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IS THERE A CASE FOR STERILIZING FOREIGN AID INFLOWS?

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Is There a Case for Sterilizing Foreign Aid Inflows?

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Abstract

This paper presents evidence that aid inflows can cause a significant but small real exchange rate appreciation and develops a theoretical model to identify the conditions under which a policy that prevents the real appreciation by sterilizing the base money effect of aid improves welfare. The empirical results are based on a real exchange rate measure that uses black-market nominal exchange rates in place of official rates for all countries with dual exchange rate systems. We also use a country-specific export-weighted commodity price index to control for terms of trade shocks and country-specific trends to capture the possible effect of productivity growth. A doubling of ODA flows is estimated to cause a real appreciation of up to 4 percent at impact which could increase to about 18 percent after 5 years. Sterilization policy is found to be quite effective in preventing real appreciation. In the theoretical open economy model, we assume that aid cannot be saved directly, the capital account is closed, and there is a learning-by-doing externality in the tradable sector. In this framework, monetary policy has permanent effects on real variables and sterilization can increase national savings by leading to an accumulation of international reserves. Sterilization increases welfare whenever aid is too front-loaded (i.e., its Dutch disease costs are greater than its consumption and productivity benefits) and the economy is better off saving part of the aid for later use. Sterilization can, instead, reduce welfare when the consumption and productivity benefits of aid are large relative to its Dutch disease costs. The case for sterilization is also weaker when aid is in the form of grants rather than loans or sterilization crowds out private investment.

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I. INTRODUCTION

In recent years, several U.N. reports and declarations have called for a dramatic increase in official development assistance (ODA) to achieve the Millennium Development Goals by 2015.[2] The declared objective—reiterated at a meeting in Monterrey in March 2002—is to raise ODA to 0.7 percent of industrial countries' GDP from a level that is currently only about one third of that target[3]. While it is unclear whether such massive increase will ultimately take place, there is no doubt that aid flows already constitute a very large share of many recipient countries' GDP, thus posing several challenges to macroeconomic management. This paper addresses the question of whether aid inflows can cause a real exchange rate appreciation and whether monetary policy—in the form of sterilization of the base money effect of aid inflows—could and should be used to prevent it.

The association between aid inflows and real exchange rate appreciation is a source of concern because of its potential negative implications for growth.[4] This phenomenon is known as "Dutch disease".[5] The mechanism of the Dutch disease is well-known (see van Wijnbergen (1984) for an early contribution): part of the international transfer (natural resource revenue or foreign aid) is spent on non-tradable goods and leads to a real appreciation. The rise in the price of non-traded goods relative to traded goods draws resources out of the traded-goods sector into the non-traded goods sector. While this reallocation is not inefficient per se, the shrinking of the tradable sector may have negative

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[2] The Millennium Development Goals (MDGs), which emerged from the September 2000 Millennium Declaration by the world's leaders gathered at the United Nations, are a set of specific, time-limited, and measurable targets for halving world poverty between 1990 and 2015.

[3] See Heller and Gupta (2002).

[4] The economic literature has considered also other possible negative effects of aid flows on institutions, corruption, and the recipient's internal political process. Burnside and Dollar (2000) show that the effectiveness of aid depends on policies. Svensson (2000) and Torvik (2002) show that aid may increase rent-seeking. Tornell and Lane (1998,1999) show that powerful groups may appropriate windfall earnings, leading to a 'voracity' effect. Alesina and Weder (2002) show that corrupt government do not receive less aid. These consequences are, however, not the focus of this paper.

[5] Specifically, the term 'Dutch disease' refers to the adverse effects on the (manufacturing) traded sector of natural resource discoveries, or of foreign aid. Its origin is the overvaluation of the Dutch real exchange rate that followed the discovery of natural gas deposits in the North Sea, within the borders of the Netherlands, in the 1950s and 1960s.

implications for growth if the source of productivity growth—e.g., learning-by-doing externalities—is located in the traded-sector.[6]

The theoretical literature on the "Dutch disease" is quite substantial but very few papers have tried to assess the empirical significance of this phenomenon. Specifically, there is little evidence of the association between aid flows and real appreciation, which is an essential element of the theory.[7] This lack of evidence may reflect the difficulty in obtaining accurate nominal exchange rate measures in countries that are often characterized by a dual exchange rate system.[8] In this paper, we use the series of black-market exchange rates recently collected by Reinhart and Rogoff (2002) to compute a measure of real exchange rate appreciation that takes into account – when needed - the significant relative price adjustments reflected in black-market rates.

We find that aid flows are associated with a significant but small appreciation of the real exchange rate, creating a potential for some Dutch disease effects. This evidence is important because recent empirical research has shown that real overvaluation is one of the few macro variables that, after taking into account the effect of institutions on growth, can contribute to explain poor growth performance (Easterly and Levine (2002) and Acemoglu and Johnson (2002)).

We also find that sterilization significantly reduces the impact of aid flows on the real exchange rate, suggesting that it could be used to limit Dutch disease effects. Sterilization is defined as the use of open market operations to counteract the effects of exchange market operations on a country's monetary base[9]. To our knowledge, ours is the first empirical evidence of the effectiveness of sterilization in aid-receiving countries. Most of the empirical literature on sterilized intervention has, in fact, focused on industrial countries with an open capital account (see the recent contribution of Payne and Vitale (2002) for Switzerland and

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[6] Van Wijnbergen (1984), Krugman (1987), Sachs and Warner (1995), Gylfason et al. (1997) develop models along these lines. Torvik (2001) shows that the impact on growth may be ambiguous if there is learning by doing also in the non-tradable goods sector.

[7] Elbadawi (1999) and Sekkat and Varoudakis (2000) provide some rare evidence supporting this link.

[8] See Devarajan (1997) for a discussion of this issue.

[9] Sterilization may also be realized through an increase in the reserve requirements or by shifting government deposits from the banking sector to the central bank when such funds are available. More generally, when the government keeps its deposits at the central bank, a tightening of fiscal policy would also result in a sterilization of foreign exchange inflows. These policies are more likely to be used in countries with underdeveloped financial systems.

the earlier results of Dominguez (1999) and Dominguez and Frankel (1993) for the United States and Germany).[10]

Evidence of real appreciation and of sterilization effectiveness is not sufficient, however, to justify the use of the latter as a policy tool in aid-receiving countries. Aid increases consumption and may also increase the economy's productivity. From a welfare point of view, these effects may well offset in full or in part the negative effects of real appreciation on growth especially when aid is disbursed for humanitarian purposes. If sterilization policy reduces the positive effects of aid on consumption and productivity, its welfare implications are no longer straightforward. To conduct a meaningful welfare analysis, we develop a theoretical model that departs from traditional Dutch disease models in two important respects.

First, we allow for the possibility that foreign aid does not only increase consumption but also the country's productivity in the medium term.[11] By trading off the consumption and productivity-enhancing effects of aid against the costs of Dutch disease we can characterize the optimal distribution *of a given net present value of aid* over time and the associated optimal time paths of the real exchange rate and the current account.[12] Consumption benefits of aid concur to determine the optimal distribution of aid over time. Consumption levels close to subsistence would, for example, imply that humanitarian aid should be front-loaded. The contribution of aid to overall productivity is consistent with the significant share of ODA that is used to finance infrastructure, sanitation, education, and health projects. The extent of this contribution is likely to be country-specific and to depend on several factors, including capacity constraints and corruption.

Second, as most Dutch disease models are *real* models, we add a monetary sector to analyze the effects of sterilization policy. We assume a closed capital account and flexible prices and follow a modelling approach by which monetary policy affects real variables, as in Edwards (1988) and Calvo et al. (1995). In our model, monetary policy effectiveness is due

[10] The theoretical case for the effectiveness of sterilized intervention in countries with an open capital account is based on a portfolio-balance effect or a signaling channel (Mussa (1981), Bhattacharya and Weller (1997), and Vitale (1999)).

[11] See Arellano et al. (2002) for another paper in which foreign aid affects investment.

[12] We allow for productivity-enhancing effects of aid because of the substantial share of non-humanitarian aid in total aid and because we are interested in discussing the welfare implications of both loans and grants (section VIII). The welfare effects of an increase in consumption financed through outright *grants* would be sufficient to generate a meaningful trade-off with the Dutch disease costs of aid. But if aid were in the form of (subsidized) *loans*, only its consumption smoothing effect could be traded off against the Dutch disease costs.

to incomplete markets. Specifically, we assume--as it is the case in practice--that aid-receiving governments and private sector agents are forced to spend all aid when it is disbursed, without any possibility of saving part of it. By selling bonds, the central bank relaxes this saving constraint and increases national savings. The resulting increase in the current account surplus and international reserves reduces the real exchange rate appreciation caused by aid inflows and, effectively, allows the aid-receiving country to redistribute aid over time towards its optimal path.

In the model of this paper, monetary policy is then non-neutral even though prices are fully flexible[13]. An important difference from the earlier literature is that these otherwise *temporary* real effects of monetary policy become *permanent* thanks to the presence of learning-by-doing externalities in the tradable sector. The learning-by-doing externality depends on the size of the tradable goods sector which, in turn, is a function of the real exchange rate. Temporary effects of sterilization policy on the real exchange rate translate into permanent effects on growth (and the long-term real exchange rate) through changes in the size of the learning-by-doing externality.

As long as donors do not deliver aid according to the optimal time path, there is then scope for policy intervention aimed at bringing the economy on the optimal path. The high volatility of aid flows and the highly-decentralized decisions of donors suggest that the relevant practical case is, indeed, one in which aid is disbursed suboptimally over time.

The paper is organized as follows. Section II discusses analogies and differences between aid flows and capital flows. Section III presents the empirical evidence on the association between aid flows and real appreciation and on the effectiveness of sterilization. Section IV discusses the key assumptions and the structure of the model. Section V analyzes the static equilibrium conditions and derives the comparative statics. Section VI determines the optimal timing of foreign aid flows. Section VII demonstrates the effectiveness of monetary policy. Section VIII shows that the case for sterilization is weaker when aid is provided in the form of grants rather than loans and when sterilization crowds out private investment. This section also discusses the optimal composition of aid flows, showing that consumption aid should increase when the productivity-enhancing effect of aid decreases. We also show that terms of trade shocks affect the optimal timing of aid disbursements: to minimize the Dutch disease costs in the presence of strong learning-by-doing effects, aid should be disbursed when the export sectors characterized by the learning-by-doing externality are benefiting from a positive terms of trade shock. Section IX concludes.

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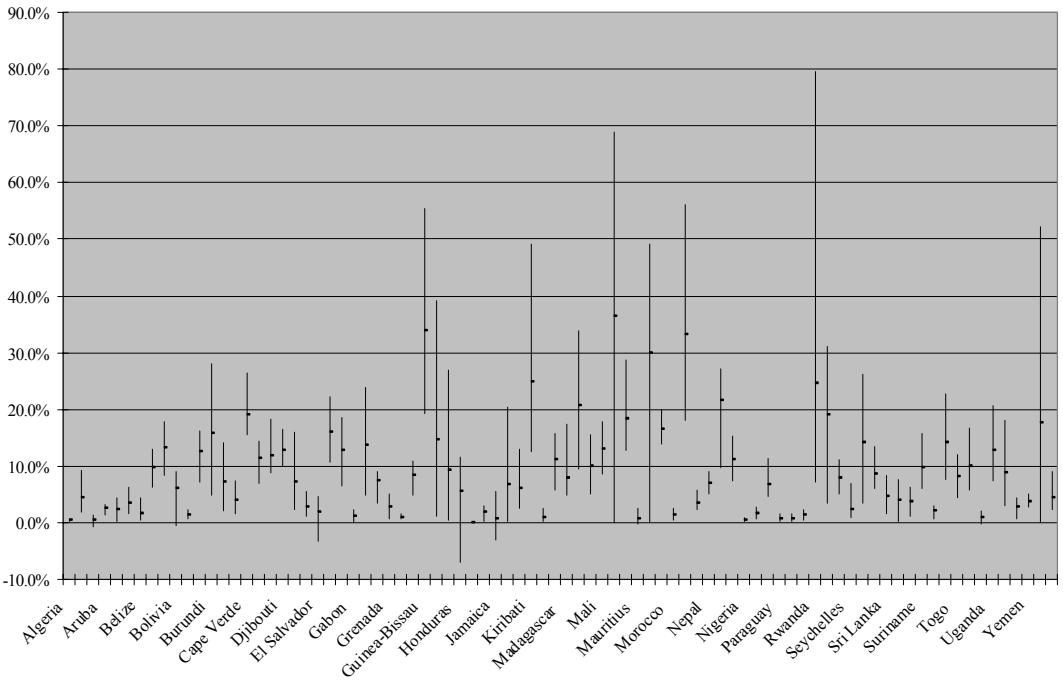
[13] Note that sticky prices would make sterilization policy even more effective and all our results would be confirmed. We assume flexible prices in view of the evidence—presented in Reinhart and Rogoff (2003)—that several aid-receiving African countries have experienced long and repeated periods of *deflation*.

