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The Macroeconomics of Medium-Term Aid Scaling-Up Scenarios

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Abstract

We develop a model to analyze the macroeconomic effects of a scaling-up of aid and assess the implications of different policy responses. The model features key structural characteristics of low-income countries, including varying degrees of public investment efficiency and a learning-by-doing (LBD) externality that captures Dutch disease effects. On the policy front, it distinguishes between spending the aid, which is controlled by the fiscal authority, and absorbing the aid—financing a higher current account deficit—which is influenced by the central bank's reserve accumulation policies. We calibrate the model to Uganda and run several experiments. We find that a policy mix that results in full spending and absorption of aid can generate temporary demand and real exchange rate appreciation pressures, but also have a positive effect on real GDP in the medium term, through higher public capital. Full spending with partial absorption, on the other hand, may stem appreciation pressures but can also induce adverse medium-term real GDP effects, through private sector crowding out. When aid is very inefficiently invested and there are strong LBD externalities, aid can be harmful, and partial absorption policies may be justified. But in this case, a welfare improving solution is to defer spending or—even better if possible—raise its efficiency.

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Table of Contents Page

Tables

Figures

Appendix

I. Introduction

Aid surges offer both challenges and opportunities to recipient countries. Some argue that these surges may hurt growth by inducing real exchange rate appreciation pressures, to the detriment of growth-promoting exporting industries;[1] while others believe they may spur growth by financing much-needed public investment in infrastructure.[2]

Concerns about the potential negative effects of aid surges may trigger policy responses aimed at dampening these effects. For instance, Berg et al. (2007) documents how, during aid surges, concerns about real appreciation induced several African economies to accumulate much of the additional aid-related foreign currency in reserves. This response may have helped contain the appreciation pressures. But when combined with a fiscal policy that entailed the full spending of the local currency counterpart to the aid, this response turned out to be problematic. It led to an increase in the money supply, and different sterilization policies posed new challenges to these economies: those that did not sterilize faced high inflation; whereas those that did sterilize experienced high interest rates.

These differing views and concerns about aid surges have created the need for a common framework to analyze the *short and medium* term macroeconomic effects of aid surges, as well as the appropriate policy responses. This paper proposes such a framework, by developing a dynamic quantitative model that can be useful for Fund staff teams and policy-makers in recipient countries. The model has already been used to help formulate country-specific aid scaling up scenarios. As part of the United Nations Millennium Development Goals (MDG) Africa Steering and Working Groups, the IMF was requested to provide macroeconomic assessments of "Gleneagles aid scaling-up scenarios" for several African countries. IMF (2008a) and IMF (2008b) present the first six country scenarios, five of which used the model presented here.[3]

The novelty of our model stems from its structure, which captures the main mechanisms and policy issues of interest in low-income countries (LICs). The model features a learning-by-doing mechanism (LBD) that creates an externality associated with the production of traded goods and captures the notion that real exchange rate appreciation may harm productivity growth in the traded sector; a role for public capital in production, so that government spending can raise output directly and potentially crowd in private investment; and less-than-full conversion of public investment into useful public capital.[4]

The model also allows for separate and possibly uncoordinated fiscal spending and reserve accumulation responses to aid surges, permitting a variety of policy combinations. By assumption, the fiscal

[1] See Rajan and Subramanian (2010), among others.

[2] See, for instance, Collier (2006).

[3] IMF and UNDP (2010) describes the full joint project. The assessments have been developed for Benin, Central African Republic, Ghana, Liberia, Niger, Rwanda, Sierra Leone, Togo, Tanzania, and Zambia. The model used for Niger is described in Farah et al. (2009).

[4] The model also features hand-to-mouth consumers to capture financial market imperfections that can give fiscal policy larger real effects in the short run; limited access to international capital markets that gives sterilized intervention an important role; and imperfect mobility of productive factors across traded and non-traded sectors, which affects the degree of real exchange rate appreciation.

authority eventually spends all the incremental aid; the question here is about the effects of doing so as the aid comes in, which we define as full spending of aid. The monetary authority, on the other hand, influences aid absorption, which we define as the use of the foreign currency proceeds from aid to finance higher current account deficits (net of aid). It does so by accumulating part of the aid flows in international reserves.

In previous work we have shown, using a smaller model without private or public investment, that policies that are frequently implemented in response to aid flows can have striking implications for the short-run behavior of macro variables such as the real exchange and the real interest rate.[5] Here, we demonstrate that the same policy responses can sometime have adverse medium-term effects as well, depending on the efficiency of public investment and the extent of learning by doing externalities in the economy.

We show these results by calibrating our model to the Ugandan economy and running several experiments. To fix ideas, we start with a baseline scenario of a flexible exchange rate regime, somewhat efficient public investment, mild LBD externalities, and fiscal and reserve accumulation rules that imply the full spending and absorption of aid. As the government spends the aid, demand pressures emerge. These combine with nominal price rigidities in the non-traded sector to create a short-lived spike in real gross domestic product (GDP). The real exchange rate substantially appreciates and the traded sector suffers a contraction but recovers in the medium term. Over time, price rigidities dissipate and the demand impulse fades out, but GDP continues to grow on the strength of higher public capital and the resulting higher private capital accumulation.

The substantial short-term real appreciation pressures of the baseline scenario may concern policy-makers who are committed to maintaining competitiveness in the traded sector. We therefore investigate the consequences of *partial absorption policies* that may help counteract these pressures: (i) accumulating some of the aid flows in reserves in the context of a (managed) float, and (ii) operating a fixed exchange rate regime.

Accumulating reserves succeeds in mitigating appreciation pressures but crowds out private consumption and investment in the short run, thus lowering real GDP over the medium term relative to the full-absorption baseline. The underlying cause of the crowding out is the attempt to use the same aid resources twice: the central bank uses aid inflows to build up reserves, while the fiscal authority uses the domestic currency counterpart of these inflows to increase spending. Aid resources can be used either by the government for increased spending or by the central bank for reserve buildup, but not for both without crowding out the private sector.

A fixed exchange rate regime may also stem appreciation pressures, depending on the associated monetary policy. This regime induces the authorities to accumulate reserves in resisting nominal appreciation. If the authorities do not sterilize the associated monetary emission, the resulting inflation induces a real appreciation and produces roughly a full-absorption scenario that closely resembles the baseline in real terms. Efforts to resist the inflation by sterilizing the monetary emission will again succeed in narrow terms but at a cost of partial aid absorption, higher real rates, and private sector

[5] See Berg, Mirzoev, Portillo, and Zanna (2010).

crowding out.[6] As before, this implies lower real GDP in the medium term.

Why might governments nonetheless consider partial absorption policies? Maybe because, in contrast to our baseline assumptions, the efficiency of public investment is low, while very strong LBD externalities imply a significant loss in productivity of the traded sector when output in this sector contracts. In this context, accumulating some additional aid in reserves may relieve some of the short-term appreciations pressures *without* inducing adverse medium-term effects on real GDP. To fully understand this result, it is necessary to investigate the roles of the efficiency of public investment and the LBD externalities—and their interaction—in the model.

Consider the role of efficiency, i.e., the extent to which public investment is actually converted into useful capital. In our model, there is a distinction between the efficiency of steady-state investment and that of the investment financed by the scaling-up of aid. What matters for the effects of aid on real GDP (in percent changes) is the efficiency of the aid-surge investment spending *relative to* steady-state efficiency. Our focus in this paper is on this "relative efficiency" concept. In our model, countries that are less efficient in this sense enjoy lower medium-term benefits in real GDP terms, as less public capital is accumulated and the crowding in effect on private investment is smaller.

Strong LBD externalities, on the other hand, raise the stakes: they may amplify positive effects of aid on traded output and real GDP—which we refer to as "Dutch vigor"—but the may also make aid *harmful*—causing "Dutch Disease." Whether the strong externalities amplify the positive or negative effects of aid depends on the efficiency of public investment, as this will determine if the shrinkage in the traded sector is temporary or protracted.

When efficiency is low and externalities are strong, Dutch-disease type effects can dominate—under full absorption policies—so that aid reduces real GDP. By limiting the contraction in traded sector output, partial absorption policies can help mitigate these effects, even if they still crowd out private investment in the short run.

In these circumstances, however, there are better ways to respond to aid surges, while mitigating appreciation pressures, than partial absorption policies. First, if government spending is inefficient and there are strong externalities, then the reserve accumulation policy could be accompanied by partial spending of aid. Second, if aid were to be used more efficiently, then the GDP effect of scaled-up aid would always be positive, and more so with full absorption.[7]

We support these findings with some simple welfare analysis. With low efficiency and strong externalities, accumulating some of the additional aid inflows in reserves may generate small welfare gains if aid is fully spent, although partial spending is preferable. However, with high efficiency, this result is overturned, as there are large gains from fully spending and absorbing the aid.

[6] The model features limited international capital mobility making sterilization policies effective in a small-open-economy set-up, even when the exchange rate is fixed.

[7] Spending more aid on investment rather than consumption or allocating more public investment towards the traded goods sector are policies that are not explored in this paper but that would—like achieving higher efficiency—yield better growth outcomes than partial absorption in the face of strong LBD externalities.

