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.097 (.032)	.096 (.128)	.096	.095	.095	.095	.094
r	.104	.102	.102	.101	.101	.10	.10
RER	.94	.93	.93	.93	.93	.93	.92
CA	.004	.003	.002	.001	.001	.001	0

Table 7. Transition Path in a Crawling Peg when Aid Increases by 2 percent of GNP and 75 percent of the Additional Aid is Spent

τ = .25 and σ = .75							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.041 (.025)	.037 (.064)	.035	.034	.034	.033	.033
r	.120	.110	.106	.103	.102	.101	.10
RER	.95	.94	.93	.93	.93	.93	.92
CA	.007	.004	.002	.001	.001	0	0
τ = .50 and σ = .75							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.042 (.015)	.038 (.055)	.035	.033	.032	.032	.031
r	.115	.108	.105	.103	.102	.101	.10
RER	.97	.95	.94	.94	.93	.93	.92
CA	.012	.008	.005	.003	.002	.001	0
τ = .25 and σ = 2							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.029 (.035)	.028 (.063)	.027	.027	.026	.026	.026
r	.106	.103	.102	.101	.101	.10	.10
RER	.93	.93	.93	.93	.93	.93	.92
CA	.002	.001	.001	0	0	0	0
τ = .50 and σ = 2							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.032 (.022)	.029 (.052)	.027	.026	.025	.025	.024
r	.110	.106	.103	.102	.101	.101	.10
RER	.96	.95	.94	.93	.93	.93	.92
CA	.009	.006	.003	.002	.001	.001	0
	τ = .25 and σ = 3						
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.022 (.043)	.022 (.064)	.023	.023	.023	.023	.023
r	.098	.099	.099	.10	.10	.10	.10
RER	.92	.92	.92	.92	.92	.92	.92
CA	-.001	-.001	0	0	0	0	0
τ = .50 and σ = 3							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.027 (.027)	.025 (.052)	.023	.022	.022	.021	.021
r	.107	.104	.103	.102	.101	.101	.10
RER	.95	.94	.93	.93	.93	.93	.92
CA	.007	.004	.003	.002	.001	.001	0

Table 8. Transition Path in a Flexible Exchange Rate System When Nontradables Prices are Sticky, Aid Increases by 2 percent of GNP, and 75 percent of the Additional Aid is Spent

	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
τ = .25 and σ = .75							
π	-.006 (-.08)	.019	.028	.031	.032	.033	.033
r	.183	.125	.108	.103	.101	.10	.10
RER	.83	.89	.91	.92	.92	.92	.92
CA	-.006	-.002	-.001	0	0	0	0
Q_n	-.040	-.014	-.005	-.002	-.001	0	0
τ = .50 and σ = .75							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	-.044 (-.10)	.008	.024	.029	.030	.030	.031
r	.210	.131	.109	.103	.101	.10	.10
RER	.80	.88	.91	.92	.92	.92	.92
CA	.001	0	0	0	0	0	0
Q_n	-.069	-.023	-.007	-.002	-.001	0	0
τ = .25 and σ = 2							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	-.081 (-.14)	-.016	.009	.019	.023	.025	.026
r	.259	.140	.110	.101	.099	.099	.10
RER	.71	.82	.88	.90	.91	.92	.92
CA	-.025	-.013	-.007	-.004	-.002	-.001	0
Q_n	-.071	-.030	-.012	-.005	-.002	-.001	0
τ = .50 and σ = 2							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	-.127 (-.16)	-.025	.008	.018	.022	.023	.024
r	.30	.149	.112	.102	.099	.099	.10
RER	.69	.82	.87	.90	.91	.92	.92
CA	-.016	-.011	-.007	-.004	-.003	-.002	0
Q_n	-.106	-.040	-.014	-.005	-.002	-.001	0
τ = .25 and σ = 3							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	-.124 (-.17)	-.038	-.002	.012	.018	.021	.023
r	.305	.150	.111	.10	.098	.098	.10
RER	.66	.79	.86	.89	.91	.92	.92
CA	-.038	-.020	-.011	-.006	-.003	-.002	0
Q_n	-.082	-.038	-.016	-.007	-.003	-.002	0
τ = .50 and σ = 3							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	-.172 (-.18)	-.044	-.002	.012	.017	.019	.021
r	.344	.159	.113	.101	.099	.099	.10
RER	.63	.78	.85	.89	.90	.91	.92
CA	-.028	-.018	-.011	-.007	-.004	-.002	0
Q_n	-.117	-.046	-.017	-.007	-.003	-.001	0