II. AID FLOWS AND CAPITAL FLOWS: ANALOGIES AND DIFFERENCES

The literature on capital inflows has studied extensively the pros and cons of sterilization.[14] Less attention has received the sterilization of foreign exchange inflows associated with large aid flows in countries with relatively closed capital accounts. The question of whether, and how, these flows should be sterilized is, however, central to these countries' monetary policy strategy and critical for their macroeconomic management.

Figure 1: ODA flows in percent of GDP during the 1990s
(average, minimum, maximum)



While there are several analogies between the monetary implications of capital and aid inflows,[15] there are important differences that justify a separate study of the latter. First, in relation to recipient countries' GDP, aid flows can be substantially larger and more volatile than capital inflows. Figure 1 and Table 1 show that, in the 1990s, the average ratio of ODA to GDP was in the 10 to 30 percent range for several aid-receiving countries. By comparison, the annual average of net capital inflows was 7.4 percent of GDP in Mexico

[14] See, for instance, Calvo, Leiderman, and Reinhart (1993).

[15] In both cases, for example, there is a need to consider the implications of sterilization costs for debt sustainability. See Calvo (1991) for a discussion of the issue of sterilization costs.

(1991-93), 12.1 percent in the Czech Republic (1993-95), 14.5 percent in Hungary (1993-95), and 10.3 percent in Thailand (1990-96), to mention a few episodes often cited as examples of large capital inflows.

The *volatility* of aid flows was also very high in the 1990s with several aid-receiving countries experiencing average annual absolute changes greater than 10 percent of GDP and sudden reversals.[16] In some countries, aid flows fell by as much as 30-40 percent of GDP in a single year. These contractions can exceed the capital flow reversals that emerging markets usually experience during crises. Net capital inflows fell, for example, by 13.5 percent of GDP in Mexico between 1993 and 1995 and by 24.4 percent of GDP in Thailand between 1996 and 1998. The size and volatility of aid flows implies that the challenges for macroeconomic management faced by aid-receiving countries are probably at least as large as the challenges faced by emerging markets with volatile capital flows.

Second, countries benefiting from large aid inflows have de facto no access to international capital markets because of their high levels of official indebtedness. Moreover, only a handful of these countries had no capital account restrictions in 2002 (Table 2). This implies that, in aid-receiving countries, sterilization policy is likely to be more effective. A contraction in the central bank's net domestic assets can increase interest rates and reduce base money growth without the risk of stimulating capital inflows that would ultimately offset the initial reduction in base money.

Third, the literature on capital inflows has mostly focused on the implications of international flows for stabilization programs. In this context, the rationale for conducting sterilization operations is to prevent a surge in capital inflows from endangering a disinflation program[17] or creating a lending boom that may then put the stability of the financial sector at risk. This literature has also argued that the rationale for sterilization was weaker in the case of transition economies where capital inflows were more likely to be driven by structural reforms associated with booms in economic activity and increases in money demand.[18] By contrast, in aid-receiving countries, the main rationale for sterilizing aid inflows is to limit the negative implications for growth of the associated real exchange rate appreciation.

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[16] Bulir and Hamann (2002) discuss the fiscal implications of the volatility and (un)predictability of foreign aid.

[17] Calvo and Vegh (1993).

[18] Calvo, Sahay, and Vegh (1996).

III. EMPIRICAL EVIDENCE: FOREIGN AID INFLOWS AND THE REAL EXCHANGE RATE

The dataset used in our empirical investigation is an annual panel including all observations with non-missing data on aid flows, black market rates, commodity prices, and the central bank's net domestic assets for aid-receiving countries over the period 1960-1998. The starting date varies across countries but can be as early as 1961. The end-date is 1998 for all countries. ODA disbursements (excluding technical cooperation) are obtained from the OECD database. Black-market nominal exchange rates are from Reinhart and Rogoff's (2002) and are available up to 1998. We compute *real* black-market effective exchange rates using the trade weights and the methodology of the IMF Effective Exchange Rate Facility. The CPI is from the IFS. The commodity price index is computed following the methodology of Cashin et al. (2002) and extended back to 1960.

Tables 3 presents the results of our regression analysis. The dependent variable is the percentage change in the black-market real exchange rate. We first estimate the following specification:

$$\Delta \log e_{i,t} = \gamma \cdot \left(\log e_{j \in I,t-1} - \beta_{j \in I} \cdot \log Com_{j \in I,t-1} \right) + \theta^{Ec} \cdot Comshare_i \cdot \Delta \log Com_{i,t}$$
$$+ \delta^{NHyp,Ec}_{ODA \geq 2\%} . \log ODA_{i,t-1} + \delta^{NHyp,Ec}_{ODA<2\%} . \log ODA_{i,t-1} + \delta^{NHyp,NEc}_{ODA \geq 2\%} . \log ODA_{i,t-1} + \delta^{NHyp,NEc}_{ODA<2\%} . \log ODA_{i,t-1}$$
$$+ \alpha \cdot \Delta \log e_{i,t-1} + Hyp_{i,t} + f_i + d_t + \varepsilon_{it}$$

where e_{it} is the real exchange rate, Com_{it} is a country-specific export-weighted commodity price index, γ is the error correction coefficient estimated only for the subset I of countries for which e_{it} and Com_{it} are cointegrated, $ComShare_i$ is the share of commodity exports in total exports and ODA_{it} is ODA relative to GDP, Hyp_{it} is a dummy variable for hyperinflation episodes, f_i is a country fixed effect, d_t is a set of year dummies, and ε_{it} is the standard residual.

Since ODA flows can be expected to have a non-linear effect on the real exchange rate, we allow for a different coefficient of ODA whenever it is above or below a certain threshold. The results that we report are obtained with a threshold of 2% (subscript *ODA>2%*).[19] We also estimate separate coefficients for the subgroup of countries whose real exchange rate is cointegrated with commodity prices (superscript *Ec*) to be able to compute the associated long-run elasticity and we estimate the effect of aid only on non-hyperinflation periods (superscript *NHyp*).

[19] Our results are unchanged with a threshold of 3%.

The estimated specification corresponds to an error-correction model allowing for cointegration between the real exchange rate and the commodity price index (see Cashin et al. (2002))[20] for a subset *I* of countries. For each aid receiving country, we test for the presence of a cointegration vector between the real exchange rate and the commodity price[21] index using Johansen methodology. Next, for each country in which a cointegration relationship is identified between the two I(1) variables, we estimate the coefficient β by running an OLS regression of the real exchange rate on the commodity price index.[22, 23] The coefficient θ^{Ec} is correspondingly estimated in a preliminary stage only for the countries for which the real exchange rate and commodity prices are cointegrated.

We consider ODA flows a stationary variable on economic grounds, as it cannot be expected to take unbounded values. As a consequence, ODA could be equivalently included either in the cointegration vector or as a simple regressor. We choose the latter option. For the subset of countries with commodity currencies (i.e., countries whose real exchange rate is cointegrated with the commodity price index), there is a long-run effect of ODA that differs from its short-run effect and that can be obtained by dividing the short-run coefficients (δ^{Ec}) by the absolute value of the error correction coefficient (γ). For the subset of countries whose real exchange rate is not cointegrated with the commodity price index, the short-run and long-run effects of ODA are the same and given by the coefficients δ^{NEc}. In this case, the real exchange rate follows a random walk with a drift that shifts when ODA changes.

The fixed effects capture country-specific trends in the real exchange rate possibly due to productivity growth. ODA flows are lagged one period to control partially for simultaneity bias. Other possible sources of endogeneity of the aid variable—such as an omitted variable (i.e., an unobserved event correlated with both ODA and the real exchange rate appreciation.)--are addressed using the GMM estimation technique. The commodity price is also constructed so as to avoid any endogeneity problem. In a dynamic panel dataset, the presence of the lagged dependent variable introduces a bias in the estimated coefficients (see Hsiao (1986)). In order to control for this bias and the possible endogeneity of the aid variable, we report not only standard fixed effects estimates but also the results obtained by implementing the Arellano and Bond (1991) difference GMM estimator.

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[20] Allowing for country-specific α and β coefficients does not improve the estimates significantly nor changes the results.

[21] Dickey-Fuller and Phillips-Perron tests show that the real exchange rate and the commodity price index are *I(1)* in most countries.

[22] Note that in presence of cointegration, the OLS estimate of β is "super-consistent".

[23] Stationarity tests of ODA are ambiguous and yield mixed results depending on the country reflecting the high volatility and numerous breaks in the ODA series.

The results in column (1) of Table 3 confirm that ODA flows are associated with an appreciation of the real exchange rate and that the effect is larger when ODA is larger (especially for the subgroup of countries for which e_{it} and Com_{it} are cointegrated). The most reliable estimates are presented, however, in columns (2) and (2'), where we take into account an important potential omitted variable: sterilization policy. If the base money effect of aid flows is effectively sterilized, neglecting sterilization effects may lead to underestimating the impact of aid disbursements on the real exchange rate.

We construct a measure, $Steril_{i,t}$, of the degree to which the increase in net foreign assets associated with ODA flows is offset by a reduction in net domestic assets of the central bank. Specifically, the sterilization variable is equal to: *i)* zero, if the change in net domestic assets is greater than zero; *ii)* a fraction between zero and one (computed as minus the change in net domestic assets over the ODA flow), if the reduction in net domestic assets is smaller (in absolute value) than the ODA flow; *iii)* one, if the reduction in net domestic assets is greater (in absolute value) than the ODA flow. Note that a reduction in net domestic assets captures not only sterilization policies implemented through sales of government bonds but also sterilization through higher government deposits at the central bank resulting from a fiscal policy response to aid inflows. This is important because in many aid-receiving countries domestic bond markets are underdeveloped and sterilization is implemented through changes in fiscal policy. Specifically, we estimate:

$$\Delta \log e_{i,t} = \gamma \cdot \left(\log e_{j\in I,t-1} - \beta_{j\in I} \cdot \log Com_{j\in I,t-1}\right) + \theta^{Ec} \cdot Comshare_i \cdot \Delta \log Com_{i,t}$$
$$+ (\delta^{NHyp,Ec}_{ODA\geq 2\%} + \varphi^{NHyp,Ec}_{ODA\geq 2\%} \cdot Steril_{i,t-1}) \cdot \log ODA_{i,t-1} + (\delta^{NHyp,Ec}_{ODA<2\%} + \varphi^{NHyp,Ec}_{ODA<2\%} \cdot Steril_{i,t-1}).\log ODA_{i,t-1}$$
$$+ (\delta^{NHyp,NEc}_{ODA\geq 2\%} + \varphi^{NHyp,NEc}_{ODA\geq 2\%} \cdot Steril_{i,t-1}) \cdot \log ODA_{i,t-1} + (\delta^{NHyp,NEc}_{ODA<2\%} + \varphi^{NHyp,NEc}_{ODA<2\%} \cdot Steril_{i,t-1}) \cdot \log ODA_{i,t-1}$$
$$+ \alpha \cdot \Delta \log e_{i,t-1} + Hyp_{i,t} + f_i + d_t + \varepsilon_{it}$$

The hypothesis that we want to test is that the impact of aid inflows on the real exchange rate is smaller when the base money effect of ODA flows is sterilized (in full or in part) by a reduction in net domestic assets (see Section VI.) We then expect the estimated coefficient φ to be negative. The results in column (2) of Table 3 confirm this hypothesis by indicating that sterilization policy contributes significantly to reduce the real appreciation associated with ODA flows. Moreover, the direct effect of ODA is significant even when this variable is instrumented (column (2')) to address possible endogeneity problems.

While ODA flows have a significant effect on the real exchange rate, the effect is relatively small with a short-run elasticity at impact of at most 4 percent for the countries with ODA greater than 2 percent of GDP. A doubling of ODA would then cause the real exchage rate to increase only by 4 percent. However, for some countries (the countries whose real exchange rate is cointegrated with commodity prices), this initial effect is followed by a very gradual dynamic effect which can bring the total appreciation due to a doubling of ODA to 18 percent after 5 years, 30 percent after 10 years, and 55 percent in the long run.

IV. THE MODEL

We consider an economy that lasts for two periods. We consider a three goods small open economy (exportables, importables, and non-tradables), as in the literature that stresses the role of the terms of trade in the determination of the real exchange rate[24]. Domestic agents consume the non-tradable and the importable goods, and live for two periods. They hold real money balances (that enter directly in their utility function) and they can buy domestic bonds issued by the Central Bank. As in the standard monetary approach to the balance of payment, we focus on a fixed exchange rate regime in which sterilization policy (generally a reduction in domestic credit) allows to target the balance of payment. Since the capital account is assumed to be closed, this is equivalent to targeting the current account balance.

In this framework, sterilization operates in the following way. The Central Bank reduces its net domestic assets, and thus overall money supply, by selling government bonds. As a result, interest rates increase and agents reduce domestic consumption, the current account improves, and there is accumulation of reserves. This feeds back into the money supply and *partially* offsets the impact of the initial open-market operation.[25] Moreover, the price of non-tradable goods falls to maintain the equilibrium on the non-tradable goods market. The real exchange rate depreciates.[26] Finally, the intertemporal budget constraint implies that the first period current account surplus (deficit) is exactly offset by the second period current account deficit (surplus).