Our work distinguishes itself from the literature by simultaneously analyzing both short-term (demand) and the medium-term (supply) effects, in a context where fiscal and central bank policies shape the spending and absorption of aid and matter for medium-term outcomes. Adam et al. (2009), our previous work Berg et al. (2010), Buffie et al. (2008), and Prati and Tressel (2006), among others, also focus on the effects of various policy responses to aid inflows, but they do so in models where sectoral output is exogenous or capital accumulation is absent. The absence of capital accumulation is a notable simplification, given that all the way from the work of Keynes (1936) and Hicks (1939) to that of Kydland and Prescott (1982), macroeconomic theories have underscored investment dynamics as an important channel for the transmission of aggregate shocks. By introducing both public and private capital, our work shows that investment spending plays a key role in shaping the effects of monetary and fiscal policies under aid surges.

Our work also differs from papers that present real models with capital, including Adam and Bevan (2006), Agenor et al. (2008), Agenor and Yilmaz (2008), Arellano et al. (2009), Cerra et al. (2008), and Chatterjee and Turnovsky (2007), among others. Despite their important contribution, they do not model fiscal and monetary policies and, therefore, do not permit a rich discussion of the interaction of these policies and their implications for the short-to-long run effects of aid. In addition, these works have not underscored the role of the efficiency of public investment, as our work does.[8] These investment inefficiencies may have important implications for the empirical calculations of capital as well as for growth analysis.[9]

Finally, our partial absorption results are reminiscent of those in Calvo et al. (1995), which are derived in a small stylized model: absent international capital mobility, preventing the real exchange rate from appreciating leads to some combination of temporary higher inflation and higher domestic real interest rates.

The remainder of this paper is organized as follows. Section II presents the structure of the model. Section III discusses the calibration to Uganda. Section IV presents and elaborates on the results of the experiments, starting by the baseline scenario. A discussion of the scope of our results, including some welfare analysis, is presented in section V. Finally, section VI concludes.

II. The Model

Consider an infinite-horizon small open economy. The economy has two goods, a traded good (T) and a non-traded good (N), and consists of the following agents: i) two types of households, some participating in asset markets and others not; ii) two sectors with firms producing traded and non-traded goods using labor, private capital, and public capital; iii) a central bank in charge of exchange rate policy and monetary policy, including reserve accumulation policy; and iv) a fiscal authority that is the direct recipient of aid and decides how much of this aid to spend as part of its fiscal policy.

[8] Agenor et al. (2008) is a partial exception using a structural model that is not fully microfounded.

[9] See Hulten (1996) and Prichett (2000).

There is exogenous deterministic growth of the labor-augmenting type, which is the same across sectors. The labor productivity level $\mathcal{T}_t$ grows at the constant factor $\mathfrak{n}$ so that $\mathcal{T}_t = \mathfrak{n}\mathcal{T}_{t-1}$. To facilitate the description of the model, we will present its structure in stationary terms.[10] This involves rescaling variables by $\mathcal{T}_t$ when required, such that all the variables are constant in the long run (steady state).

We assume that the law of one price holds for the traded good. Therefore $P_t^T = S_t P_t^{T*}$, where P_t^T is the price of traded goods, S_t corresponds to the nominal exchange rate, and P_t^{T*} is the foreign price of traded goods. By denoting the domestic (foreign) Consumer Price Index (CPI) as P_t (P_t^*), we can express the CPI-based real exchange rate as $s_t = \frac{S_t P_t^*}{P_t}$ and the relative price of non-traded goods as $p_t^N = \frac{P_t^N}{Pt}$. We also define real gross domestic product (GDP) as:

$$y_t = \bar{p}^N y_t^N + \bar{s} y_t^T, \tag{1}$$

i.e., the sum of the production of the non-traded good, y_t^N, and the traded good, y_t^T, valued at their steady-state relative prices $\bar{p}^N$ and $\bar{s}$. Next, we describe the objectives and constraints of the different agents of this economy.

A. Households

There is a continuum of households on the interval $[0, 1]$. A fraction $\mathfrak{p}$ is represented by households who are forward-looking and smooth consumption by being able to trade in asset markets. These are asset holders or savers and will be indexed by the superscript "a". The rest of the households $1 - \mathfrak{p}$ have no assets and cannot smooth consumption. They will be indexed by the superscript "h" and behave in a "hand-to-mouth" fashion, fully consuming their current labor income.[11]

A.1. Asset Holders

Savers must decide how to allocate consumption expenditures among different goods. Consumption of the traded good and the non-traded good, denoted by c_t^{aT} and c_t^{aN}, respectively, are combined into a CES basket

$$c_t^a = \left[\varphi^{\frac{1}{\chi}} \left(c_t^{jN}\right)^{\frac{\chi-1}{\chi}} + (1-\varphi)^{\frac{1}{\chi}} \left(c_t^{jT}\right)^{\frac{\chi-1}{\chi}}\right]^{\frac{\chi}{\chi-1}}, \tag{2}$$

with the associated CPI $P_t = \left[\varphi \left(P_t^N\right)^{1-\chi} + (1-\varphi)(P_t^T)^{1-\chi}\right]^{\frac{1}{1-\chi}}$, where χ denotes the intratemporal elasticity of substitution, and φ is the degree of home bias in consumption. This CES aggregator implies the following demand functions for traded and non-traded goods: $c_t^{aN} = \varphi \left(p_t^N\right)^{-\chi} c_t^a$ and $c_t^{aT} = (1-\varphi) {s_t}^{-\chi} c_t^a$. The non-traded good is in turn a composite good with a continuum of varieties indexed by $i \in [0, 1]$ satisfying $c_t^{aN} = \left[\int_0^1 \left(c_{it}^{aN}\right)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}$, with θ measuring the elasticity of substitution of

[10] The first part of the Appendix discusses in more detail how to transform the model in stationary terms.

[11] A recent survey conducted in Uganda finds that almost 62 percent of the sample does not access formal or informal financial markets. See Steadman Group (2009).

these varieties. The demand for variety i is given by:

$$c_{it}^{aN} = \left(\frac{p_{it}^N}{p_t^N} \right)^{-\theta} c_t^{aN}, \tag{3}$$

where $p_{it}^N \equiv \frac{P_{it}^N}{P_t}$ and $P_t^N = \left[\int_0^1 \left(P_{it}^N \right)^{1-\theta} di \right]^{\frac{1}{1-\theta}}$.

The representative saver maximizes his life-time utility:[12]

$$\sum_{t=0}^{\infty} (\beta^a)^t \left[u^a(c_t^a, m_t^a) - \frac{\varkappa^a}{1+\psi} (l_t^a)^{1+\psi} \right], \tag{4}$$

with

$$u^a(c_t^a, m_t^a) \equiv \log \left\{ \left[\vartheta^a (c_t^a)^{\frac{\eta-1}{\eta}} + (1-\vartheta^a)\,(m_t^a)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{1-\eta}} \right\}, \tag{5}$$

where $c_t^a \equiv \frac{C_t^a}{\mathcal{T}_t}$ refers to a consumption basket of the type described in (2), $m_t^a \equiv \frac{M_t^a}{P_t \mathcal{T}_t}$ are the holdings of real money balances, and l_t^a is the amount of labor supplied to firms for the production of the non-traded and traded goods. The parameter $\beta^a \in (0,1)$ corresponds to the subjective discount factor of the asset holders, $\vartheta^a \in (0,1)$ is the share of consumption in the utility $u^a(.)$, $\eta > 0$ measures the elasticity of substitution between c_t^a and m_t^a, $\varkappa^a$ is a scale parameter, and $\psi > 0$ is the inverse of the labor supply elasticity.

We want to capture the notion that labor mobility is limited across sectors and that intersectoral wage differentials are possible. Supplied labor is then defined as in Bouakez et al. (2009):

$$l_t^a = \left[\delta^{-\frac{1}{\varrho}} \left(l_t^{aN} \right)^{\frac{1+\varrho}{\varrho}} + (1-\delta)^{-\frac{1}{\varrho}} \left(l_t^{aT} \right)^{\frac{1+\varrho}{\varrho}} \right]^{\frac{\varrho}{1+\varrho}}, \tag{6}$$

where $\delta \in (0,1)$ is the share of labor supplied to the non-traded sector, l_t^{aN}, in total employment, and $\varrho > 0$ is the elasticity of substitution between labor services provided to the two sectors. The index of real wages associated with the aggregator (6) corresponds to:

$$w_t = \left[\delta \left(w_t^N \right)^{1+\varrho} + (1-\delta) \left(w_t^T \right)^{1+\varrho} \right]^{\frac{1}{1+\varrho}}. \tag{7}$$

The budget constraint of the representative agent, deflated by the domestic CPI and expressed in stationary terms, is given by:

$$c_t^a + m_t^a + b_t^{ac} + s_t b_t^{a*} + s_t \mathcal{P}_t^a = (1-\tau) w_t l_t^a + \frac{m_{t-1}^a}{\mathfrak{n}\pi_t} + i_{t-1} \frac{b_{t-1}^{ac}}{\mathfrak{n}\pi_t} + s_t i_{t-1}^* \frac{b_{t-1}^{a*}}{\mathfrak{n}\pi^*} + \Omega_t^a + s_t r m^* + \tau^a, \tag{8}$$

where $b_t^{ac} \equiv \frac{B_t^{ac}}{P_t \mathcal{T}_t}$ is the saver's real holdings of domestic bonds issued by the government, which pay a "gross" nominal interest rate $i_t \equiv 1 + \mathfrak{r}_t$ and $b_t^{a*} \equiv \frac{B_t^{a*}}{P_t^* \mathcal{T}_t}$ denotes his real holdings of foreign assets that pay a "gross" nominal international interest rate i_t^* and are subject to portfolio adjustment costs $\mathcal{P}_t^a$.