Table 9. Transition Path in a Crawling Peg When Nontradables Prices are Sticky, Aid Increases by 2 percent of GNP, and 75 percent of the Additional Aid is Spent

τ = .25 and σ = .75							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.062	.046	.039	.036	.034	.034	.033
r	.091	.101	.103	.102	.102	.101	.10
RER	1	.96	.94	.94	.93	.93	.92
CA	.009	.005	.003	.002	.001	.001	0
Q_n	.022	.008	.004	.002	.001	0	0
τ = .50 and σ = .75							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.058	.042	.036	.034	.033	.032	.031
r	.099	.109	.109	.107	.105	.104	.10
RER	1	.96	.95	.94	.94	.93	.92
CA	.008	.006	.005	.003	.002	.002	0
Q_n	.023	.008	.003	.001	.001	0	0
τ = .25 and σ = 2							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.061	.040	.032	.028	.027	.027	.026
r	.064	.088	.096	.099	.10	.10	.10
RER	1	.95	.94	.93	.93	.93	.92
CA	.006	.003	.001	.001	0	0	0
Q_n	.028	.010	.004	.002	.001	0	0
τ = .50 and σ = 2							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.052	.036	.030	.027	.026	.025	.024
r	.088	.10	.102	.102	.102	.101	.10
RER	1	.96	.94	.94	.93	.93	.92
CA	.008	.006	.004	.003	.002	.001	0
Q_n	.023	.008	.003	.001	.001	0	0
	τ = .25 and σ = 3						
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.062	.037	.028	.025	.024	.023	.023
r	.047	.081	.093	.098	.099	.10	.10
RER	1	.95	.93	.93	.93	.92	.92
CA	.003	.001	0	0	0	0	0
Q_n	.034	.012	.004	.001	.001	0	0
τ = .50 and σ = 3							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.052	.033	.026	.024	.022	.022	.021
r	.079	.096	.10	.101	.101	.101	.10
RER	1	.96	.94	.93	.93	.93	.92
CA	.006	.005	.003	.002	.001	.001	0
Q_n	.027	.009	.003	.001	.001	0	0

Table 10. Transition Path in a Crawling Peg When Aid Increases by 2 percent of GNP, 75 percent of the Additional Aid is Spent, and the Central Bank Engages in Temporary Sterilization 1/

	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
τ = .25 and σ = .75							
π	.065	.050	.041	.037	.034	.033	.033
r	.255	.152	.121	.109	.104	.101	.10
RER	1	.95	.93	.92	.91	.91	.92
CA	.020	.008	.002	-.001	-.003	-.003	0
τ = .50 and σ = .75							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.054	.045	.039	.035	.033	.032	.031
r	.145	.120	.110	.106	.103	.101	.10
RER	1	.96	.94	.93	.92	.92	.92
CA	.020	.010	.005	.002	0	-.001	0
τ = .25 and σ = 2							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.063	.045	.035	.030	.028	.026	.026
r	.312	.162	.123	.109	.103	.10	.10
RER	1	.95	.92	.91	.91	.91	.92
CA	.020	.006	0	-.003	-.005	-.005	0
τ = .35 and σ = 2							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.057	.043	.034	.030	.027	.026	.025
r	.207	.138	.117	.107	.103	.101	.10
RER	1	.95	.93	.92	.91	.91	.92
CA	.020	.008	.001	-.002	-.003	-.004	0
τ = .50 and σ = 2							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.050	.039	.033	.029	.026	.025	.024
r	.154	.123	.111	.105	.103	.101	.10
RER	1	.96	.94	.93	.92	.92	.92
CA	.020	.009	.003	0	-.002	-.002	0
τ = .25 and σ = 3							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.063	.043	.033	.027	.024	.023	.023
r	.360	.169	.124	.109	.102	.10	.10
RER	1	.94	.92	.91	.90	.90	.92
CA	.020	.005	-.002	-.005	-.006	-.006	0
τ = .35 and σ = 3							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.057	.041	.032	.027	.024	.022	.022
r	.226	.142	.117	.107	.103	.10	.10
RER	1	.95	.92	.91	.91	.91	.92
CA	.020	.007	0	-.003	-.005	-.005	0
τ = .50 and σ = 3							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.049	.037	.030	.026	.023	.022	.021
r	.162	.125	.111	.105	.103	.101	.10
RER	1	.96	.93	.92	.91	.91	.92
CA	.020	.009	.002	-.001	-.003	-.003	0

1/ 80 percent of the debt sold at t = 0 is paid off over 10 years (α = .161).