We augment this simple model with endogenous productivity growth between the two periods. First, we assume, as in the Dutch disease literature, that learning by doing takes place in the export sector[27]. Second, part of first period aid flows is invested in a public good that enhances productivity in both sectors in the second period.

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[24] See De Gregorio and Wolf (1994), Obstfeld and Rogoff (1996) among others. See also Cashin, Cespedes and Sahay (2002).

[25] The creation of base money through the improved current account (e.g. accumulation of foreign exchange reserves) offsets only partially the base money impact of sterilization because bonds holdings have increased (hence money demand has fallen).

[26] The real exchange rate is defined as the relative price of non-tradable and tradable goods. If the law of one price holds for tradable goods and the nominal exchange rate is fixed, movements in the real exchange rate are determined by changes in the price of non-tradable goods.

[27] To avoid changes in productivity differentials between the tradable and non-tradable sectors, we assume that there is a perfect spillover from the export to the non-tradable sector.

Consumers and Prices

The economy consists of a continuum of identical individuals who live for two periods. Agents consume the importable good (c_T) and the non-tradable good (c_N). They also value real money balances, as in the standard money-in-the-utility-function model (see Obstfeld and Rogoff (1999)). For simplicity the subjective discount rate is equal to 1.
The representative agent *i* maximizes:

$$V^i = U^i{}_1 + U^i{}_2 = \log C_1{}^i + \chi \log\left(\frac{M_1{}^i}{P_1}\right) + \log C_2{}^i$$

where M_1^i denotes nominal money balances held between period 1 and period 2 and C_t^i (t=1,2) is a consumption index, which corresponds to Cobb-Douglas preferences with respect to tradable and non-tradable goods:

$$C^i = \left(c_T{}^i\right)^{\gamma} \cdot \left(c_N{}^i\right)^{1-\gamma}$$

For the sake of simplicity, agents are assumed not to value money holdings at the end of period 2.

The consumer price index P is defined as the minimum cost of one unit of the consumption index C:

$$P = p_T{}^{\gamma} \cdot p_N{}^{1-\gamma}$$

where p_T is the price in local currency of one unit of the tradable good, and p_N is the price of one unit of the non-tradable good. The law of one price is assumed to hold for the imported good and the exportable good:

$$p_T = E \cdot p_T{}^* \text{ and } p_X = E \cdot p_X{}^*$$

where E is the nominal exchange rate (domestic currency per dollar); $p_T{}^*$ and $p_x{}^*$ are respectively the price of the imported good and the price of the exportable good in dollar. The real exchange rate e is:

$$e = \frac{p_N}{p_T}$$

Hence, the consumer price index (in period 1 and period 2) is a function of the nominal exchange rate, the real exchange rate and the international price of importable goods:

$$P_1 = E_1 \cdot e_1{}^{1-\gamma} \cdot p^1{}_T^* \qquad (1\text{-}1)$$

$$P_2 = E_2 \cdot e_2{}^{1-\gamma} \cdot p^2{}_T^* \qquad (1\text{-}2)$$

The terms of trade q is defined by:

$$q = \frac{p_X}{p_T}$$

Individual *i*'s budget constraints in periods 1 and 2 are respectively:

$$\begin{aligned} P_1 C_1^i + \left(M_1^i - M_0^i\right) + B^i &= I_1^i + E_1 \cdot A_1^i \\ P_2 C_2^i &= I_2^i + E_2 \cdot A_2^i + (1+r)B^i + T_2^i \end{aligned} \quad \text{(2-1) and (2-2)}$$

where B^i is domestic bond holdings between period 1 and period 2, r is the nominal interest rate on domestic bonds, I_1^i and I_2^i are respectively nominal income in period 1 and period 2, E_1 and E_2 the nominal exchange rate respectively in period 1 and period 2, T_2^i is a government transfer in period 2, and A_1^i and A_2^i are transfers from abroad (foreign aid), expressed in international currency, respectively in period 1 and period 2. The nominal exchange rates E_1 and E_2 are predetermined.

The Public Sector

In order to focus on monetary policy we consider a highly simplified public sector. In the first period, foreign aid is assumed to finance in part the production of a public good x_P [28]. We assume that the public good is produced with tradable goods in quantity x_T as well as non-tradable goods in quantity x_N. We assume that the public good is produced according to a Leontief production technology:

$$x_P = Min\left(\frac{p_N \cdot x_N}{1-\gamma}, \frac{p_T \cdot x_T}{\gamma}\right) \qquad (3)$$

Hence, the importable and the non-tradable goods are used as inputs in the same proportion as that implied by consumers' preferences: $\frac{p_N x_N}{1-\gamma} = \frac{p_T x_T}{\gamma}$. For simplicity, we assume that the public good is financed with the grant only[29]:

$$p_N^1 x_N + p_T^1 x_T = \widetilde{A} \qquad (4)$$

[28] For instance, expenditures on health, education and infrastructure.

[29] This possibly strong assumption captures the fact that in many low income countries, the public sector has a limited capacity to finance spending on education, infrastructure, health, etc.

where $\widetilde{A}$ is a grant received in period 1.

The central bank issues money that is backed by domestic bonds and international reserves. Let M_0 stand for the initial stock of money (exogenous) and M_1 the stock of money held between period one and period two.
The balance sheet of the monetary authority is the following:

$$M_1 = M_0 - B + E_1 R \qquad (5)$$

where B is the face value of domestic public debt held by domestic agents, and which is issued at a nominal interest rate r, and R is the value of international reserves (in dollars) accumulated by the central bank between period one and period two. For notational simplicity, we assume that international reserves are invested in foreign assets that yield zero interest between period one and period two.

The central bank balance sheet can be interpreted as follows. Domestic agents (exporters and aid recipients) accumulate international reserves (see the current account constraint (13)) and exchange them against domestic currency or domestic bonds. The central bank targets either the money supply or the nominal interest rate, and adjusts the supply of bonds B accordingly.

In period two, the government budget is balanced[30]:

$$T_2 = -(1+r)\cdot B + E_2 \cdot R \qquad (6)$$

Official Development Assistance

The total net present value $\overline{A}$ of aid flows over the two periods, expressed in dollars, is exogenous. A proportion α of total aid flows goes to the budget in period one to finance the production of the public good. The remainder is directly transferred to consumers:

$$\widetilde{A} = \alpha \overline{A} \qquad (7)$$
$$(1-\alpha)\overline{A} = A_1 + A_2 \qquad (8)$$

where A_1 and A_2 are respectively direct transfers to domestic agents in period one and period two. The time path and the composition of aid are exogenous.[31]

[30] We do not discuss the impact of distortionary taxes and the associated adverse effects of sterilization. See Calvo (1991).

Production

The exportable (y_X) and the non-tradable goods (y_N) are produced according to the following production functions in period one and period two:

$$y_X = a_X \cdot F_X(L_X) \qquad \text{(9-1) and (9-2)}$$

and:

$$y_N = a_N \cdot F_N(L_N) \qquad \text{(10-1) and (10-2)}$$

where L_i ($i=X,N$) are labor inputs in the exportable and non-tradable sectors, $L = L_X + L_N$ is the aggregate supply of labor, and the productivity parameters are a_X and a_N respectively in the exportable and non-tradable sectors. The production technologies have standard characteristics:

$$F_X' > 0, \quad F_X'' < 0 \text{ and: } F_N' > 0, \quad F_N'' < 0.$$

The model can be interpreted as the standard specific-factors model: labor is the only mobile factor across sectors and there are diminishing returns to labor in each sector. The main difference is the presence of learning-by-doing (LBD) in the exportable sector. The assumption is standard: LBD is external to firms and each firm is too small to take its contribution to LBD into account. We follow Sachs and Warner (1995) by assuming that LBD is generated only in the traded sector and there is a perfect learning spillover to the non-traded sector[32].

In addition, the public good is assumed to affect the level of productivity in each sector. More specifically:

---

[31] Endogenizing A_1 , A_2 and $\tilde{A}$ (for a given net present value of total aid flows $\bar{A}$) is beyond the scope of this paper. In the case of multilateral, aid flows could, for example, be determined by the objective function of the multilateral institution or could be shaped by agency and asymmetric information problems between the donor and the recipient. The case of bilateral aid is likely to be more complex, as it is not clear whether a donor takes into account other donors' development assistance programs when deciding about its own program, or simply pursues its own interest (Alesina and Dollar (2000) show that colonial history and political closeness are significant determinants of bilateral aid).

[32] Torvik (2002) develops a more general model of the Dutch disease in which LBD takes place in both the tradable and the non-tradable sectors.

$$\begin{cases} a_X = h_X\left(x_P(-1)\right)\cdot a_X(-1)\cdot\left(1+z\cdot L_X(-1)\right) \\ a_N = h_N\left(x_P(-1)\right)\cdot a_N(-1)\cdot\left(1+z\cdot L_X(-1)\right) \end{cases} \quad \text{(11) and (12)}$$

where (-1) denotes the previous period, z is a parameter and h is a function that embodies the effect of the public good x_P on productivity:

$$h_X' > 0,\ h_X'' < 0, \text{ and } h_N' > 0,\ h_N'' < 0.$$

Note that in the general case $h_X \neq h_N$: the impact of health, education and other productivity improving public expenditures can be sector specific. However, we will focus on the case in which the provision of the public good has the same effect on the non-tradable and the tradable good by assuming $h_X = h_N = h$.

The Current Account

The domestic consumption path is constrained by the inter-temporal budget constraint. We assume that the only foreign financial asset available to domestic agents or the public sector is the foreign currency[33]. In particular, we assume that the economy has no access to the international capital markets. A less stringent assumption would be to assume that the government can buy foreign bonds[34]. This would not modify our results in a significant way.

More specifically, the current account balance CA_t in each period t=1, 2 (which is mirrored by the accumulation, or decumulation, of reserves R at the central bank) is given by:

$$\begin{cases} CA_1 = R = \left(p_X{}^1\right)^*\cdot y_X{}^1 + \widetilde{A} + A_1 - \left(p_T^1\right)^*\cdot c_T^1 - \left(p_T^1\right)^* x_T^1 \\ CA_2 = -R = \left(p_X^2\right)^*\cdot y_X^2 + A_2 - \left(p_T^2\right)^* c_T^2 \end{cases} \quad \text{(13-1) and (13-2)}$$

where a star corresponds to prices in dollars.

The inter-temporal budget constraint implies that:

$$CA_1 + CA_2 = 0$$

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[33] Since only the domestic currency enters the utility function, agents do not use the foreign currency as a storage technology between the two periods.

[34] In practice, multilateral institutions do not allow recipient countries to save the development assistance that they receive.

V. EQUILIBRIUM CONDITIONS AND COMPARATIVE STATICS

The static analysis of this model is standard. The static equilibrium relation between the real exchange rate and the allocation of labor at each period is the outcome of the equilibrium conditions on the labor market and non-tradable goods markets. First, perfect mobility of labor implies that the marginal productivity of labor is the same in the tradable and non-tradable goods markets:

$$w^t = p_X{}^t \cdot a_X{}^t \cdot F_X{}'\left(L - L^t{}_N\right) = p_N{}^t \cdot a_N{}^t \cdot F_N'\left(L_N{}^t\right), \text{ t=1,2.}$$

Hence:

$$e^t = q^t \frac{a_X{}^t}{a_N{}^t} \cdot \frac{F_X{}'}{F_N{}'}, \text{ t=1,2. (14-1) and (14-2)}$$

Second, equilibrium on the non traded-goods market implies that:

$$\begin{cases} (1-\gamma)P_1C_1 + p_N^1 x_N{}^1 = p_N^1 y_N^1 \\ (1-\gamma)P_2C_2 = p_N^2 y_N^2 \end{cases}$$

Combining these conditions with the aggregate budget constraints, we obtain the two following equilibrium relations:

Period 1:

$$e^1 \cdot \left[\gamma \cdot a_N^1 F_N\left(L^1{}_N\right) - x_N^1\right] = (1-\gamma) \cdot \left[q^1 \cdot a_X^1 F_X\left(L - L_N^1\right) + \frac{\left(A_1{}' - R\right)}{\left(p_T^1\right)^*}\right] \qquad (15\text{-}1)$$

Period 2:

$$e^2 \cdot \gamma \cdot a_N^2 F_N\left(L^2{}_N\right) = (1-\gamma) \cdot \left[q^2 \cdot a_X^2 F_X\left(L - L_N^2\right) + \frac{\left(A_2{}' + R\right)}{\left(p_T^2\right)^*}\right] \qquad (15\text{-}2)$$

The demand for real money balances is standard:

$$\frac{M_1}{P_1} = \chi\left(1 + \frac{1}{r}\right)C_1 \qquad (16)$$

Note that by combining the aggregate private sector constraint with the money supply identity, we obtain the following economy-wide resource constraint:

$$P_1C_1 + E_1 \cdot R = I_1 + E_1 \cdot A_1 \qquad (17\text{-}1)$$

and:

$$P_2C_2 = I_2 + E_2 \cdot A_2 + E_2 \cdot R \qquad (17\text{-}2)$$

Therefore, in this economy with a closed capital account and no accumulated factor of production, national savings is mirrored by the accumulation of foreign exchange reserves at the central bank. Monetary policy affects the inter-temporal allocation of resources insofar as it has a (temporary) effect on the current account balance by reducing (or increasing) aggregate demand.