[12] Because we are writing the problem of the agent in stationary terms, the objective function should also include the term $(\beta^a)^t log(\mathcal{T}_t)$. We can omit this term, since $\mathcal{T}_t$ is exogenous and does not represent a control variable.

Total labor income satisfies $w_t l_t^a = w_t^N l_t^{aN} + w_t^T l_t^{aT}$ with $w_t^k \equiv \frac{W_t^k}{P_t T_t}$ denoting the real wage in sector $k = N, T$. Moreover, $\pi_t = \frac{P_t}{P_{t-1}}$ denotes "gross" domestic inflation, while π^* is foreign inflation, which is assumed to be constant; Ω_t^a denotes real profits from domestic firms; τ is an income tax rate set by the government; rm^* are remittances received from abroad and assumed to be constant; and τ^a is a transfer from asset holders to hand-to-mouth consumers.[13] This budget constraint implies that spending (left-hand side) must equal income (right-hand side).

The portfolio adjustment costs are given by $\mathcal{P}_t^a \equiv \frac{\upsilon}{2}(b_t^{a*} - \bar{b}^{a*})^2$, where $\bar{b}^{a*}$ is the steady-state value of the real foreign assets. These costs serve two purposes. First, they ensure stationarity of b_t^{a*}.[14] Second, they allow us to model different degrees of international capital mobility. When $\upsilon \to +\infty$, the capital account is practically closed; whereas when $0 < \upsilon << \infty$, it is partially open.

The problem of the asset holders reduces to maximizing (4) with respect to consumption, real money balances, labor supply in both sectors, and domestic and foreign assets, subject to the constraint (8) and a transversality condition associated with all asset holdings. The first-order conditions of this problem are presented in the Appendix.

A.2. Hand-to-Mouth Consumers

Households that do not have access to asset markets rely on labor income, remittances, and transfers as their only source of income. The representative agent from this group maximizes utility as in (4) and (5), where c_t^h and l_t^h take the same form as in (2) and (6). The agent is subject to a transversality condition associated with money holdings and the budget constraint:[15]

$$c_t^h + m_t^h = (1-\tau) w_t l_t^h + \frac{m_{t-1}^h}{\mathfrak{n}\pi_t} + s_t rm^* + \tau^h, \tag{9}$$

with $w_t l_t^h = w_t^N l_t^{hN} + w_t^T l_t^{hT}$ and $\tau^h = -\frac{\mathfrak{p}}{1-\mathfrak{p}}\tau^a$. Note that in principle hand-to-mouth consumers could smooth consumption by changing their money holdings. To prevent this, we can assume that their subjective discount factor β^h is set to zero. In this regard, their problem becomes static. The first-order conditions of this problem are listed in the Appendix.

B. Non-Traded Good Sector

This sector faces monopolistic competition and nominal price rigidities. Each monopolist produces a variety i of the non-traded good. The technology of the representative producer i is given by:

$$y_{it}^N = z^N \left[\left(k_{it-1}^N\right)^{\phi_N} (q_{t-1})^{1-\phi_N} \right]^{1-\alpha_N} \left(l_{it}^N\right)^{\alpha_N}, \tag{10}$$

[13] This transfer simplifies the analysis of the model by avoiding the need to keep track of the different consumers. They ensure that consumption at the steady state is the same for the two types of households. See Galí et al. (2007).

[14] See Schmitt-Grohé and Uribe (2003) for alternative methods to ensure stationarity of net foreign assets.

[15] The share of consumption in the utility for these consumers, ϑ^h, can be different from that of asset holders. In this way we ensure that real money balances are the same across both types of households, at the steady state, given that the demand functions are not the same for both types, as shown in the first-order conditions stated in the Appendix.

where z^N is a constant productivity parameter, l_{it}^N is the amount of labor employed, k_{it-1}^N is private capital, which is firm-specific, and q_{t-1} is public capital. The coefficient α_N indicates the production share of labor, while ϕ_N denotes the share of private capital in total capital used in production. Private capital is subject to a depreciation rate δ_N. It is accumulated via investment x_{it}^N, which is a composite of traded and non-traded goods like in (2), and subject to adjustment costs $\mathcal{F}_{it}^N \equiv \frac{\kappa_N}{2}\left(\frac{x_{it}^N}{x_{it-1}^N}-1\right)^2$, as in Christiano et al. (2005). Then:

$$\mathfrak{n}k_{it}^N = (1-\delta_N)k_{it-1}^N + \left(1-\mathcal{F}_{it}^N\right)x_{it}^N. \tag{11}$$

The monopolist is subject to a demand constraint of the Dixit-Stiglitz type described in (3)

$$y_{it}^N = \left(\frac{p_{it}^N}{p_t^N}\right)^{-\theta} y_t^N, \tag{12}$$

where y_t^N is the overall demand for the non-traded good. She also faces price adjustment costs $\mathcal{G}_{it} \equiv \frac{\zeta}{2}\left[\left(\frac{p_{it}^N}{p_{it-1}^N \pi_{t-1}^N}\right)-1\right]^2 p_t^N y_t^N$, where π_t^N is the non-traded goods inflation with the steady-state value represented by $\bar{\pi}^N$. These costs are a variant of those proposed by Rotemberg (1982), as they allow for indexation to past values of inflation.

The maximization problem of the monopolist corresponds to choosing the price level p_{it}^N, the amount of labor, capital, and investment in order to maximize the discounted profits

$$\sum_{t=0}^{\infty} J_t \left\{(1-\varpi)(1+\iota_N)\left[p_{it}^N y_{it}^N - \mathcal{G}_{it}\right] - w_t^N l_{it}^N - x_{it}^N + (\varpi-\iota_N)(p_t^N y_t^N - \mathcal{G}_t)\right\},$$

subject to equations (10)-(12), where $\mathcal{G}_t$ corresponds to $\mathcal{G}_{it}$ with $p_{it}^N = p_t^N$.[16] The first-order conditions are presented in the Appendix.

There is a tax distortion ϖ that reduces the value of firms' sales net of price adjustment costs for any given level of production. This distortion is offset in the aggregate, as the amount $\varpi(p_t^N y_t^N - \mathcal{G}_t)$ is restituted to each firm, but it affects firms' incentive to hire labor and invest in new capital. It is meant to capture a broad set of institutional features that keep poor countries from investing at the high rates that might otherwise be justified by the very low stocks of private capital. In this way, we match the observed low investment shares in many low-income countries. In addition, each firm receives a subsidy ι_N per unit produced and net of price adjustment costs, which is financed with a tax common to the entire sector. This simplifies the steady-state analysis by ensuring that distortions arising from monopolistic competition are zero at steady state.

[16] The discount factor J_t of the profits is stochastic and related to the asset holders' marginal utility of consumption, since they own the firms.

C. Traded Good Sector

The traded sector features perfect competition and flexible prices. The representative firm j is endowed with a similar technology to that of the non-traded sector:

$$y_{it}^T = z_t^T \left[\left(k_{it-1}^T\right)^{\phi_T} (q_{t-1})^{1-\phi_T} \right]^{1-\alpha_T} \left(l_{it}^T\right)^{\alpha_T} . \tag{13}$$

The representative firm also accumulates capital k_{it}^T through investment x_{it}^T which is subject to adjustment costs $\mathcal{F}_{it}^T \equiv \frac{\kappa_T}{2} \left(\frac{x_{it}^T}{x_{it-1}^T} - 1 \right)^2$. Accumulation is dictated by

$$\mathfrak{n} k_{it}^T = (1-\delta_T) k_{it-1}^T + \left(1 - \mathcal{F}_{it}^T\right) x_{it}^T. \tag{14}$$

The firm picks the amount of capital, labor and investment in order to maximize the discounted profits

$$\sum_{t=0}^{\infty} J_t \left[(1-\varpi) s_t y_{it}^T - w_t^T l_{it}^T - x_{it}^T + \varpi s_t y_t^T \right],$$

subject to equations (13) and (14). As in the non-traded sector, sales in this sector are also subject to the tax rate ϖ. The Appendix lists the first order conditions.