Table 11. Initial Bond Sales and the Path of Capital Flows When the Central Bank Engages in Temporary Sterilization

Path of F (F_o = .12) 1/					
τ	t = 0	t = 1	t = 2	Long Run	σ
.25	.078 (.103)	.094 (.108)	.104 (.110)	.114	.75
.50	.086 (.102)	.099 (.109)	.108 (.113)	.120	
.25	.044 (.073)	.058 (.075)	.067 (.076)	.077	2
.35	.047 (.072)	.060 (.074)	.069 (.076)	.078	
.50	.052 (.070)	.063 (.074)	.071 (.077)	.081	
.25	.024 (.052)	.035 (.052)	.043 (.052)	.051	3
.35	.027 (.050)	.037 (.051)	.044 (.051)	.052	
.50	.031 (.047)	.040 (.050)	.046 (.051)	.054	

Value of b after bond sales at t = 0 (b_o = .09)			
τ	σ = .75	σ = 2	σ = 3
.25	.130	.146	.155
.35	-	.140	.148
.50	.119	.131	.138

Offset Coefficient 2/			
τ	σ = .75	σ = 2	σ = 3
.25	.60	.52	.43
.35	-	.50	.40
.50	.55	.44	.33

1/ The number in parentheses is the value of F when there is no temporary sterilization.
2/ The offset coefficient is calculated as $[F(0)_{ns} – F(0)]/[b(0) – b_o]$, where F(0) and $F(0)_{ns}$ are the post-jump values of foreign currency holdings at t = 0 with and without sterilization.

Table 12. Transition Path in a Dirty Float when Aid Increases by 2 percent of GNP and 75 percent of the Additional Aid is Spent 1/

τ = .25 and σ = .75 (Ω = .15)							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.023	.029	.031	.032	.032	.032	.033
r	.118	.108	.104	.102	.101	.10	.10
RER	.94	.93	.93	.93	.93	.93	.92
CA	.005	.003	.001	.001	0	0	0
Z	.069 (.067)	.067	.065	.065	.065	.064	.064 (.081)
τ = .50 and σ = .75 (Ω = .10)							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.003	.019	.025	.028	.029	.030	.031
r	.128	.111	.105	.102	.101	.101	.10
RER	.97	.95	.94	.93	.93	.93	.92
CA	.012	.006	.003	.002	.001	.001	0
Z	.081 (.068)	.075	.072	.071	.070	.070	.069 (.095)
τ = .25 and σ = 2 (Ω = 1)							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.028	.027	.026	.026	.026	.026	.026
r	.099	.099	.10	.10	.10	.10	.10
RER	.92	.92	.92	.92	.92	.92	.92
CA	0	0	0	0	0	0	0
Z	.090 (.097)	.092	.092	.092	.093	.093	.093 (.102)
τ = .50 and σ = 2 (Ω = .25)							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.010	.018	.021	.023	.023	.024	.024
r	.118	.107	.103	.102	.101	.10	.10
RER	.96	.94	.93	.93	.93	.93	.92
CA	.008	.004	.002	.001	.001	0	0
Z	.115 (.10)	.109	.105	.104	.103	.102	.102 (.120)
τ = .25 and σ = 3 (Ω = 1)							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.033	.028	.025	.024	.023	.023	.023
r	.093	.096	.098	.099	.10	.10	.10
RER	.91	.92	.92	.92	.92	.92	.92
CA	-.004	-.002	-.001	0	0	0	0
Z	.093 (.118)	.104	.109	.112	.113	.113	.113 (.116)
τ = .50 and σ = 3 (Ω = .25)							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.014	.018	.020	.020	.020	.021	.021
r	.111	.104	.102	.101	.10	.10	.10
RER	.94	.93	.93	.93	.93	.93	.92
CA	.005	.003	.001	.001	0	0	0
Z	.133 (.123)	.129	.127	.126	.125	.125	.125 (.138)

1/ The row for Z shows the path of reserves. Z equals .05 initially. The number in parentheses is level of reserves in a crawling peg.