The choice of the nominal interest rate by the central bank affects private savings decisions according to the inter-temporal consumption smoothing decision:

$$1 + r = \frac{P_2C_2}{P_1C_1} \qquad (18)$$

Summary:

We have 14 unknown variables: the real exchange rates e_1 and e_2, the equilibrium allocation of labor between non tradable and tradable production L_N^1 and L_N^2, the CPI levels P_1 and P_2, the aggregate consumption indices C_1 and C_2, the nominal interest rate r, the money supply M_1, the face value of sterilization bonds B, the reserves accumulated during period 1 R and the allocation of budget aid $\widetilde{A}$ between non-tradable x_N and tradable goods x_T.

We have 12 equations: the equilibrium on the non-traded good market (15-1) and (15-2), demand for labor in traded and non-traded sectors (14-1) and (14-2), definition of the consumer price index (1-1) and (1-2), aggregate resource constraints (17-1) and (17-2), demand for domestic bonds (18), the demand for real money balances (16), the money supply identity (5), the balanced budget equation (4) and the production technology of the public good.

Hence, in the closed economy, the government can use monetary policy (the supply of sterilization bonds *B*, or the nominal interest rate *r*) to affect macroeconomic outcomes.

Comparative Statics

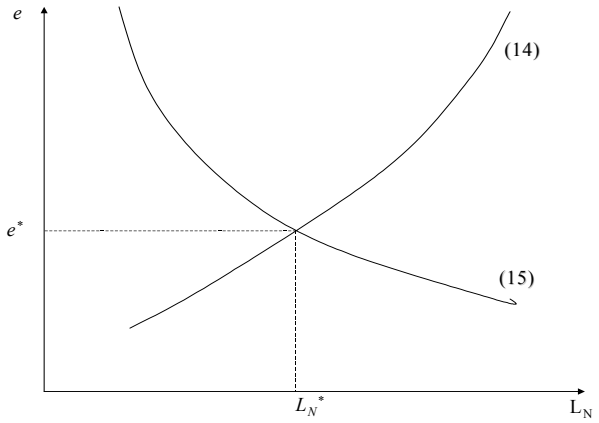
In this paragraph, we derive some simple comparative statics results. From equations (17-1) and (17-2), one obtains:

$$\begin{cases} C_1 = e_1^{\gamma} \cdot \left[y_N^1 + \dfrac{q_1}{e_1} \cdot y_X^1 + \dfrac{A_1 - R}{e_1 \cdot p^{1*}_T} \right] \\ C_2 = e_2^{\gamma} \cdot \left[y_N^2 + \dfrac{q_2}{e_2} \cdot y_X^2 + \dfrac{A_2 + R}{e_2 \cdot p^{2*}_T} \right] \end{cases}$$

An increase in the real exchange rate has no direct effect on real consumption (see Appendix). The intuition is straightforward. Relative price movements cause a reallocation of labor between sectors until the marginal product of labor is equalized. Hence the change in relative prices has no direct effect on real income. However, it is clear that foreign aid flows and (positive) terms of trade shocks have a direct positive effect on consumption.

The real exchange rates in period 1 and period 2 are determined by *i)* equilibrium on the non-traded good market (15-1) and (15-2), and *ii)* labor market equilibrium conditions (14-1) and (14-2). It is straightforward to verify that an equilibrium exists for an non-empty set of parameters. Equations (15-1) and (15-2) yield a positive relationship between the real exchange rate e and the share of labor employed in the non-traded sector L_N : an increase in the real exchange rate implies a lower demand for non-traded goods. Equations (14-1) and (14-2) yield a positive relationship between the real exchange rate and the share of labor employed in the non-traded sector: an increase in the real exchange rate corresponds to an increase in the marginal product of labor in the non-traded sector relative to the traded sector, henceforth an increase in the demand for labor in the non-traded sector[35].

Figure 2: Determination of the real exchange rate



[35] The proof is left to the interested readers.

From equations (14) and (15) described in Figure 2, it is straightforward to verify the following effects. First, an increase in foreign aid inflows leads to a real exchange rate appreciation. The mechanism is well known. Since part of the revenue is spent on non-tradable goods, an increase in foreign aid inflows leads to an increase in the demand for non-tradable goods (the locus (15) shifts up) and to an increase in the price of non-tradable goods relative to the price of tradable goods.

Second, a positive shock on the terms of trade of the same magnitude as the foreign aid inflow[36] leads to a larger real exchange rate appreciation. The reason is simple. On the one hand, there is the same spending effect as in the case of a foreign aid inflow (the locus (15) shifts up). On the other hand, the marginal product of labor increases in the exportable sector (the locus (14) shifts up), which implies a reallocation of labor towards the tradable sector. This second effect reinforces the real appreciation as less labor will flow to the non-tradable sector to meet the increased demand for non-tradable goods. However, the effect on the sectoral allocation of labor is ambiguous.

Third, the accumulation of foreign reserves during period one and two (or equivalently a current account surplus) is associated with a real exchange rate *depreciation*. Indeed, the accumulation of reserves corresponds to a shift of resources between period one and two, hence it is associated with a fall in the demand for non-tradable goods in the first period.

We now proceed to characterize the optimal timing of aid flows in this economy with a closed capital account. We will then show that we show that monetary policy can affect relative prices.

VI. THE OPTIMAL TIMING OF OFFICIAL DEVELOPMENT ASSISTANCE

In this section, we characterize the optimal composition and timing of foreign aid inflows. Specifically, we derive the optimal timing of foreign aid disbursement, as well as the composition of aid, *for a given net present value of aid inflows*. The net present value of aid inflows is exogenously fixed at $\overline{A}(= A_1 + A_2 + \widetilde{A})$.

Two main forces affect the optimal timing of aid inflows. First, foreign aid helps smooth income fluctuations. This is crucial in the context of low income countries in which agents have limited ability to borrow (or lend) to smooth their consumption path[37]. Second,

[36] Specifically, for a shock on the terms-of-trade that has the same effect on domestic income.

[37] By controlling the interest rate, the monetary authority can however affect private savings decision.

foreign aid may affect productivity growth by putting upward pressures on the real exchange rate. A discussion of other factors affecting the timing of aid disbursements is postponed to section VI.

We assume that the objective function of the donors is to maximize the inter-temporal welfare of the representative agent in the recipient country. We focus on the case in which the central bank does not issue sterilization bonds (*B=0*) and redistributes all seignorage to the consumers[38]. We relax this assumption in the next section.

The maximization program is the following:

$Max_{(A_1,A_2,\tilde{A})} W = \left\{ \log C_1 + \log C_2 + \chi \log\left(\frac{M}{P}\right) \right\}$ subject to: $\bar{A} = A_1 + A_2 + \tilde{A}$, where $\bar{A}$ is exogenous. The optimal timing of foreign aid inflows is derived under the assumption $\tilde{A} = 0$[39]. This assumption is relaxed in section VII where we discuss the optimal composition of aid.

Proposition 1: The timing of Aid Disbursements

- In the benchmark case, e.g. in absence of LBD, there exists an optimal path of aid disbursements (A_1^*, A_2^*) *reflecting the need to smooth consumption.*
- In presence of a LBD effect, the optimal path of aid disbursements $\left(\bar{A}_1, \bar{A}_2\right)$ *is such that aid should be lower in the first period, relative to the benchmark case, e.g.* $\bar{A}_1 < A_1^*$ *and* $\bar{A}_2 > A_2^*$.

Proof.
See the appendix. The first part of the proposition simply states that a rationale for official development assistance is the need to smooth aggregate shocks when the economy has no access to international capital markets. The second part states that, in presence of the LBD externality, it is optimal to have a more gradual increase in foreign aid inflows, e.g. it should be lower in the first period and higher in the second period, relative to the benchmark case. The intuition is straightforward: the real exchange rate appreciation caused by the foreign aid inflow has an adverse effect on productivity growth. Hence, for a given net present value of

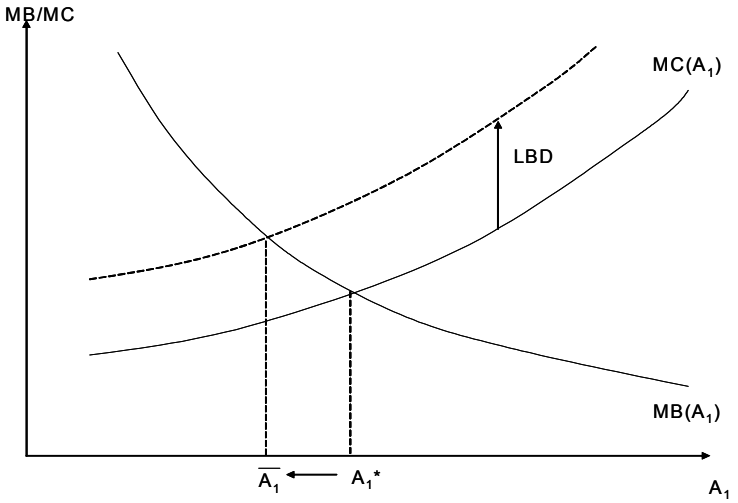
[38] Hence, money supply is $M^S = R$, and seignorage $T = M^S$ is redistributed to agents, so that the first period budget constraint is: $P_1 C_1 + M^S = I_1 + A_1 + T$, or: $P_1 C_1 = I_1 + A_1$, which implies that the current account is balanced in each period.

[39] We could assume that $\tilde{A} \neq 0$ so that the optimal composition of aid in the benchmark case would reflect not only the need to smooth consumption but also the productivity enhancing benefits of aid. The qualitative results would remain unchanged: in presence of LBD, first period aid should be lower than in the benchmark case.

total aid flows, it is optimal to have a lower aid flow initially to maintain a lower real exchange rate initially and allow the productive capacity to expand in the second period.

Figure 3 illustrates these results. This figure plots the first period aid against its marginal cost (the upward sloping curve) and its marginal benefit (the downward sloping curve) derived in the appendix. In presence of LBD, the marginal cost curve shifts up, as shown by the dotted curve. First period aid shifts down. In section VII, we further discuss the timing of aid disbursements by focusing on the impact of terms of trade shocks.

Figure 3: The Optimal Timing of Foreign Aid Inflows



VII. THE IMPACT OF MONETARY POLICY

In this section we discuss the impact of monetary policy on aggregate consumption, real exchange rate and output, for a given composition and timing of foreign aid inflows. Our approach is the following. In the previous section, we have characterized the existence of an optimal timing of aid disbursements for a given monetary policy. In this section, we assume that aid flows are exogenous and show that monetary policy can be effective in replicating the macroeconomic effects of the optimal timing of aid flows, whenever the actual path differs from the optimal one.

We argue that monetary policy can limit a real exchange rate appreciation and have permanent effects on the productive structure of the economy. Higher nominal interest rates can lead to a temporary real depreciation and a contraction in domestic absorption as agents increase their savings. In order to reestablish equilibrium in the non-tradable goods market, the price of non-tradable goods must fall. Since the price of tradable goods is fixed

internationally, the real exchange rate must depreciates. Similar temporary effects of monetary policy can be found in Edwards (1988) and Calvo et al. (1995).[40]

With predetermined exchange rates, the Central Bank, can choose the degree of sterilization of foreign exchange inflows by targeting the nominal interest rate or the money supply. Note that the conclusions drawn in this section depend crucially on two assumptions: *i)* the fixed exchange rate (or the fixed rate of change of the nominal exchange rate if $E_1 \neq E_2$) can be sustained, which means implicitely that the Central Bank has enough reserves to defend the value of the domestic currency; and *ii)* the capital account is closed.

By combining equations (16) and (18), we obtain the following relation between money demand and the consumption path:

$$M_1 = \chi \cdot \frac{1}{\frac{1}{P_1 C_1} - \frac{1}{P_2 C_2}} \quad (22)$$

From the economy's resource constraints (17-1) and (17-2), we can link the money demand to the accumulation (or decumulation) of foreign exchange reserves, or equivalently the current account surplus (or deficit). Equation (22) determines the locus of levels of money demand and current account balance that are mutually consistent. Equation (5) provides the accounting relationship between the accumulation of reserves and the money supply. In the following proposition, we claim first that monetary policy can be used in order to engineer a temporary real exchange depreciation, and second that a larger monetary contraction is needed in order to engineer a given current account surplus (e.g. accumulation of reserves) in the presence of learning by doing.

Proposition 2

- Monetary policy has an effect on the real exchange rate and the current account balance: a monetary tightening leads to a real exchange rate depreciation and an improvement in the current account balance.
-In the presence of learning by doing, a greater contraction of the money supply is necessary to engineer a given improvement of the current account or real exchange rate depreciation.

Proof. See the appendix.