One of the chief concerns with a scaling up of aid is the possibility of Dutch disease effects. Frequently, the real appreciation and shrinkage of the traded sector are interpreted as evidence of these effects. However both effects may not constitute a "disease", as they are an indispensable part of the transmission mechanism to shift resources from the traded to the non-traded sector in order to meet higher government demand for non-traded goods. Rather, to capture the idea of a "disease", we introduce learning-by-doing (LBD) effects into the traded sector: a decline in the traded sector will impose an economic cost through lost total-factor productivity (TFP) in this sector.[17]

More formally, we assume that the productivity in the traded sector depends on the history of the deviations of the previous sectoral outputs from the steady state, as can be inferred from

$$\frac{z_t^T}{\bar{z}^T} = \left(\frac{z_{t-1}^T}{\bar{z}^T} \right)^{\rho_z} \left(\frac{y_{t-1}^T}{\bar{y}^T} \right)^{\mathfrak{v}}, \tag{15}$$

where $\bar{z}^T$ is the steady-state value of the productivity in the traded sector, and $\rho_z \in (0,1)$ and $\mathfrak{v} > 0$. This specification is a variation of the one in Matsuyama (1992) and Krugman (1987).[18] It implies that there are no permanent effects of learning by doing on output or productivity. But deviations of traded sector output from trend do imply persistent productivity effects.

[17] Rodrik (2008) models LBD as one of two broadly equivalent—for our purposes—reasons why real appreciation could lower productivity growth, the other being that the traded sector is intensive in public goods such as strong contracting institutions that are scarce in many low-income countries.

[18] See also Adam and Bevan (2006) and Torvik (2001), among others.

D. The Government

Governments face potentially good opportunities for public investment but have limited access to external capital and find raising taxes very costly.[19] The government is the direct recipient of foreign aid A_t^*, which follows the process

$$A_t^* = \bar{A}^* + \rho_A (A_{t-1}^* - \bar{A}^*) + \epsilon_t^A, \tag{16}$$

where $\bar{A}^*$ is the steady state level of aid, ϵ_t^A corresponds to an exogenous increase in aid at time t, and $\rho_A \in (0,1)$ is a parameter that measures the degree of persistence of the increase in aid.

Government consumption g_t is a CES basket that includes traded and non-traded goods and is defined by

$$g_t = \left[\nu^{\frac{1}{\chi}} \left(g_t^N \right)^{\frac{\chi-1}{\chi}} + (1-\nu)^{\frac{1}{\chi}} \left(g_t^T \right)^{\frac{\chi-1}{\chi}} \right]^{\frac{\chi}{\chi-1}}, \tag{17}$$

which implies the following government price index $p_t^g = \left[\nu \left(p_t^N \right)^{1-\chi} + (1-\nu)(s_t)^{1-\chi} \right]^{\frac{1}{1-\chi}}$, expressed in terms of the CPI. In this specification, ν is the degree of home bias in government consumption, which may differ from its private counterpart. Using the aggregator (17), we can derive the following demand functions:

$$g_t^N = \nu \left(p_t^N \right)^{-\chi} g_t; \qquad \text{and} \qquad g_t^T = (1-\nu) s_t{}^{-\chi} g_t. \tag{18}$$

The government can finance its spending $p_t^g g_t$ through a variety of sources: taxes on labor income $\tau w_t l_t$, using the domestic currency value of aid proceeds, $s_t A_t^*$, drawing down on deposits held at the central bank, $\left(d_t^g - \frac{d_{t-1}^g}{\mathfrak{n}\pi_t} \right)$, or issuing domestic debt net of amortization $\left(b_t - \frac{b_{t-1}}{\mathfrak{n}\pi_t} \right)$. This domestic debt (b_t) is held by households that can save (b_t^c) and by the central bank (b_t^{cb}). The government also pays interest on the share of government debt that is held by consumers, $\frac{(i_{t-1}-1) b_{t-1}^c}{\mathfrak{n}\pi_t}$. Then we can write the period-by-period government budget constraint as

$$p_t^g g_t = \tau w_t l_t + s_t A_t^* - \left(d_t^g - \frac{d_{t-1}^g}{\mathfrak{n}\pi_t} \right) + \left(b_t - \frac{b_{t-1}}{\mathfrak{n}\pi_t} \right) - \frac{(i_{t-1}-1) b_{t-1}^c}{\mathfrak{n}\pi_t}, \tag{19}$$

where $l_t = \mathfrak{p} l_t^a + (1-\mathfrak{p}) l_t^h$ and $b_t = b_t^c + b_t^{cb}$.

Government spending g_t, which is endogenously determined by the constraint (19), can be used for public consumption or investment purposes.[20] We distinguish between the public investment that is a constant share of steady-state government spending, i.e., $x_t^{gs} = \mu_s \bar{g}$ with $\mu_s \in [0,1]$; and the public investment associated with the increase in aid, i.e., $x_t^{gA} = \mu_A (g_t - \bar{g})$ with $\mu_A \in [0,1]$. These investments serve to accumulate public capital q_t following

$$\mathfrak{n} q_t = (1-\delta_g) q_{t-1} + \varepsilon_s x_t^{gs} + \varepsilon_A x_t^{gA}, \tag{20}$$

[19] On revenue-raising capacities in low-income countries, see Heller et al. (2006).

[20] We do not model agency and asymmetric information problems between donors and recipients that may determine aid composition as in Cordella and Dell'Ariccia (2007). Neither do we consider the implications of aid for institutional development, except indirectly insofar as this is related to the size of the traded goods sector. On these issues, see e.g. Johnson, Ostry, and Subramanian (2007).

where δ_g is the depreciation rate of public capital, and $\varepsilon_s, \varepsilon_A \in [0,1]$ measure the efficiencies of the two types of public investment.

These efficiency parameters ε_s and ε_A capture the idea that less than one dollar of public capital is created for each public dollar spent on investment. The traditional "perpetual inventory method" infers the stock of public capital from information on public investment, and assumptions about depreciation rates, using equation (20), with the critical implicit assumption that $\varepsilon_s = 1$ and $\varepsilon_A = 1$. However, this assumption is fraught, particularly in developing economies. Whether because of waste and corruption, an absence of market pressures to ensure that all projects have the highest possible rate of return, or simply misclassification of current spending (e.g. salary payments to civil servants) as investment, a dollar of public investment spending may not always yields a full dollar of public capital, as argued by Pritchett (2000).[21]

The fiscal policy question of interest here is how fast to spend the local currency counterpart to aid inflows. We assume that aid dollars accrue to the fiscal authority, which then sells them to the central bank in return for a domestic currency deposit. The accumulation of government deposits is described by the following rule, which depends on the increase in aid:

$$d_t^g = \rho_d d_{t-1}^g + (1-\rho_d)\bar{d}^g + (1-\gamma)s_t\left(A_t^* - \bar{A}^*\right), \tag{21}$$

where $\bar{A}^*$ and $\bar{d}^g$ are the steady-state levels of aid and deposits, and $\rho_d \in (0,1)$. In this setup, the government will always spend the steady state amount of aid. However, an increase in aid A_t^* may or may not be spent initially, depending on the policy parameter $\gamma \in [0,1]$. If aid is not spent, it will initially accumulate as deposits but will be gradually spent over time. Both ρ_d and γ determine the speed of spending. To close the fiscal policy side of the model, we assume that domestic government debt is constant: $b_t = \bar{b}$.

E. The Central Bank

In a typical aid-dependent country, the canonical aid-related monetary policy problem can be described as follows: when the government spends the local-currency counterpart to aid inflows, how should the resulting monetary emission be handled? In particular, how much should be sterilized? And should the sterilization be done through the sale of local-currency open-market operations or through the sale of foreign exchange?

To study this problem, we introduce in the model the central bank balance sheet

$$m_t - \frac{m_{t-1}}{\mathfrak{n}\pi_t} = b_t^{cb} - \frac{b_t^{cb}}{\mathfrak{n}\pi_t} - \left(d_t^g - \frac{d_{t-1}^g}{\mathfrak{n}\pi_t}\right) + s_t\left(R_t^* - \frac{R_{t-1}^*}{\mathfrak{n}\pi^*}\right), \tag{22}$$

[21] The specification in (20) also captures some of the main insights from the theoretical literature that investigates how inefficient and corrupt bureaucracies interact with the provision of public infrastructure services and negatively affect the productivity of private capital and growth. See Chakraborty and Dabla-Norris (2009) and Sarte (2001), among others. A different approach to model inefficiency considers that governments can be viewed as producers of (public) goods. Governments that produce more of a particular good while spending less on inputs can be viewed as more efficient than governments that produce less output and use more inputs. As an application of this approach to estimate the efficiency of government expenditure on education and health in Africa, see Gupta and Verhoeven (2001).

where b_t^{cb} are the government bonds held by the central bank and R_t^* denotes the foreign currency value of reserves. The balance sheet implies that changes in money supply, $m_t - \frac{m_{t-1}}{\mathfrak{n}\pi_t}$, depend on open market operations, $b_t^{cb} - \frac{b_t^{cb}}{\mathfrak{n}\pi_t}$, changes in deposits, $d_t^g - \frac{d_{t-1}^g}{\mathfrak{n}\pi_t}$, and changes in net foreign assets, which by assumption are fully driven by changes in international reserves, $s_t\left(R_t^* - \frac{R_{t-1}^*}{\mathfrak{n}\pi^*}\right)$.