Table 13. Transition Path in a Dirty Float when Ω = 0, Aid Increases by 2 percent of GNP, and 75 percent of the Additional Aid is Spent

	τ = .25 and σ = .75						
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.034	.034	.033	.033	.033	.033	.033
r	.115	.107	.104	.102	.101	.101	.10
RER	.94	.94	.93	.93	.93	.93	.92
CA	.005	.003	.002	.001	0	0	0
Z	.066 (.067)	.066	.066	.066	.066	.066	.066 (.081)
τ = .50 and σ = .75							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.021	.027	.029	.030	.030	.030	.031
r	.120	.104	.105	.103	.101	.101	.10
RER	.97	.95	.94	.93	.93	.93	.92
CA	.012	.007	.004	.002	.001	.001	0
Z	.072 (.068)	.072	.072	.072	.072	.072	.072 (.095)
τ = .25 and σ = 2							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.026	.026	.026	.026	.026	.026	.026
r	.099	.099	.10	.10	.10	.10	.10
RER	.92	.92	.92	.92	.92	.92	.92
CA	0	0	0	0	0	0	0
Z	.092 (.097)	.092	.092	.092	.092	.092	.092 (.102)
τ = .50 and σ = 2							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.024	.024	.024	.024	.024	.024	.024
r	.110	.106	.103	.102	.101	.101	.10
RER	.95	.94	.93	.93	.93	.93	.92
CA	.007	.004	.003	.002	.001	.001	0
Z	.104 (.10)	.104	.104	.104	.104	.104	.104 (.120)
	τ = .25 and σ = 3						
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.019	.021	.022	.022	.022	.023	.023
r	.091	.095	.097	.098	.099	.099	.10
RER	.91	.92	.92	.92	.92	.92	.92
CA	-.004	-.002	-.001	-.001	0	0	0
Z	.111 (.118)	.111	.111	.111	.111	.111	.111 (.116)
τ = .50 and σ = 3							
	t = 0	t = 1	t = 2	t = 3	t = 4	t = 5	Long Run
π	.021	.021	.021	.021	.021	.021	.021
r	.107	.104	.102	.101	.101	.10	.10
RER	.94	.93	.93	.93	.93	.93	.92
CA	.005	.003	.002	.001	.001	0	0
Z	.126 (.123)	.126	.126	.126	.126	.126	.126 (.138)

Aid Inflows and Budget Support, 39 Low-Income Countries

Summary Statistics, 1990-2000

	Variable[1]	Obs	Mean	S.D.
Deficit before grants	*BD*	372	10.41	10.34
Foreign financing	*FF*	372	8.74	9.44
Domestic financing	*DF*	372	1.66	4.94
[Deficit after grants]	--	372	6.30	7.91

Year-to-year changes, 1991-2000

Fixed effects bivariate regressions of dependent variable on *FF*[2]				Sample distribution of $\Delta DepVar/\Delta FF$[3]		
Dependent Variable	obs	Coeff on *FF*	Std Err	p25	p50	p75
All 39 countries, 1991-2000						
BD	334	0.809	0.047	0.10	0.77	1.34
DF	334	−0.191	0.047	-0.90	-0.23	0.36
sub-Saharan Africa (25 countries), 1991-2000						
BD	229	0.765	0.044	-0.04	0.78	1.29
DF	229	−0.235	0.044	-1.04	-0.22	0.29
sub-Saharan Africa, 1991-1995						
BD	125	0.788	0.043	-0.28	0.71	1.19
DF	125	−0.212	0.043	-1.28	-0.29	0.19
sub-Saharan Africa, 1995-2000						
BD	126	0.681	0.059	-0.16	0.83	1.32
DF	126	−0.319	0.120	-1.16	-0.16	0.32

Data from Gupta, et al (2002).

Notes:

1. $BD = FF + DF$, where *FF* is foreign grants plus net loan disbursements.
2. These regressions take the form $y(it) = a(i) + b \cdot FF(it)$, for all countries i and periods t in the relevant sample, for y = *BD* or *DF*. The table reports the slope coefficients b and their estimated standard errors. Individual-country intercepts are estimated but not reported.
3. $\Delta z(t) = z(t) - z(t\text{-}1)$ for any variable z, so $\Delta BD(it) = \Delta DF(it) + \Delta FF(it)$.

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