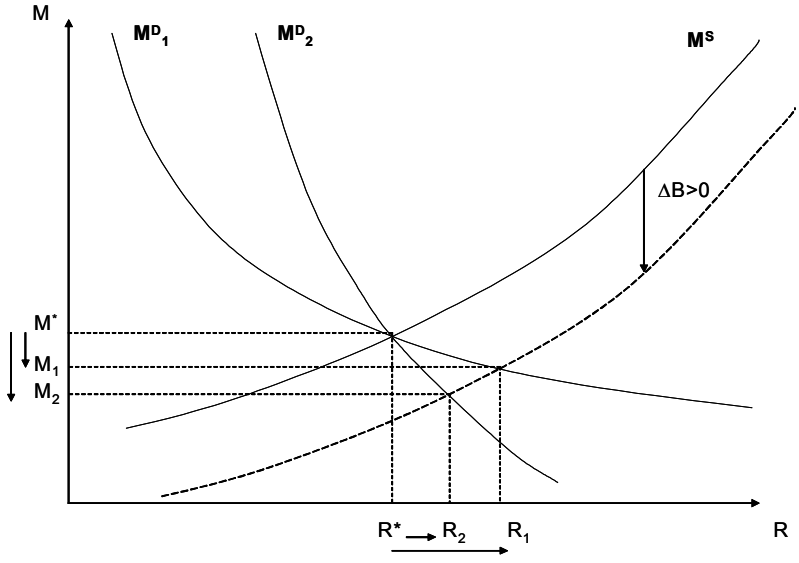
[40] It is worth emphasizing that the opposite result may hold in a new-keynesian framework with perfect capital mobility: a rise in the domestic nominal interest rate would lead to real appreciation in the short-run in order to maintain the interest parity.

The first part of the proposition is straightforward: a monetary tightening reduces domestic absorption and improves the current account by reducing the demand for imports. The intuition of the second part is the following. An increase in the interest rate leads to a contraction in aggregate demand in period one. In the absence of learning by doing, this generates a current account improvement and a corresponding accumulation of reserves. In the presence of learning by doing, the monetary contraction generates an expectation of higher productivity growth between period one and period two, hence a higher expected income in period two. Agents would then require a higher interest rate to reduce their current consumption in line with the targeted real exchange rate and current account surplus.

Figure 4 illustrates the impact of monetary tightening on both the money demand and the current account balance (or equivalently the accumulation of international reserves *R*). The locus M^d plots the money demand and the current account balance that are consistent with each other for a given nominal interest rate. The locus M^s is the accounting identity (5). The locus $M^d{}_1$ and $M^d{}_2$ correspond respectively to small and large Dutch disease effects.

This result has interesting policy implications. Any given sterilization policy (i.e. reduction in net domestic assets) would result in different changes in money supply and international reserves depending on the size of the Dutch disease effects. Specifically, when Dutch disease effects are strong, the increase in international reserves will be smaller and the reduction in money supply larger. Given that the welfare-maximizing consumption path is associated with a specific change in reserves, full sterilization of aid flows is not necessarily optimal and the monetary authority needs to choose the degree of sterilization by taking into account the strength of Dutch disease effects.

Figure 4: Impact of Sterilization on the Current Account Balance



VIII. EXTENSIONS

This section develops several extensions of the model. First, we show that the composition of aid should favor consumption when foreign aid is not so effective in increasing the productivity of the economy. Second, we discuss why a positive correlation between aid inflows and terms of trade shocks may be optimal when LBD is large. Third, we show that the case for sterilization is weaker when aid is disbursed in the form of grants rather than loans. Finally, we introduce domestic investment decisions in order to characterize the conditions under which sterilization crowds out private investment.

The Optimal Composition of Foreign Aid

In this subsection, we extend the results of section VI and characterize the optimal composition of first period aid inflows. Again, we assume that total foreign aid inflows $\overline{A}$ are exogenous. For simplicity, we also assume that $A_2 = 0$.

Proposition 3: The Composition of Aid

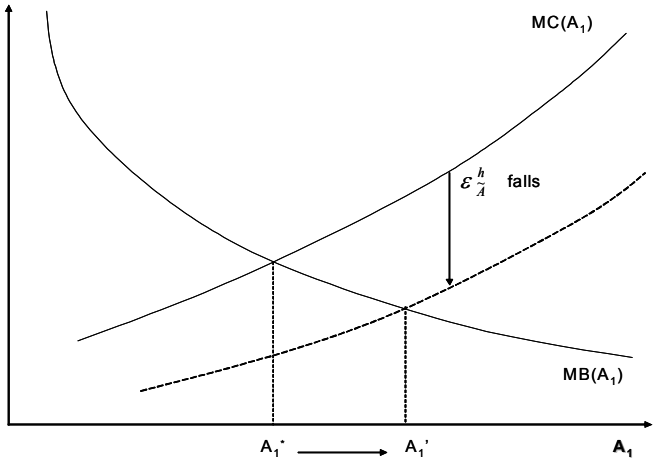
Foreign aid should be directed to productive investments rather than consumption the higher the effectiveness of foreign aid, measured by $\varepsilon_{\tilde{A}}^{h} = \dfrac{dh/h}{d\tilde{A}/\tilde{A}}$, *the elasticity of productivity with respect to foreign aid, and the higher the first period GDP, measured by* I_1, *relative to second period GDP, measured by* I_2.

Proof.
See the appendix. The stronger is the positive impact on second period productivity, the greater is the relative benefit of aid targeted at productive activities is the positive impact on second period productivity. Consumption aid provides instead greater benefits when first period income is low. These results are consistent with the intuition: for instance, it is clear that a larger proportion of aid should be consumed the poorer the recipient economy.[41].The measure of the effectiveness of foreign aid should be seen at reflecting not only the pure economic mechanisms through which public goods (health, education, various infrastructures) increase productivity, but also the political and other institutional

[41] The limit case is when first period income is so low that it is not sufficient to cover basic human needs. To be sure, it is obvious that aid has to be consumed and monetary policy has to accommodate any price effect irrespective of potential Dutch disease effects.

inefficiencies (corruption, weak property rights) that may hamper the effectiveness of aid. Our model implies that more aid should be simply left for consumption when the institutions of the recipient economy do not provide an investment friendly environment.

Figure 5: The Optimal Composition of Foreign Aid



Terms of Trade Shocks and Foreign Aid Inflows

Interestingly, the timing of aid disbursements also depends on terms of trade shocks. From equations (14) and (15) one can easily check that the impact of a dollar increase in ODA on the marginal product of labor will be lower the higher is the terms of trade. Hence, a *positive* shock to the terms of trade today, whereby the export sector expands, should be accompanied by an *increase* in foreign aid. The intuition is simple: since a positive term of trade shock increases the marginal product of labor in the export sector relative to the marginal product of labor in the non-tradable sector, the allocation of labor between the non-tradable and the tradable sector (and relative prices) is *less* affected by a given dollar value of foreign aid inflows[42].Hence the following cyclical property holds: if GDP is positively correlated to positive term of trade shocks, a positive correlation between aid flows and GDP fluctuations may be optimal[43] if Dutch disease is a concern.

[42] Obviously, the real exchange rate will appreciate more if aid flows and terms of trade improve simultaneously.

[43] See Pallage and Robe (2001) for evidence on the procyclicality of aid flows.

Proposition 4: Foreign Aid and Terms of Trade Shocks under Dutch Disease

If the share of non- tradable goods in consumption is not too large, foreign aid should be less negatively correlated to terms of trade shocks the greater the Dutch disease effect. In the limit case in which there is no need to smooth consumption, foreign aid flows should be positively correlated to terms of trade shocks.
Proof. See the appendix.

The intuition is that an improvement in the terms of trade makes the sectoral composition less sensitive to an increase in aid inflows since a positive terms of trade shock has the same implication as an increase in the tradable sector productivity: the marginal product of labor in the tradable sector increases, which counteracts the demand effect on relative prices that causes Dutch disease.

The Choice between Loans and Grants

This section focuses on the choice between loans and grants. Specifically, the question asked is whether the choice between a loan and a grant matters for a given net present value of aid flows $\overline{A}$ over the two periods. We show that the case for sterilization is stronger when the degree of concessionality is lower. The intuition is the following. For a given net present value of aid flows, a lower degree of concessionality (a larger loan component) implies a higher inflow in the first period offset by an outflow in the second period. Hence the real exchange rate appreciation is larger which implies that the Dutch disease effect is stronger. Therefore the case for sterilization is stronger.

The choice between loans and grants depends also on the effectiveness of aid. The intuition is clear: if aid is to be invested in projects ($\widetilde{A}$) rather than consumed (A_1), the case for grants relative to loans is weaker the more effective foreign aid is in increasing the country's productivity. Indeed, the marginal benefit of loans increases with the effectiveness of aid. Note again that the effectiveness of aid captures various factors affecting the productivity of aid financed projects, such as corruption and the administrative absorptive capacity.

Proposition 5: The Choice between Loans and Grants

-If the Dutch disease effect is large, the case for sterilization of aid flows is stronger the larger the loan component of official development assistance.
-The case for grants rather than loans is stronger the lower the productivity effectiveness of aid.

Proof: see the Appendix.

Introducing Investment Decisions

By increasing the cost of capital for firms, sterilization may crowd out private investment. Since the installation of new capital goods may be crucial for productivity growth in the export sector, this effect may overcome the direct Dutch disease channel. We embed this effect by assuming that capital is also an input in the tradable sector.[44] We are interested in *fixed* capital expenditures that increase the productivity of labor over the medium-term rather than working capital[45].

We assume that an investment realized in period one matures only in period two. The initial capital stock K_X^1 in period one is exogenous and fully depreciates between period one and period two. For simplicity, the capital good is composed of importable and non-tradable goods in the same proportion as in consumers' preferences[46]. The new capital stock in period two is $K_X^2 = I_X^1$, where I_X^1 is the investment realized in period one.

The production function in the tradable sector is now:

$$y_X^t = a_X^t \cdot F_X\left(L_X^t, K_X^t\right), \text{ t=1,2.}$$

Thus domestic agents can hold two types of safe financial assets between period one and period two: public bonds B and private bonds D. These financial assets are perfect substitutes and pay a nominal interest rate r. Hence, total private saving is $S = B + D$.

The individual budget constraints in period one and two are the following:

$$P_1 C_1^i + \left(M_1^i - M_0^i\right) + S^i = I_1^i + E_1 \cdot A_1^i$$
$$P_2 C_2^i = I_2^i + E_2 \cdot A_2^i + \left(1 + r\right) S^i + T_2^i$$

Thus, the aggregate budget constraints are:

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[44] It may be more realistic to have capital as an input in both tradable and non-tradable sectors. However, investment in fixed capital is probably of a lesser importance in services, which are non-traded goods. Hence, our assumption may be a reasonable first-order approximation.

[45] The reason is that external finance is more important for fixed investment, while working capital can be more easily financed through retained earnings or informal sources of funds.

[46] This simple assumption allows us to introduce capital without modifying the aggregate composition of expenditures between non tradable and tradable goods.

$$I_1 + E_1 A_1 = P_1 C_1 + E_1 R + K_X^2$$
$$P_2 C_2 = I_2 + E_2 A_2 + E_2 R + (1+r) K_X^2$$

The supply of capital K_S can be derived from equation (18). One can show (see the appendix), that:

$$K_S = K_S\left(\overset{+}{I_1}, \overset{-}{I_2}, \overset{+}{A_1}, \overset{-}{A_2}, \overset{+}{r}, \overset{-}{R}\right)$$

and:

$$K_D = K_D\left(\overset{-}{r}, \overset{+}{p_X^2}, \overset{+}{a_X^2}, L_X^2\left(\overset{-}{A_2}, \overset{-}{R}\right)\right)$$

Therefore, an increase in the supply of sterilization bonds leads to a substitution of public bonds for private debt in the portfolio of savers. Simultaneously, an increase in the supply of sterilization bonds is met by a reduction in aggregate spending, which again leads to an improvement in the current account balance and the accumulation of foreign exchange reserves.

Proposition 6: Crowding-out of Private Investment by Public Debt

- If the LBD externality is small, a tightening of monetary policy leads to an improvement in the current account balance and a fall in private investment. The impact on the rate of interest is ambiguous.
- If the LBD externality is large, the effect of a tightening of monetary policy on the demand for capital may be positive.

Proof.
See the appendix. In the first case, sterilization affects private investment through two channels. First, the supply of capital falls as a consequence of the substitution effect discussed above. Second, the demand for capital also falls. Indeed, since aggregate consumption will be higher in the second period as a consequence of the sterilization policy, employment is expected to be lower in the tradable sector (and higher in the non-tradable sector), with a simultaneous fall in the marginal product of capital.[47] Hence, the stock of capital unambiguously falls while the impact on the interest rate is ambiguous.

Figure 6 illustrates the case in which the LBD externality is small. In this figure, the supply effect dominates, so that, as a consequence of sterilization, not only the capital stock falls but also the interest rate increases.