The central bank implements the following rule for the foreign currency value of reserves:

$$R_t^* = \rho_R R_{t-1}^* + (1-\rho_R)\bar{R}^* + (1-\omega)\left(A_t^* - \bar{A}^*\right) - \omega_s(\pi_t^S - \bar{\pi}^S), \tag{23}$$

where π_t^S is the nominal depreciation of the currency, and $\bar{R}^*$ and $\bar{\pi}^S$ are the steady-state levels of reserves and nominal depreciation. The persistence parameter ρ_R satisfies $\rho_R \in (0,1)$, while $\omega_s \geq 0$ measures the degree of commitment to a nominal depreciation target.

This rule implies that the accumulation of reserves is driven by three separate factors. First, the central bank always sells the steady-state value of aid, but may react differently to *changes* in the volume of aid. The coefficient ω measures the fraction of additional aid dollars sold on the market by the central bank, i.e., the degree of immediate absorption outside of the steady state. Second, the central bank may also follow a fixed exchange rate regime by setting ω_s very high.[22] Finally, while the amount of reserves may deviate persistently from its long-run value, we assume that the central bank targets a particular long-run value of reserves, provided that ω_s is not infinite, which may be calibrated to a country's historical average or to some desired level of reserves.

Regarding the monetary policy rule, we assume that open-market operations adjust so that reserve money always grows at the rate $\mathfrak{g}\left(\frac{\pi_t}{\bar{\pi}}\right)^{-\phi_\pi}$. This captures the fact that many low-income countries still target money, at least *de jure.* Note that at the steady state, reserve money grows at the rate $\mathfrak{g}$, and otherwise its growth rate is adjusted in response to inflation. More specifically, open-market operations imply the following process for b_t^{cb}:

$$b_t^{cb} - \frac{b_{t-1}^{cb}}{\mathfrak{n}\pi_t} = \frac{m_{t-1}}{\mathfrak{n}\pi_t}\left[\mathfrak{g}\left(\frac{\pi_t}{\bar{\pi}}\right)^{-\phi_\pi} - 1\right] + \left(d_t^g - \frac{d_{t-1}^g}{\mathfrak{n}\pi_t}\right) - s_t\left(R_t^* - \frac{R_{t-1}^*}{\mathfrak{n}\pi^*}\right). \tag{24}$$

Therefore in the event that aid is spent but not absorbed, open-market operations would increase in order to fully sterilize the direct monetary injection that would follow from incremental aid inflows. Note that because the previously introduced portfolio adjustment costs $\mathcal{P}_t^a$ are a function of *private* sector net foreign assets, central bank sterilized interventions will in general matter in this set-up, as we will see below.

F. Aggregation and the Goods Market Equilibrium Conditions

We aggregate across both types of households, so $\mathfrak{a}_t = \mathfrak{p}\mathfrak{a}_t^a + (1-\mathfrak{p})\mathfrak{a}_t^h$ for $\mathfrak{a}_t = (c_t,\, c_t^N,\, c_t^T,\, m_t,\, l_t,\, b_t^*,\, b_t^c,\, rm^*,\, \Omega_t)$. We focus on a symmetric equilibrium, so we can drop the sub-indices that distinguish among firms in the productive sector. The Appendix provides a definition of equilibrium in this model.

[22] Depending on the degree of capital mobility, the commitment to an exchange rate target may be limited by the monetary policy rule.

Here we only state the goods-market equilibrium conditions. The equilibrium in the non-traded goods market is described by:

$$y_t^N = \left(p_t^N\right)^{-\chi} D_t^N, \tag{25}$$

where $D_t^N = \varphi\left(c_t + x_t^N + x_t^T + \mathcal{G}_t\right) + \nu\left(p_t^g\right)^{\chi} g_t$; while the market-clearing condition for traded goods can be derived by combining the equilibrium condition (25) and the budget constraints for all agents, including both types of consumers, the government, and the central bank:

$$A_t^* = \underbrace{c_t^T + g_t^T + x_t^{TT} + x_t^{NT} + \mathfrak{p}\mathcal{P}_t^a - y_t^T - rm^* - \frac{(i_{t-1}^* - 1)b_{t-1}^*}{\mathfrak{n}\pi^*}}_{\text{CAD}} + \underbrace{b_t^* - \frac{b_{t-1}^*}{\mathfrak{n}\pi^*}}_{\text{KAS}} + \underbrace{R_t^* - \frac{R_{t-1}^*}{\mathfrak{n}\pi^*}}_{\text{RA}}, \tag{26}$$

where x_t^{TT} and x_t^{NT} correspond to the traded components of the investments in the traded and non-traded sectors, respectively. Equation (26) also summarizes the possible uses of aid: it can finance a higher current account deficit net of aid (CAD), a capital account surplus (KAS), or an accumulation of reserves (RA).

III. Calibration

Our analysis will rely on calibrated numerical simulations.[23] Because the model is micro-founded, some parameters can be based on microeconomic evidence, such as the efficiency of investment. Other parameters depend on steady-state ratios that can be determined from national income accounts, public and private sector balance sheets and input-output matrices, or can be informed by more-or-less structural macroeconometric estimates, e.g. money demand parameters. Other parameters describe the policy response to aid or the policy regime in place and can therefore be treated as free parameters that are modified according to the policy experiment.

Some parameters will remain poorly determined, whether because data are unavailable or because the model's simplifications imply that an exact empirical counterpart may not exist. For these parameters calibration is based partly on standard values found in the macro literature, and partly on desirable properties for the dynamics of the model following the increase in aid—such as smooth hump-shaped responses. For this reason and, more generally, as a check on the overall calibration, system properties of the model, such as on the effects of aid or public investment on growth, are also compared to reduced form macroeconometric or case-study evidence.

We calibrate most of the parameters of the model to the Ugandan economy. Since there are a large number of parameters, we organize the discussion around three groups: preferences, technology, and policy. Tables 1-3 summarize the calibration or policy reactions we will study below. We now briefly discuss the calibration of some of the parameters that are crucial for the policy experiments.

The preference parameters are presented in Table 1. Regarding the value for $1 - \mathfrak{p}$, the 2009 Steadman Survey finds that 62 percent of Ugandans do not have access to formal or informal financial services. The interaction of such large share of hand-to-mouth consumers with the money targeting

[23] The model was simulated with the software Dynare. See http://www.cepremap.cnrs.fr/dynare.

rule results in large spikes in the real interest rate in the baseline scenario that do not seem plausible. As a result, a lower share was chosen. With respect to the parameter ϱ, which measures the elasticity of substitution between hours worked in the two sectors, there are no empirical estimates for developing economies. We set it to 1, which corresponds to the econometric estimates provided by Horvath (2000).

Table 1. Baseline Calibration: Preference Parameters

Parameters	Value	Source/Method
φ	0.51	Consistent with National Income Accounts
χ	0.89	Based on Tokarick (2009) estimates of import demand elasticities in Uganda
θ	12	Standard value in literature
$\varkappa^a$	0.65	Normalizes employment of savers to 1 at steady state
$\varkappa^h$	0.60	Normalizes employment of non-savers to 1 at steady state
ψ	2.5	Standard value in literature
ϑ^a	0.999	Help match Uganda's annual real interest rate
ϑ^h	0.995	Help match Uganda's real money balances in percent of GDP
η	0.180	Based on regression of real money balances on nominal interest rates and GDP
δ	0.60	Matches the share of non-traded production in value added (60 percent)
ϱ	1	In line with Horvath (2000).
rm^*	0.128	Ensures trade deficit equals 10.2 percent of GDP
β^a	0.9951	Helps match real interest rates in Uganda
$\mathfrak{p}$	0.67	Financial survey by Steadman Group (2009); system properties

As for technology parameters presented in Table 2, we have relied on recent developing economy estimates by Arslanalp et al. (2010) on the impact of public capital on growth. These estimates approximately imply that $(1-\alpha_j)\phi_j = 0.1$ for $j = N, T$.[24]

In the experiments below we assume that the economy has a closed capital account, which makes sterilization policies more effective. Consequently, we choose a very high value for υ.

The parameters of the learning-by-doing externality, $\mathfrak{v}$ and ρ_z, are in line with firm-level panel-data estimates of the learning-by-exporting literature in developing economies. Mengistae and Pattillo (2004) find that the growth rate of total-factor productivity of export-oriented manufacturing firms in Sub-Saharan countries depends on lagged total factor productivity. Their estimates roughly correspond to $\rho_z = 0.1$. Calibrating $\mathfrak{v}$ is more challenging, as most of the learning-by-exporting literature estimate representations in which the current productivity of the firm depends on the dichotomous variable of lagged export status, which captures whether the firm exported or not in the previous period.[25] By adopting this approach, most of the works implicitly assume that there is also an asymmetry in the effect of lagged export status on productivity. Isgut and Fernandes (2007), however, take an alternative approach and report estimates of learning-by-exporting effects for Colombian manufacturing firms

[24] The literature on the link between public investment (capital) and growth seems to be reaching a consensus that the link is positive, but not as big as originally estimated by works such as Aschauer (1989).

[25] See for instance Van Biesebroeck (2005), among others.

using the lagged ratio of exports to output. Following their estimates, we set $\mathfrak{v} = 0.1$.

Table 2. Baseline Calibration: Technology Parameters

Parameters	Values	Source/Method
		Production and Price Rigidities
α_T, α_N	0.7	Uganda Input-Output tables
ϕ_T, ϕ_N	0.33	In line with Arslanalp et al. (2010)
$\mathfrak{v}$	0.1	In line with estimates by Isgut and Fernandes (2007)
ρ_z	0.1	In line with estimates by Mengistae and Pattillo (2004)
κ_T, κ_N	25	Ensures smooth impulse responses for investment
$\mathfrak{n}$	1.0171	Matches Uganda's annual growth (7 percent)
$\bar{z}^T$	1	Normalization
z^N	1.045	Ensures the real exchange rate equals one at steady state
δ_N, δ_T	0.015	In line with Bu (2004)
ζ	59	Standard value in literature implying prices are sticky for almost one year
		Distortions and Subsidies
ϖ	0.074	Helps match Uganda's investment share (16 percent)
ι_N	0.091	Eliminates monopolistic distortion at steady state
		Capital Mobility
υ	10^5	Implies the capital account is closed
$\bar{b}^{a*}$	0	Normalization

We model a temporary but persistent increase in aid such that, as a result of the scaling up, aid is *on average* six percentage points of GDP higher than its steady-state value over the following five years. Note that the coefficient ρ_A in the process for aid described in (16) results in a half life of the shock of slightly more than a year, which implies the aid increase is front loaded.

Finally the value of the steady-state efficiency ε_s is based on work by Arestoff and Hurlin (2006).[26] For our baseline calibration we assume $\varepsilon_s = 0.4$. This assumption, along with the parameters that govern the steady-state investment rate, the depreciation rate, and the parameters of the production function, implies that the marginal product of public capital in the steady state is 13 percent. One might also calculate the marginal product of public *investment* at the steady state, which corresponds to the increase in output due to an additional dollar of public investment. With our baseline calibration, this equals $13\varepsilon_s$ or 5.2 percent.

[26] Arestoff and Hurlin (2006) take a close look at the relationship between dollars spent on certain specific categories of public investment and physical capital indicators and were able to infer some public investment efficiency measures, in our sense, for Colombia and Mexico. They find that the relationship between public investment and the change in the capital stock is indeed linear, as assumed in equation (20), and that ε_s has a value of about 0.40 for these two countries. Interestingly, they find a value of about 1.0 for the United States. Pritchett (2000) calculates, using a very different methodology, that ε_s equals about 0.5 in many low-income countries, with substantial heterogeneity across countries.

Table 3. Baseline Calibration: Policy Parameters and Aid Process

Parameters	Value	Source/Method
		Aid process
ρ_A	0.9	Implies a half-life of the shock of about one year
$\bar{A}^*$	0.049	Matches current share of aid in GDP (5 percent)
ϵ^A	0.226	Matches a scaling up on average of 6 percentage points of GDP in 5 years
		The Government
ν	0.7	Endogenously determined to clear non-traded goods market
τ	0.2375	Helps match the current share of government spending (18 percent of GDP)
μ_s	0.3889	Matches the current share of public investment (7 percent of GDP)
μ_A	0.5	Policy parameter
$\bar{b}^c$	0.0695	Matches the stock of outstanding domestic government debt (4.2 percent)
$\bar{b}^{cb}$	0.0828	Helps match real money balances
δ_g	0.02	Broadly in line with Arslanalp et al. (2010)
ε_s	0.4	In line with Arestoff and Hurlin (2006)
ε_A	0.4	In line with Arestoff and Hurlin (2006)
ρ_d	0.9	Policy parameter
$\bar{d}^g$	0.218	Based on Uganda's Monetary Survey
γ	1	Policy parameter for the experiments
		The Central Bank
ρ_R	0.9	Policy parameter
$\bar{R}^*$	0.298	Matches Uganda's stock of reserves (18 percent of GDP)
ω	1	Policy parameter for the experiments
ω_s	0	Policy parameter for the experiments
$\mathfrak{g}$	1.032	Consistent with Uganda's inflation (6 percent)
ϕ_π	3.863	Consistent with a Taylor rule with an inflation coefficient of 1.5

The impact of aid-surge-related public investment on the percentage deviations of real GDP from its steady state is determined by the *relative* efficiency $\frac{\varepsilon_A}{\varepsilon_s}$, and this what we generally mean by "efficiency" in this paper. The reason is simple. Consider a change in the calibration that increases both efficiencies by the same amount. In this case, the given aid surge yields the same percentage GDP deviations, because there are two opposite effects. The good news is that the aid surge will build more public capital, because ε_A is higher. The bad news is that the higher value of ε_s means that the steady-state capital stock must be larger, as implied by equation (20). But the percentage change in output is proportional to the percentage change in the capital stock. Thus, a larger capital stock implies a smaller percentage increase in capital and hence output for the same dollar increment to aid. As shown in the appendix, these two effects exactly offset for the Cobb-Douglas production technologies of our model.[27]

[27] This recalibration of both efficiency parameters can be understood in different ways. We have in mind the notion that the analyst revises her assessment of overall efficiency in a given country, not that we are comparing two different countries. In the former case, the level of output is observable and unchanged. Thus, the level of total factor productivity

For the baseline, we assume $\varepsilon_A = \varepsilon_s$. Of course, it could go either way. For example, rapid scaling up might put pressure on administrative procedures and "absorptive capacity" and reduce efficiency ε_A relative to its steady-state counterpart ε_s. On the other hand, a more careful preparation of public investment programs, and more generally better public-sector management and institutions, would tend to lead to higher efficiency ε_A. Overall, it must be stressed that the value of the efficiency parameter ε_A is surely country and context-specific.

IV. The Experiments

A. The Baseline Scenario

For the baseline scenario, we use the parametrization in Tables 1-3. In this scenario, aid-related public investment is as efficient as in steady state ($\varepsilon_A = \varepsilon_s$) and there are mild learning-by-doing externalities ($\rho_z = 0.1$ and $\mathfrak{v} = 0.1$). Moreover, the exchange rate regime is flexible ($\omega_s = 0$), and the government deposits and reserve rules imply full spending ($\gamma = 1$) and full absorption ($\omega = 1$) of aid. We also assume that open-market operations adjust so that money always grows at the rate $\mathfrak{g}\left(\frac{\pi_t}{\bar{\pi}}\right)^{-\phi_\pi}$.

The results of the simulations are presented in Figure 1, where the annual impulse responses of selected macroeconomic variables are measured as percentage deviations from steady state. The short-run macroeconomic effect of the aid surge is driven by its impact on government spending, in particular on non-traded goods. Because of nominal price rigidities, the supply of non-traded goods expands in response to greater demand, generating a short-lived spike in real GDP. This expansion in non-traded output is mostly accomplished through increased labor demand, which is partly satisfied by drawing labor from the traded sector. A higher demand for labor from the non-traded sector contributes to the rapid increase in real wages in the short run, which translates into higher non-traded goods inflation. This, however, does not induce higher CPI inflation, because the nominal appreciation causes traded goods deflation. The combination of higher wages and nominal appreciation adversely affects profitability in the traded sector leading to a decline of its output in the short term.[28]

Over time, as nominal rigidities dissipate, the demand-driven boom fades. However, part of the government spending has been used to increase public investment. The public capital stock increases, causing a persistent and positive effect on GDP that accounts for most of the output increase in the medium term. This process is reinforced by the expansion of private capital stocks in both sectors, following an increase in the marginal value of capital, reflecting the positive effect of more public

must fall if both efficiencies are raised, in order to match observed output with the higher public capital stock. The *bad news* referred to above can thus be understood as being related to the fact that the marginal product of capital—which depends on total factor productivity—must be lower. Along the same lines, the marginal product of public *investment* is invariant to ε_s; changes in ε_s affect the marginal product of capital in inverse proportion. This point is made by Pritchett (2000) in a different context.

[28] Note that the nominal interest rate also increases. Using the money demand equations from the savers and non-asset holders and the monetary rule, it is possible to show that the nominal interest rate is an increasing function of consumption and inflation. As consumption rises, then the nominal interest rate also goes up.