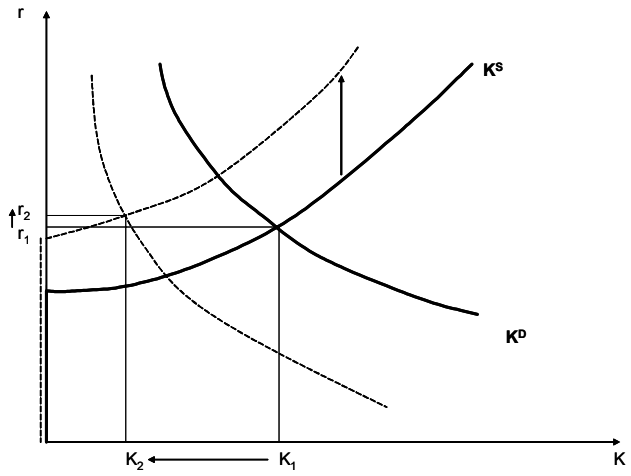
However, if the LBD externality is large, an additional channel affects the demand for capital. Indeed, a tight monetary policy, by inducing a depreciation of the real exchange rate,

[47] This may not hold if capital is also an input in the non-tradable sector.

may lead to greater learning by doing, as discussed previously. In that case, if learning by doing is large enough, the marginal product of capital may *increase* in the tradable sector, inducing a higher demand for capital.

Finally, note that, if the marginal product of capital of the first dollar invested is not infinitely large,[48] the market for capital may collapse as a result of a tight monetary policy. In this context, the welfare costs of tight monetary policy may be very large[49] if financial disintermediation implies a loss of information in the banking system.

Figure 6 Crowding out of Investment by Sterilization Bonds



IX. CONCLUSION

This paper provides a theoretical framework for studying whether the sterilization of the base money effect of foreign aid inflows can increase the welfare of aid-receiving countries. We characterize the optimal distribution over time of a given net present value of aid. The greater are the Dutch disease costs of aid in relation to its consumption and productivity-enhancing benefits, the more back-loaded aid disbursements should be. Whenever actual aid flows are more front-loaded than in the optimal path, sterilization can have positive welfare effects. We also show that, when aid is in the form of loans rather than

[48] For instance if there is a fixed cost of investing, or if the initial capital stock does not fully depreciate between period one and period two.

[49] For instance, Hausman and Rigobon (2002) argue that the welfare costs of uncertain transfers are significantly higher when the tradable sector vanishes.

outright grants, the scope for sterilization is greater. The benefits of sterilization might, instead, be smaller if private investment is crowded out. Our empirical analysis finds that aid inflows are associated with significant but small real exchange rate appreciation and that sterilization can offset it.

While in the theoretical model sterilization is implemented through open market operations, other means of reducing net domestic assets may be used in practice if financial markets are insufficiently developed, as it is often the case in low-income countries. Any policy resulting in an increase of government deposits at the central bank—through higher fiscal surpluses or a shift of government deposits from the banking sector—would have the same effects. An increase in reserve requirements would also do. Our empirical results are robust to the actual means of sterilization as the sterilization measure is computed using the overall change in net domestic assets no matter how this is realized.

But what is the practical relevance of our results? When should aid-receiving countries try to sterilize aid inflows and to what extent? An important note of caution is that our results regard only the welfare implications of the *distribution* of a given net present value of aid over time. They do not provide any indication that an increase in the *overall* net present value of aid can reduce welfare. It is also clear that exact policy prescriptions could only be based on country-specific assessments of the costs and benefits of aid flows.

While these notes of caution are warranted, this paper still provides insights into the design of monetary policy for countries receiving large amounts of aid. Specifically, we show that, when the capital account is relatively closed, useful inputs to monetary policy decisions include the path of expected future aid disbursements and their likelihood, the impact of aid on consumption and productivity, and the contribution of the export sector to growth and its resilience to real exchange rate fluctuations.

While our model is stylized, some of its features can be broadly interpreted to match well-known problems in aid-receiving countries. Factors such as corruption and capacity constraints in aid distribution can be seen, for example, as the ultimate determinants of the consumption and productivity benefits of aid.

Do our policy prescriptions apply to humanitarian aid? The benefits of humanitarian aid are so large that it may appear absurd to trade them off against potential Dutch disease costs. In the model of this paper, a situation in which humanitarian aid is needed and consumption is close to the subsistence level would, indeed, be reflected in very large marginal utilities of consumption that would swamp any possible Dutch disease costs. In this case, the model would imply a front-loaded optimal path of aid disbursements. Humanitarian aid flows can also be expected to cause relatively little real appreciation as they are generally in kind or spent on imports. This may explain why we find the association between real appreciation and aid flows to be statistically significant but small. In future empirical

research, we plan on testing whether different types of aid have a different impact on the real exchange rate.[50]

Another relevant question is whether the effects of Dutch disease on growth are really so large that monetary authorities should take them explicitly into account, possibly incurring significant sterilization costs.[51] The answer to this question is beyond the scope of this paper and needs to be addressed on empirical grounds. The results presented in Section III suggest that aid flows have a statistically significant—but small--impact on the real exchange rate. The effects at the country level could, however, vary and the relevant overall impact could be assessed only by estimating the effect of real appreciation on growth.[52]

Finally, should the relevance of Dutch disease concerns be dismissed by observing that a large manufacturing export sector does not exist in many low-income countries?[53] We do not think so. The manufacturing sector—while small in absolute terms--accounts for a non-negligible share of exports in many low-income countries (15%, 25%, 15%, and 90% of total exports respectively in Tanzania, Kenya, Ghana, and Bangladesh.)[54] Moreover, manufacturing exports were initially small in most countries that successfully developed over

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[50] This argument is based on the assumption that humanitarian aid is unlikely to be *fungible* because it tends to be given to governments that do not have enough resources and their expenditure is therefore constrained. If humanitarian aid were, instead, fungible, the government could spend for other purposes the resources that it would have spent for humanitarian goals, putting pressure on non-tradable prices and causing a real appreciation even if the actual aid is mainly spent on imports. In this case, the effect of aid on the real exchange rate would *not* depend on its type and there would be scope for sterilization also in the case of humanitarian aid. This policy could be meaningfully discussed in a variant of our model in which consumers are heterogeneous and the agents that benefit from humanitarian aid are not the same agents whose consumption is reduced (and savings increased) by sterilization operations.

[51] Adam and Bevan (2003) calibrate a model on Uganda data to show that the impact of aid on the real exchange rate can be complex and may not be large.

[52] As mentioned in the introduction, recent research (Easterly and Levine (2002) and Acemoglu and Johnson (2002)) has shown that real overvaluation is, indeed, negatively associated with long-run growth and is the only robust policy variable in growth regressions.

[53] These countries, the argument goes, export mainly commodities with little scope for productivity gains. Productivity gains (and/or quality improvements) could, however, take place also in the commodity-exporting sectors because commodities are often processed domestically to meet international standards.

[54] World Bank Development Indicators 2002.

the past 40 years and their size was initially comparable to that of today's manufacturing exports in low-income countries. In the early sixties, for example, manufacturing exports represented 20%, 2%, and 5% of total exports respectively in Korea, Thailand, and Malaysia. At the end of the nineties, the same shares were respectively 90%, 75%, and 90%.

Could also the *non-tradable* sector be a source of learning-by-doing spillovers, thus reducing the significance of a real appreciation for the growth prospects of low-income countries?[55] To our knowledge, there is no evidence of learning-by-doing spillovers in the non-tradable sector of aid-receiving countries. Indeed, there are reasons to believe that this phenomenon could be limited to relatively developed economies. In these economies, learning-by-doing may be present also in the non-tradable sector because innovation takes place in research centers, which could be present in both the tradable and the non-tradable sectors. In developing countries, instead, productivity grows mainly through adoption of existing technologies imported from developed economies. Moreover, export-based industries of developing countries tend to increase their productivity by adopting standards, marketing, and management techniques of developed countries' industries. These are the key features of the export-based development strategies that have been so successful over the past 40 years.

Finally, there is little doubt that greater donors' coordination and planning in disbursing aid flows, or allowing recipient countries to save part of the disbursements, would go a long way towards improving welfare of recipient countries. In this paper, the main rationale for sterilization is the suboptimal distribution over time of aid disbursements. However, sterilization is costly and will tend to become less effective as globalization of international capital markets progresses to include aid-receiving countries. Still, reducing the volatility of consumption in developing countries would yield substantial gains, as shown by Pallage and Robe (2003)[56]. Increasing multilateral and bilateral donors' coordination in disbursing aid—a key objective of the PRSP process introduced in the late 1990s—is then of critical importance. Furthermore, donor countries could create a reserve fund and save part of the aid for the future when conditions are appropriate. These country-specific reserve funds could be owned by the recipient countries but the timing of their disbursements would be controlled by independent experts appointed by donor countries and international institutions. This mechanism would not only serve to obviate the coordination problem among the donors of disbursing aid in a desirable manner, but the ownership of funds, with their disbursement conditional on good political and economic performance and the dire needs of the poor, would create the incentives for recipient countries to reform. The spreading of aid flows over time could then be beneficial for smoothing consumption and investment in economies with high volatility and uncertainty of aid flows.

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[55] Torvik (2002).

[56] Pallage and Robe (2003) show that the median welfare cost of business cycles in developing countries ranges from 10 to 30 times its estimate for the United States, depending on th model used.

APPENDIX

Proof of Proposition 1

Note that:

$$\begin{cases} C_1 = \dfrac{I_1 + E_1 \cdot A_1}{P_1} = e_1^{\gamma} \cdot \left[\dfrac{q_1}{e_1} \cdot y_X^1 + y_N^1 + \dfrac{1}{e_1} \cdot \dfrac{A_1}{\left(p_T^*\right)^1} \right] \\ C_2 = \dfrac{I_2 + E_2 \cdot A_2}{P_2} = e_2^{\gamma} \cdot \left[\dfrac{q_2}{e_2} \cdot y_X^2 + y_N^2 + \dfrac{1}{e_2} \cdot \dfrac{A_2}{\left(p_T^*\right)^2} \right] \end{cases}$$

and: $M_1 = \chi \cdot P_1 C_1$

Hence the welfare function is:

$$W = \gamma(1+\chi)\log(e_1) + \gamma\log(e_2) + (1+\chi)\log\left(\frac{q_1}{e_1} y_X^1 + y_N^1 + \frac{1}{e_1} \cdot \frac{A_1}{\left(p_T^*\right)^1} \right)$$

$$+ \log\left(\frac{q_2}{e_2} y_X^2 + y_N^2 + \frac{1}{e_2} \cdot \frac{\overline{A} - A_1 - \widetilde{A}}{\left(p_T^*\right)^2} \right)$$

The derivative of the welfare function with respect to A_1 and A_2 is the following:

$$\frac{dW}{dA_1} = \frac{\partial W}{\partial A_1} + \frac{\partial W}{\partial e_1} \cdot \frac{\partial e_1}{\partial A_1} + \frac{\partial W}{\partial L_N^1} \cdot \frac{\partial L_N^1}{\partial e_1} \cdot \frac{\partial e_1}{\partial A_1} - z \cdot \left[\frac{\partial W}{\partial a_X^2} + \frac{\partial W}{\partial a_N^2} \right] \cdot \frac{\partial L_N^1}{\partial e_1} \cdot \frac{\partial e_1}{\partial A_1}$$

where $z = -\dfrac{\partial a_X^2}{\partial L_N^1} = -\dfrac{\partial a_N^2}{\partial L_N^1}$,

and: $\dfrac{dW}{dA_2} = \dfrac{\partial W}{\partial A_2} + \dfrac{\partial W}{\partial e_2} \cdot \dfrac{\partial e_2}{\partial A_2} + \dfrac{\partial W}{\partial L_N^2} \cdot \dfrac{\partial L_N^2}{\partial e_2} \cdot \dfrac{\partial e_2}{\partial A_2}$.

Note that:

(1) $\dfrac{\partial W}{\partial L_N^t} = \dfrac{\partial I_t}{\partial L_N^t} \cdot \dfrac{\partial W}{\partial I_t} = 0$, t=1,2.

Indeed, from the firms' profit maximization conditions: $\dfrac{\partial I_t}{\partial L_N^t} = p_N^t \cdot \dfrac{\partial y_N^t}{\partial L_N^t} - p_X^t \cdot \dfrac{\partial y_X^t}{\partial L_X^t} = 0$.

(2) $\dfrac{\partial W}{\partial e_t} = 0$, t=1,2.

Indeed:

$$\frac{\partial C_t}{\partial e_t} = \gamma e_1^{\gamma-1} \cdot \left[\frac{q_1}{e_1} \cdot y_X^1 + y_N^1 + \frac{1}{e_1} \cdot \frac{A_1}{\left(p_T^*\right)^1} \right] - e_1^{\gamma} \cdot \left[\frac{q_1}{{e_1}^2} \cdot y_X^1 + \frac{1}{{e_1}^2} \frac{A_1}{\left(p_T^*\right)^1} \right]$$

$$= \frac{1}{e_t} \frac{p_T^t \cdot c_T^t - p_X^t \cdot y_X^t - E_t A_t}{P_t} = \frac{1}{e_t} \cdot \frac{CA_t}{P_t} = 0$$

Simple algebra yield:

$\frac{\partial W}{\partial A_t} = \frac{1}{I_t^* + A_t}$, t=1,2, with: $I_t^* = \frac{I_t}{E_t}$.