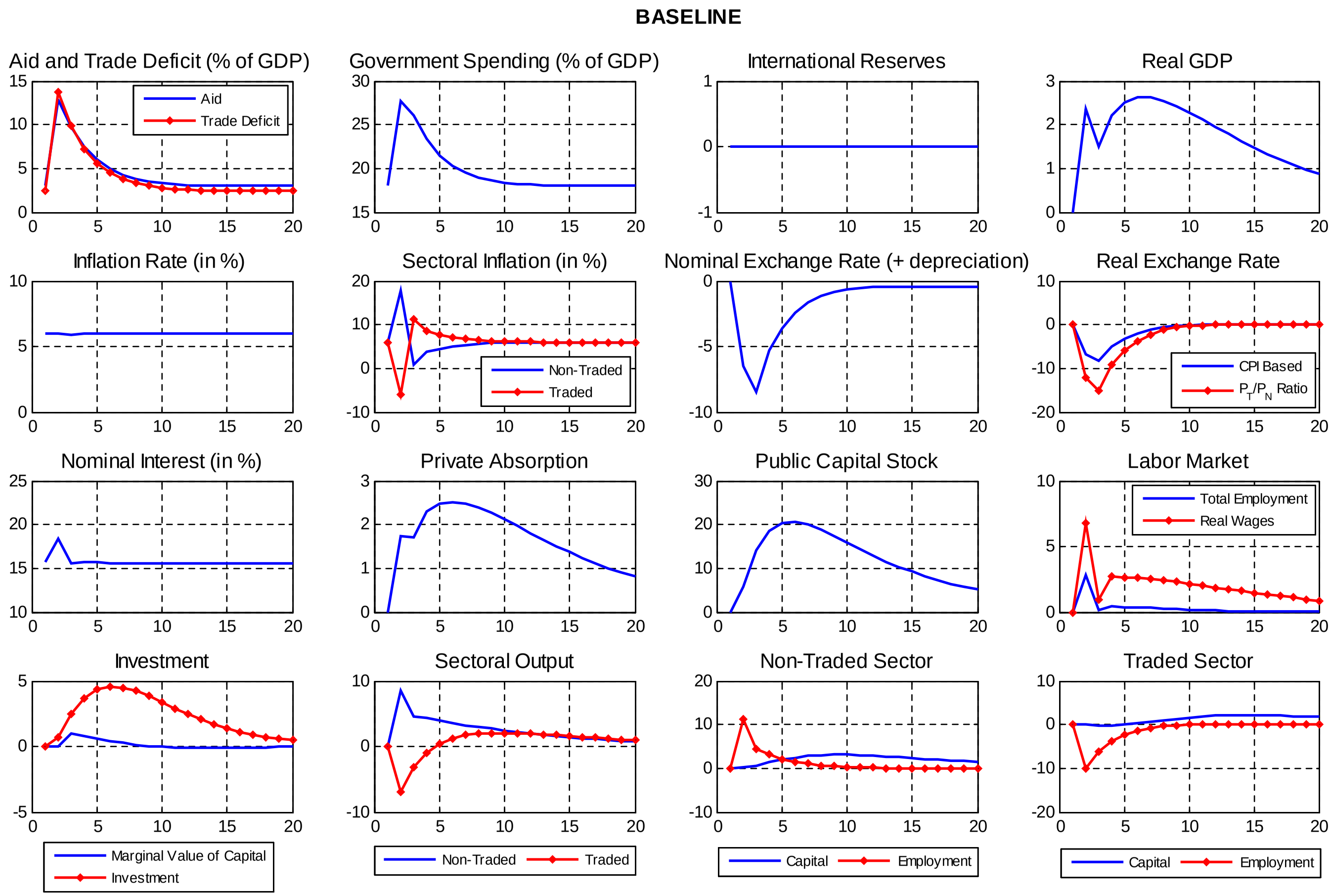

Figure 1: Baseline scenario. Impulse responses are shown in annual terms and as percentage deviations from steady state, unless otherwise noted.

capital on the marginal productivity of private capital.[29]

The overall effects of aid on output do not appear strikingly large. With our 6 percent-of-GDP aid surge extending over some 5 years, output is some 2.6 percent higher than steady state at its maximum (6 years after the beginning of the aid surge). To provide some context, our baseline marginal product of capital of 13 percent may be compared to estimates of rates of return on World Bank projects of roughly 20 percent.[30] However, other evidence suggests our growth impacts may not be too far off. We can also define the *macro* rate of return of public investment as the internal rate of return implied by the stream of additional output less additional aid-financed investment. This return is close to 17 percent in the baseline calibration, reflecting all the frictions and features of the model. This result is broadly consistent with aggregate evidence in Arslanalp et al. (2010) about the growth effects of public investment and Clemens et al. (2004) about the growth effects of *high-impact* aid. Of course, an increase in public investment efficiency relative to steady state, more aid allocated to investment, more responsive factor markets, and lower adjustment costs to private investment and other changes in the calibration would yield larger medium-term growth effects, and sensitivity exercises along these lines may be worthwhile in particular cases.

The real exchange rate appreciation plays numerous roles in the transmission mechanism. First, by making traded goods relatively cheaper, the real appreciation shifts private sector demand from non-traded to traded goods. This frees domestic capacity to meet the higher government demand for non-traded goods. Second, by increasing imports and lowering traded output, the real appreciation contributes to an increase in the trade deficit. This implies that for a given output, domestic consumption and investment can expand. This is clearly facilitated by the central bank's reserve policy of fully absorbing the aid. As we will discuss below, without such a reserves policy, higher government spending related to the aid surge would imply that private sector consumption and/or investment would have to decline, meaning higher government spending would crowd out the private sector.

B. Partial Aid Absorption Policies

B.1. Reserve Accumulation Rules under a Flexible Exchange Rate Regime

Policy makers are likely to be most worried about the loss of competitiveness due to the real exchange rate appreciation resulting from the aid surge. The central bank may therefore decide to limit the amount of foreign exchange sales to the market, using the aid inflows instead to build up

[29] The marginal value of capital is calculated as a weighted average of the implied marginal Tobin Qs for each productive sector.

[30] One might consider that the World Bank rates of return should be compared to the lower marginal product of *investment* in our model. On the other hand, World Bank projects may be relatively efficient, particularly the small fraction (well below half in recent years) for which ex post rates of return are calculated (Warner, 2010). For example, very few projects report a negative net rate of return, even when other indications exist that returns may be negative, and ex post returns are calculated for very few projects whose execution is deemed highly unsatisfactory. More generally, there are a number of reasons to think that these estimated project returns are substantially overstated.

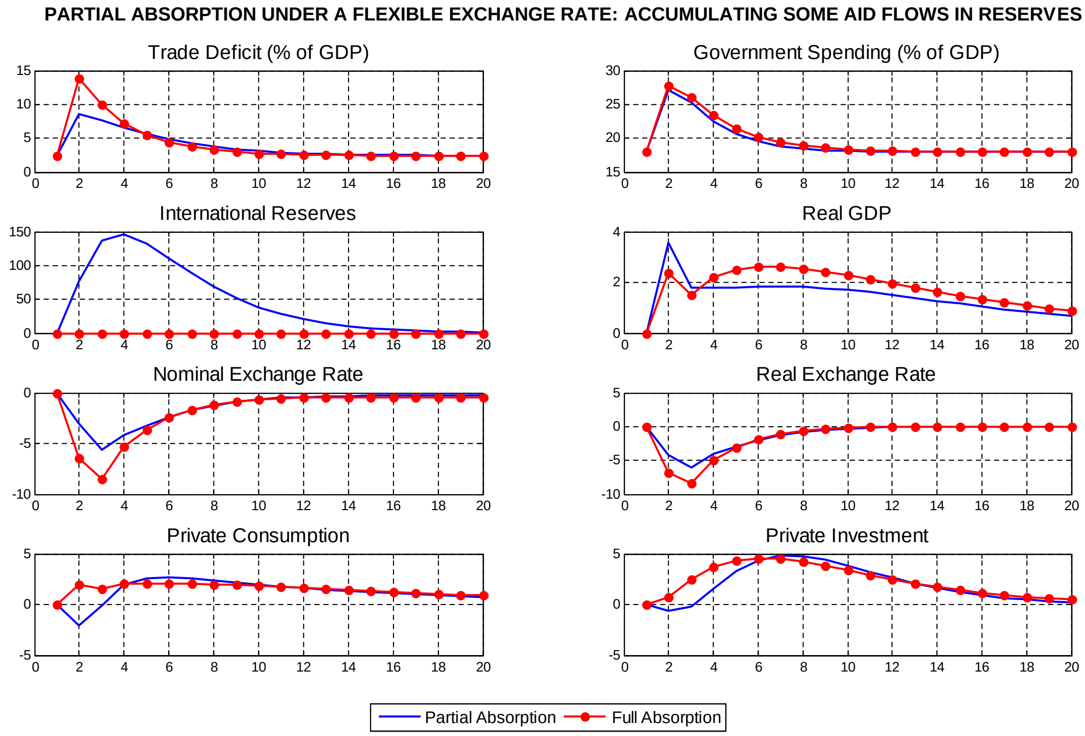

Figure 2: Comparison of the impulse responses, in annual terms, for selected macroeconomic variables under full and partial absorption of aid, assuming flexible exchange rates. Partial absorption is the result of accumulating some of the aid surge in reserves. The responses are shown as percentage deviations from steady state, unless otherwise noted.

foreign exchange reserves and, in this way, contain some of the appreciation.[31] Berg et al. (2007) find that this is exactly what many sub-Saharan central banks did during aid surges. As some governments were also trying to spend most of the aid, then accumulating aid flows in reserves created an excess of liquidity and, consequently, inflation pressures. Some central banks then decided to implement bond sterilization policies to counteract these pressures.

We simulate the model to study the macroeconomic implications of accumulating some of the increased aid flows in reserves (a partial absorption policy with $\omega = 0.5$), while the government implements a deposit rule that implies full spending of aid. We compare this with the full-absorption policy of the baseline ($\omega = 1$). We also assume full sterilization through domestic open-market operations of the resulting monetary emission. The simulations are shown in Figure 2.