And:

$$\frac{\partial W}{\partial a_X^2} + \frac{\partial W}{\partial a_N^2} = \frac{1}{a^2} \cdot \frac{I_2}{I_2 + E_2 A_2}.$$

Therefore the marginal benefit (MB) and marginal cost (MC) of increasing A_1 are respectively:

$$MB(A_1) = \frac{1}{I_1^* + A_1}$$

$$MC(A_1) = \frac{1}{I_2^* + A_2} + \frac{I_2^*}{I_2^* + A_2} \frac{z}{a^2} \frac{\partial L_N^1}{\partial e_1} \frac{\partial e_1}{\partial A_1}.$$

The proposition derives directly from these two equations.

Proof of Proposition 2

From equation (22), money demand is an increasing function of today's consumption and decreasing function of tomorrow's expected consumption. The intuition for the latter relationship is the following. An increase in tomorrow's purchasing power implies that a higher interest rate is required to maintain the current level of savings. Hence, given today's consumption (or savings), an increase in tomorrow's purchasing power implies that a higher interest rate is necessary to maintain the level of savings. However, an higher interest rate implies that agents substitute bonds for money, hence the money for money decreases.

From equation (22) :

Moreover, $\frac{dP_1C_1}{dR} = \frac{dI_1}{dR} - E_1$ $\qquad \frac{d\left(\frac{\chi}{M_1}\right)}{dR} = \frac{d}{dR}\left[\frac{1}{P_1C_1} - \frac{1}{P_2C_2}\right]$

and $\frac{dP_2C_2}{dR} = \frac{dI_2}{dR} + E_2$.

Therefore:

$$-\frac{d\left(\frac{\chi}{M_1}\right)}{dR} = \frac{1}{\left(P_1C_1\right)^2}\left[\frac{dI_1}{dR} - E_1\right] - \frac{1}{\left(P_2C_2\right)^2}\left[\frac{dI_2}{dR} + E_2\right]$$

where:

$$\frac{dI_1}{dR} = \underbrace{\underbrace{\frac{\partial I_1}{\partial L_N}}_{=0} \cdot \frac{\partial L_N^1}{\partial e_1} \cdot \frac{\partial e_1}{\partial R}}_{=0} + \underbrace{\underbrace{\frac{\partial I_1}{\partial e_1}}_{>0} \cdot \underbrace{\frac{\partial e_1}{\partial R}}_{<0}}_{<0}$$

This equation states that:
(1) monetary policy cannot affect income through the sectoral allocation of labor because firms adjust their demand for labor to existing prices. This result holds for an arbitrary number of inputs as long as these inputs are perfectly mobile across sectors.
(2) *nominal* income increases when the real exchange rate appreciates (in a fixed exchange rate regime). Hence an increase in foreign exchange reserves leads to a decrease in nominal income.

Similarly, second period nominal income is affected by an increase in foreign exchange reserves between period 1 and period 2 through several channels:

$$\frac{dI_2}{dR} = \underbrace{\frac{\partial I_2}{\partial L_n^2} \cdot \frac{\partial L_N^2}{\partial e_2} \cdot \frac{\partial e_2}{\partial R}}_{=0} + \underbrace{\underbrace{\frac{\partial I_2}{\partial e_2}}_{>0} \cdot \underbrace{\frac{\partial e_2}{\partial R}}_{>0}}_{>0} - z \cdot \left[\underbrace{\frac{\partial I_2}{\partial a_X^2} + \frac{\partial I_2}{\partial a_N^2}}_{>0} \right] \cdot \underbrace{\frac{\partial L_N^1}{\partial e_1}}_{>0} \cdot \underbrace{\frac{\partial e_1}{\partial R}}_{<0}$$

Now, an additional term enters the equation. It corresponds to the productivity effect: the real exchange rate depreciation that is associated with the improvement in the current account balance (equivalently the accumulation of reserves) leads to greater productivity growth between period one and period two.
This implies that in presence of learning by doing, the money demand is *more* sensitive to changes in reserves. The intuition is the following. An increase in the interest rate leads to a contraction in aggregate demand in period one. In absence of learning by doing, this generates a current account improvement and a corresponding accumulation of reserves. In presence of learning by doing, the monetary contraction generates an expectation of higher productivity growth between period one and period two, hence a higher expected income in period two. This expectation implies that a higher interest rate, hence a larger monetary contraction, are needed in order to engineer a given current account surplus (e.g. accumulation of reserves) or real exchange rate depreciation.

Proof of Proposition 3

From Proposition 1, we know that:

$$\frac{dW}{dA_1} = \frac{1}{I_1^* + A_1} + \frac{I_2^*}{I_2^* + A_2} \frac{z}{a^2} \frac{\partial L_N^1}{\partial e_1} \frac{\partial e_1}{\partial A_1}.$$

Moreover,

$$\frac{dW}{d\widetilde{A}} = \frac{\partial W}{\partial e_1}\cdot\frac{\partial e_1}{\partial \widetilde{A}} + \frac{\partial W}{\partial L_N^1}\cdot\frac{\partial L_N^1}{\partial e_1}\cdot\frac{\partial e_1}{\partial \widetilde{A}} + \left(\frac{\partial W}{\partial a_X^2} + \frac{\partial W}{\partial a_N^2}\right)\cdot\left(\frac{\partial a^2}{\partial h}\cdot\frac{\partial h}{\partial \widetilde{A}} + \frac{\partial a^2}{\partial L_N^1}\cdot\frac{\partial L_N^1}{\partial e_1}\cdot\frac{\partial e_1}{\partial \widetilde{A}}\right)$$

Hence:

$$\frac{dW}{dA_1} - \frac{dW}{d\widetilde{A}} = \frac{1}{I_1^* + A_1} - \frac{1}{\widetilde{A}}\varepsilon_{\widetilde{A}}^{h}$$

where $\varepsilon_{\widetilde{A}}^{h} = \dfrac{dh/h}{d\widetilde{A}/\widetilde{A}}$ is the elasticity of total factor productivity with respect to foreign aid flows targeted at productivity enhancing expenses.

The first term is decreasing in A_1 while the second term is clearly decreasing in $\widetilde{A}$. Hence an equilibrium exists for a non empty subset of parameters (for instance, this is obvious if h verifies the Inada conditions, and $\overline{A}$ is large enough).

Proof of Proposition 4

First, simple algebra yields:

$\dfrac{\partial e}{\partial A} = \dfrac{1-\gamma}{p_T^*\left[\gamma a_N^1 F_N\left(L_N^1\right) - \widetilde{x}_N\right]}$ and $\dfrac{\partial L_N}{\partial e} = \dfrac{1}{q}\cdot\dfrac{a_N}{a_X}\cdot H\left(L_N\right)$, where $H_{L_N} > 0$.

Furthemore:

$MB\left(A_1\right) = U'\left(A_1\right)$

and:

$$MC\left(A_1\right) = U'\left(A_2\right) + zg\left(\overset{-}{q_1}, \overset{+}{q_2}\right)\cdot G\left(\overset{+}{L_N^1}\right)$$

while $U'\left(A_1\right)$ and $U'\left(A_2\right)$ are unambiguously decreasing functions of contemporaneous term of trade shocks ($\dfrac{\partial U'\left(A_t\right)}{\partial q_t}$), the impact that goes through the term of trade shock is ambiguous, since it depends on how employment is affected by term of trade shocks. Equations (14) and (15) indeed show that the impact of a positive term of trade shock depends on two opposite effects: on the one hand, production shifts towards tradable goods (the supply effect) because of the increase in the marginal productivity of labor in the tradable sector caused by the term of trade shock (equation 14), while on the other hand, production of tradable will need to increase to respond to greater spendings on non-tradable goods (equation 15). If the share of revenue spent on non tradable goods is not too large (γ large), the supply effect will dominate and:

$$\frac{\partial g\left(\overset{-}{q_1},\overset{+}{q_2}\right)\cdot G\left(\overset{+}{L_N^1}\right)}{\partial q_1}<0$$

Proof of Proposition 5

The total net present value of aid flows is:
$\overline{A}=\widetilde{A}+A_1$ (net flows in the second period are assumed to be non positive).
This net flow of official development assistance can be decomposed in a grant component $\widetilde{A}+A_1$ and a loan component $\beta\left(\widetilde{A}+A_1\right)$ so that net flows in the first period and the second period are respectively $(1+\beta)\cdot\left(\widetilde{A}+A_1\right)$ and $-\beta\cdot\left(\widetilde{A}+A_1\right)$.
The total effect of a marginal increase in the loan component of development assistance can be decomposed in the following way, for a fixed composition of aid (which is measured by the ratio $\frac{\widetilde{A}}{A_1}$):

$$\frac{dW}{d\beta}=\underbrace{\frac{\partial W}{\partial\beta}}_{?}+\underbrace{\frac{\partial W}{\partial e_1}\cdot\frac{\partial e_1}{\partial\beta}+\frac{\partial W}{\partial L_N^1}\cdot\frac{\partial L_N^1}{\partial e_1}\cdot\frac{\partial e_1}{\partial\beta}+\frac{\partial W}{\partial e_2}\cdot\frac{\partial e_2}{\partial\beta}+\frac{\partial W}{\partial L_N^2}\cdot\frac{\partial L_N^2}{\partial e_2}\cdot\frac{\partial e_2}{\partial\beta}}_{=0}$$

$$+\underbrace{\underbrace{\left[\frac{\partial W}{\partial a_X^2}+\frac{\partial W}{\partial a_N^2}\right]}_{>0}\cdot\underbrace{\frac{\partial a^1}{\partial L_N^1}}_{<0}\cdot\underbrace{\frac{\partial L_N^1}{\partial e_1}}_{>0}\cdot\underbrace{\frac{\partial e_1}{\partial\beta}}_{>0}}_{<0}+\underbrace{\left[\frac{\partial W}{\partial a_X^2}+\frac{\partial W}{\partial a_N^2}\right]\cdot\frac{\partial a^2}{\partial h}\cdot\frac{\partial h}{\partial\beta}}_{>0}$$

If the Dutch disease effect is large, the second component of the derivative will dominate, which implies that increasing the loan component of official assistance is welfare decreasing. Hence, the case for sterilizing aid flows is stronger.
Consider now the composition of aid. The sign of the first term is ambiguous: a larger first period inflow increases first period consumption but decreases second period consumption. However, it is straightforward to show that the second period negative effect is weaker the more effective foreign aid is(as measured by the elasticity defined in proposition 4). Moreover, the more effective foreign aid is, the larger the positive last effect.
Hence, the total derivative with respect to β is less likely to be negative the more effective foreign aid is.

Proof of Proposition 6

The supply of capital is given by:

$$I_X{}^S = \frac{1}{2}\cdot\left[I_1 + E_1(A_1 - R) - \frac{1}{1+r}(I_2 + E_2 A_2 + E_2 R)\right]$$

From the firm profit maximization problem, the demand of capital is:

$$I_X{}^D = \left(F_X^K\right)^{-1}\left(\frac{1+r}{p_X^2 a_X^2}, L_X^2\right) - (1-\delta)K_X^1, \text{ hence: } K^D = K^D\left(r, p_X^2, a_X^2\left(\overset{+}{R}\right), L_X^2\left(\overset{-}{R}\right)\right)$$

The equilibrium of the market for productive capital can be represented as usual by plotting the demand and supply of capital as a function of the interest rate r. However, the interest rate (e.g. the instrument of monetary policy) also affects the current account balance (the accumulation of reserves R). This is illustrated by a shift of the demand and supply curves. Moreover, one can easily check that there exists a maximum interest rate under which there is no demand for capital. Hence: $I_X^D = 0$ if and only if $r \geq \underline{r}$, with $(1-\delta)K_X^1 = \left(F_X^K\right)^{-1}\left(\frac{1+\underline{r}}{p_X^2 a_X^2}, L_X^2\right)$

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Table 1 - Official Development Assistance Flows in the 1990s

country	*Official Development Assistance, % GDP, 1990s*			*Annual Absolute Change, %GDP*	
	Average	Maximum	Minimum	Average	Maximum
Albania	14.7%	53.2%	0.1%	12.9%	34.5%
Algeria	0.5%	0.8%	0.2%	0.2%	0.3%
Angola	4.4%	9.4%	1.8%	1.8%	5.2%
Antigua & Barbud	0.4%	1.4%	-0.7%	0.7%	1.4%
Armenia	6.0%	13.1%	0.1%	3.2%	6.8%
Aruba	2.5%	3.2%	1.5%	0.6%	0.7%
Azerbaijan	2.3%	4.4%	0.1%	1.8%	4.1%
Bangladesh	3.4%	6.3%	1.5%	1.1%	2.4%
Belize	1.7%	4.3%	0.4%	1.5%	3.0%
Benin	9.8%	13.0%	6.2%	1.4%	3.3%
Bhutan	13.3%	17.9%	8.4%	3.5%	9.5%
Bolivia	5.9%	9.0%	-0.4%	3.1%	9.4%
Botswana	1.4%	2.3%	0.7%	0.4%	0.9%
Burkina Faso	12.6%	16.3%	7.2%	1.9%	4.4%
Burundi	15.8%	27.9%	4.8%	6.2%	16.5%
Cambodia	7.1%	14.1%	2.0%	2.7%	5.9%
Cameroon	3.8%	7.4%	1.6%	2.3%	3.8%
Cape Verde	19.1%	26.3%	15.4%	2.2%	6.3%
Chad	11.4%	14.4%	6.9%	2.7%	5.1%
Comoros	11.9%	18.4%	8.7%	3.0%	7.9%
Djibouti	12.8%	16.3%	9.9%	1.6%	3.3%
Dominica	7.3%	15.9%	2.4%	4.3%	11.9%
Egypt	2.9%	5.7%	1.2%	0.9%	1.9%
El Salvador	1.8%	4.6%	-3.3%	1.9%	7.4%
Eritrea	16.0%	22.2%	10.7%	5.0%	7.9%
Ethiopia	12.7%	18.5%	6.4%	3.2%	6.5%
Gabon	1.2%	2.2%	-0.1%	0.8%	1.7%
Gambia	13.6%	24.0%	4.9%	2.9%	7.8%
Georgia	3.5%	6.7%	0.0%	1.6%	3.8%
Ghana	7.4%	9.0%	3.4%	1.7%	5.5%
Grenada	2.8%	5.1%	0.8%	1.6%	4.1%
Guatemala	1.0%	1.5%	0.7%	0.2%	0.4%
Guinea	8.4%	11.0%	4.7%	2.0%	4.2%
Guinea-Bissau	33.8%	55.4%	19.2%	17.6%	36.2%
Guyana	14.7%	39.3%	1.0%	10.8%	38.3%
Haiti	9.3%	26.8%	0.4%	6.1%	22.9%
Honduras	5.5%	11.6%	-6.9%	4.8%	18.6%
Jamaica	0.6%	5.5%	-3.0%	3.3%	8.4%
Jordan	6.6%	20.4%	0.2%	4.6%	14.6%
Kenya	6.0%	12.9%	2.6%	2.3%	6.3%
Kiribati	24.9%	49.3%	12.5%	9.9%	22.3%
Lebanon	0.9%	2.5%	0.3%	0.4%	1.7%
Lesotho	11.0%	15.7%	5.9%	1.4%	4.1%
Madagascar	7.8%	17.4%	4.8%	4.8%	12.5%
Malawi	20.7%	33.9%	9.6%	9.1%	15.2%

Table 1 - Continued

country	*Official Development Assistance, % GDP, 1990s* Average	Maximum	Minimum	*Annual Absolute Change, %GDP* Average	Maximum
Maldives	10.0%	15.5%	5.1%	2.9%	8.4%
Mali	13.0%	17.9%	8.6%	3.1%	9.4%
Malta	0.8%	2.3%	-0.1%	0.8%	1.9%
Marshall Islands	36.5%	68.8%	0.0%	17.2%	34.6%
Mauritania	18.3%	28.7%	12.7%	4.8%	16.0%
Mauritius	0.7%	2.6%	-0.2%	0.5%	0.9%
Micronesia	30.0%	49.1%	0.0%	13.3%	24.9%
Mongolia	16.3%	20.0%	13.8%	4.1%	6.1%
Morocco	1.4%	2.4%	0.5%	0.4%	0.7%
Mozambique	33.2%	56.1%	18.1%	8.3%	24.9%
Namibia	3.5%	5.7%	2.2%	1.3%	3.0%
Nepal	7.0%	9.1%	5.1%	1.0%	3.0%
Nicaragua	21.5%	27.2%	9.6%	7.4%	17.3%
Niger	11.1%	15.4%	7.3%	3.4%	6.9%
Nigeria	0.5%	0.8%	0.3%	0.1%	0.4%
Pakistan	1.6%	2.7%	0.8%	0.6%	1.6%
Papua New Guinea	6.7%	11.4%	4.6%	1.3%	4.3%
Paraguay	0.7%	1.6%	0.3%	0.5%	1.3%
Peru	0.7%	1.6%	0.3%	0.4%	0.9%
Philippines	1.3%	2.4%	0.5%	0.4%	0.8%
Rwanda	24.6%	79.6%	7.3%	18.6%	66.2%
Samoa	19.0%	31.2%	3.4%	5.8%	10.1%
Senegal	7.8%	11.2%	5.1%	1.7%	6.1%
Seychelles	2.4%	7.0%	0.9%	1.2%	3.5%
Sierra Leone	14.1%	26.2%	3.5%	6.0%	15.5%
Solomon Islands	8.5%	13.3%	5.9%	2.6%	5.9%
Sri Lanka	4.6%	8.4%	1.6%	1.1%	3.1%
St. Lucia	3.9%	7.6%	0.1%	1.9%	3.8%
Sudan	3.6%	6.3%	1.1%	0.9%	2.0%
Suriname	9.7%	15.8%	5.9%	3.0%	9.9%
Swaziland	2.0%	3.0%	0.6%	0.6%	1.6%
Tanzania	14.2%	22.6%	7.7%	5.2%	12.5%
Togo	8.2%	12.0%	4.4%	2.6%	5.4%
Tonga	9.9%	16.6%	5.8%	3.2%	10.3%
Tunisia	0.9%	2.0%	-0.2%	0.4%	1.0%
Uganda	12.8%	20.6%	7.5%	3.3%	5.8%
Vanuatu	8.8%	18.0%	3.0%	3.5%	7.7%
Viet Nam	2.7%	4.3%	0.8%	1.5%	3.5%
Yemen	3.8%	5.2%	2.7%	1.1%	2.1%
Zambia	17.7%	52.2%	-0.1%	14.6%	40.2%
Zimbabwe	4.4%	8.9%	2.3%	1.9%	5.7%

Note: countries excluded are: (1) DAC countries Part II, (2) middle income countries receiving negligible amounts of ODA

Table 2 - Controls on Capital Movements, 2002

Country	On capital market securities	On money market instruments	On collective investment securities	Controls on personal capital movements
Algeria	yes	yes	n.r.	n.a.
Angola	yes	yes	yes	yes
Antigua	no	no	no	no
Aruba	yes	yes	yes	yes
Azerbaijan	yes	yes	yes	yes
Bangladesh	yes	yes	yes	yes
Belize	yes	yes	yes	yes
Benin	yes	yes	yes	yes
Bhutan	yes	yes	yes	yes
Bolivia	no	no	no	no
Botswana	yes	yes	no	no
Burkina Faso	yes	yes	yes	yes
Burundi	yes	yes	n.r.	yes
Cambodia	n.r.	n.r.	n.r.	yes
Cameroon	yes	yes	yes	yes
Cape Verde	yes	yes	no	yes
Chad	yes	yes	yes	yes
Comoros	yes	n.r.	n.r.	yes
Djibouti	no	no	no	no
Dominica	yes	yes	yes	yes
Egypt	yes	no	no	no
El Salvador	no	no	no	no
Eritrea	yes	yes	n.a.	yes
Ethiopia	yes	no	no	yes
Gabon	yes	yes	yes	n.a.
Gambia	no	no	no	n.a.
Ghana	yes	yes	yes	yes
Grenada	yes	yes	yes	yes
Guatemala	yes	no	no	no
Guinea	yes	yes	no	yes
Guinea-Bissau	yes	yes	yes	yes
Guyana	no	no	no	no
Haiti	n.a.	n.a.	n.a.	n.a.
Honduras	yes	no	yes	no
Iran	yes	yes	yes	yes
Israel	yes	yes	yes	no
Jamaica	n.r.	yes	yes	n.r.
Jordan	no	no	no	no
Kenya	yes	yes	yes	no
Kiribati	yes	yes	yes	n.r.
Lebanon	yes	yes	yes	no

Table 2 – Continued

Country	On capital market securities	On money market instruments	On collective investment securities	Controls on personal capital movements
Lesotho	yes	yes	yes	yes
Madagascar	yes	n.r.	n.r.	n.a.
Malawi	yes	yes	yes	yes
Maldives	yes	no	no	yes
Mali	yes	yes	yes	yes
Marshall Islands	n.a.	n.a.	n.a.	n.a.
Mauritania	yes	yes	yes	yes
Mauritius	yes	no	no	no
Micronesia	yes	n.r.	no	n.r.
Mongolia	yes	yes	yes	yes
Morocco	yes	yes	yes	yes
Mozambique	yes	yes	yes	yes
Namibia	yes	yes	yes	yes
Nepal	yes	no	n.a.	yes
Nicaragua	no	no	no	no
Niger	yes	yes	yes	yes
Nigeria	yes	yes	no	yes
Pakistan	yes	yes	yes	yes
Papua New Guinea	yes	yes	yes	yes
Paraguay	no	no	no	yes
Peru	no	no	no	no
Philippines	yes	yes	yes	yes
Rwanda	yes	yes	yes	yes
Samoa	yes	yes	yes	yes
Senegal	yes	yes	yes	yes
Seychelles	yes	no	no	no
Sierra Leone	yes	yes	yes	n.r.
Solomon Islands	yes	yes	yes	yes
Somalia	yes	yes	yes	n.a.
Sri Lanka	yes	yes	yes	yes
St Lucia	yes	yes	yes	yes
Sudan	yes	no	no	no
Suriname	n.a.	n.a.	n.a.	yes
Swaziland	yes	yes	yes	yes
Tanzania	yes	yes	yes	yes
Togo	yes	yes	yes	yes
Tonga	yes	yes	yes	yes
Tunisia	yes	yes	yes	yes
Uganda	no	no	no	no
Vanuatu	n.r.	n.r.	n.r.	n.r.
Vietnam	yes	yes	yes	yes
Yemen	no	no	no	no
Zambia	no	no	no	no
Zimbabwe	yes	yes	yes	yes

Table 3 – Estimation Results

Dependent variable: Δ log Effective Real Exchange Rate = Δ log e_t				
		(1)	**(2)**	**(2')**
Estimation technique		**F.E.**	**F.E.**	**GMM**
error correction: log e_{t-1} - β log Com_{t-1}		-0.044	-0.056	-0.077*
		(-1.27)	(-1.61)	(-1.74)
Countries with error correction:	$Comshare_t$*Δ log Com_t	0.151**	0.137**	0.171***
		(2.19)	(2.03)	(2.84)
Countries with error correction and ODA/GDP>2% (Hyp_t=0):	log ODA_{t-1}	0.028***	0.040***	0.042***
		(2.46)	(3.62)	(3.40)
	$Steril_{t-1}$*log ODA_{t-1}	.	-0.055***	-0.042***
		.	(-4.04)	(-2.78)
Countries with error correction and ODA/GDP<2% (Hyp_t=0):	log ODA_{t-1}	0.016	0.018*	0.027**
		(1.58)	(1.90)	(2.42)
	$Steril_{t-1}$*log ODA_{t-1}	.	-0.005	-0.008**
		.	(-1.22)	(-2.02)
Countries with *no* error correction and ODA/GDP>2% (Hyp_t=0):	log ODA_{t-1}	0.019**	0.029***	0.034***
		(2.25)	(2.97)	(4.08)
	$Steril_{t-1}$*log ODA_{t-1}	.	-0.022**	-0.033***
		.	(-2.27)	(-3.62)
Countries with *no* error correction and ODA/GDP<2% (Hyp_t=0):	log ODA_{t-1}	0.017***	0.025***	0.023***
		(3.43)	(5.31)	(4.47)
	$Steril_{t-1}$*log ODA_{t-1}	.	-0.010***	-0.007***
		.	(-3.63)	(-2.94)

$\Delta \log e_{t-1}$	-0.018	-0.024	-0.022
	(-0.58)	(-0.72)	(-0.74)
Hyp_t	-0.077***	-0.085***	-0.095***
	(-2.63)	(-3.05)	(-3.43)
country fixed effects	yes	yes	yes
year dummies	yes	yes	yes
Nb. Of Obs	1263	1238	913
adj R2	0.248	0.240	.
Wald test (joint significance)	.	.	1908.54
Degrees of Freedom	.	.	48
p-value	.	.	0.000
Test of autocorrelation of order 1	.	.	-4.57
Test of autocorrelation of order 2	.	.	-0.98
Sargan test	.	.	810.94
Degrees of freedom	.	.	1713
p-value	.	.	0.999

*, ** and ***: significant respectively at 10%, 5% and 1% level
t-statistics are corrected for heteroschedasticity
The nominal black market exchange rates are from Reinhart and Rogoff (2002), US $ dollar against domestic currency
The methodology for computing effective exchange rates is from the IMF Effective Exchange Rate Facility
Trade weights are from the EER Facility and Consumer Price Indices are from the IFS
logODA = log of official development assistance, excluding technical cooperation, relative to GDP
logCom = log of commodity price index, from Cashin et al. (2002), extended before 1980
ComShare = the share of commodity exports in total exports (in percent)
Hyp = dummy variable for hyperinflation sub-group
The sterilization measure (Steril) is defined in the following way:
(1) = 0 if change in net domestic assets>0
(2) = minus change in net domestic assets / official development assistance if change in net domestic assets is between 0 and 1
(3) =1 if minus change in net domestic assets>offical development assistance