Limiting the sale of aid-related foreign exchange is indeed effective in reducing the appreciation, both in nominal and real terms. As a result, the trade deficit widens by less, which implies only a partial absorption of aid inflows. Given full aid spending, partial absorption at an economy-wide level

[31] Note that this type of policies cannot be a first-best way to address concerns about competitiveness. In principle, a remedy targeted at the root distortion would be ideal. For example, a learning-by-doing externality in the export sector would call for an across-the-board export subsidy. However, as Rodrik (2008) notes, such policies can be very difficult to design and implement and could run afoul of WTO restrictions.

must imply a reduction in private sector demand. This implies a significant private sector consumption and investment crowding out, which takes place in the first three to five years. Moreover, the reduction in private investment has a significant adverse impact on real GDP, roughly halving the positive GDP effect of scaled-up aid over the five-to-ten-year horizon. Hence, limiting foreign exchange sales in order to stem the nominal appreciation comes at a significant cost.[32]

The underlying cause of the private sector crowding out is the authorities' attempt to use the same aid resources twice: on the one hand, the central bank uses the foreign exchange value of aid inflows to build up reserves; on the other hand, the government uses the domestic currency counterpart to increase spending. Whereas government spending of aid resources would normally correspond to an externally-financed increase in spending, the central bank use of the foreign exchange counterpart for building up its foreign reserves effectively transforms this into domestically-financed spending. Externally- and domestically-financed government spending have very different impacts on the private sector. In an externally-financed case, the foreign exchange inflows are used for financing a larger current account deficit. This allows government spending to increase without crowding out private sector demand. In the case where the foreign counterpart of aid inflows is used for reserve buildup, the current account deficit does not increase. Consequently, higher government spending necessitates a lower private sector demand, unless there is a very large supply response.

B.2. A Fixed Exchange Rate Regime with Sterilization

Many aid recipients have fixed exchange rate regimes or may consider pegging as a way to avoid nominal appreciations associated with aid surges. Therefore, we proceed to study the implications of implementing a fixed exchange rate regime ($\omega_s = 10000$) in comparison to the flexible regime of the baseline scenario ($\omega_s = 0$).

For the simulations we consider both full sterilization bond policies, as in the baseline, and no sterilization. To shut down sterilization, we replace the sterilization rule (24) by a rule in which central bank purchases of nominal government bonds grow at the rate $\mathfrak{g}\left(\frac{\pi_t}{\bar{\pi}}\right)^{-\phi_\pi}$, implying the following process:

$$b_t^{cb} - \frac{b_{t-1}^{cb}}{\mathfrak{n}\pi_t} = \frac{b_{t-1}^{cb}}{\mathfrak{n}\pi_t}\left[\mathfrak{g}\left(\frac{\pi_t}{\bar{\pi}}\right)^{-\phi_\pi} - 1\right].$$

At steady state, this process ensures that nominal money supply grows at the gross rate $\mathfrak{g}$, which pins down the steady-state level of inflation. Outside of the steady state, however, this rule does not ensure a constant growth rate for nominal money, as the growth rate will be affected by whether aid is spent but not absorbed. Specifically, equation (22) shows that the combination of declining government deposits (spending aid) and increased accumulation of reserves (not fully absorbing aid) may lead to a faster nominal money growth rate than $\mathfrak{g}\left(\frac{\pi_t}{\bar{\pi}}\right)^{-\phi_\pi}$.

We start with the case of no sterilization under a fixed regime. The simulations are presented in

[32] Note that real GDP is higher in the short run with the partial absorption policy. This is explained by the more pronounced expansion of the non-traded sector in response to higher demand pressures generated by the partial absorption.

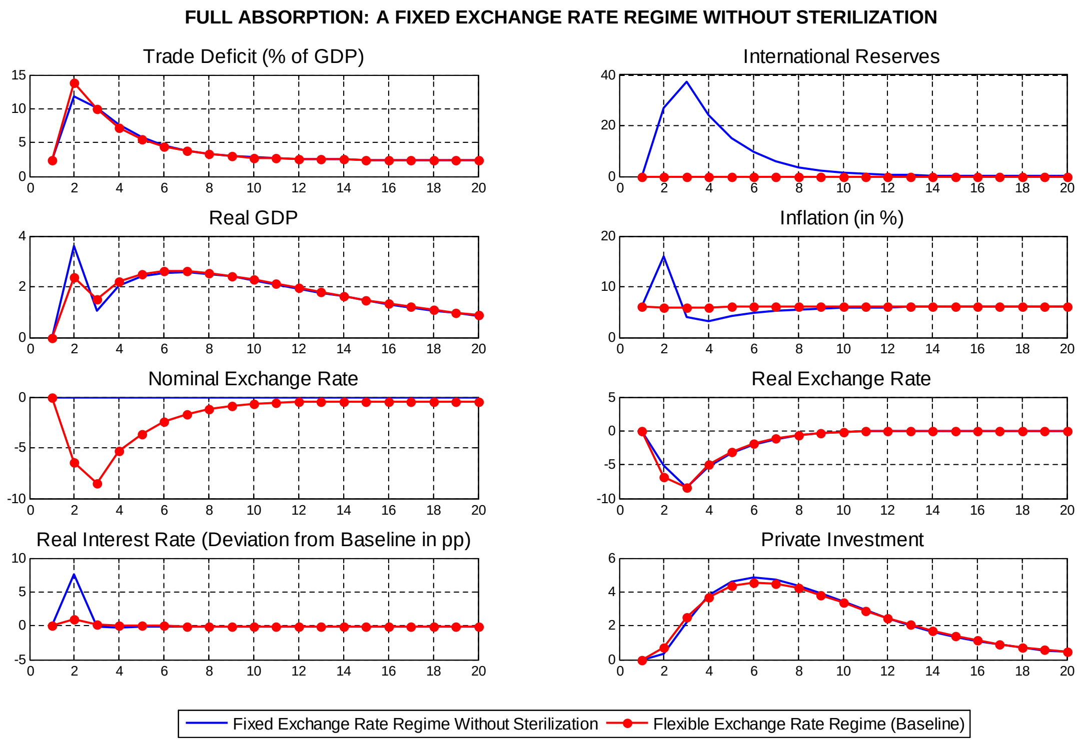

Figure 3: Comparison of the impulse responses, in annual terms, for selected macroeconomic variables under a flexible exchange rate regime and a fixed exchange rate regime without money supply sterilization. The responses are shown as percentage deviations from steady state, unless otherwise noted.

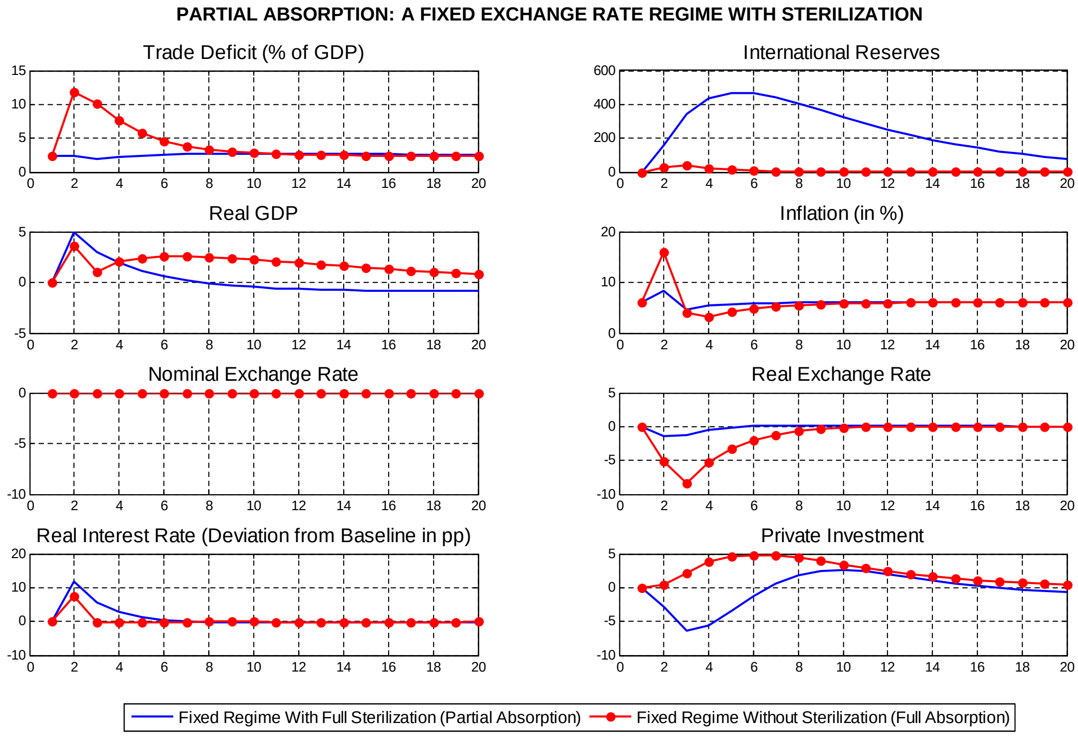

Figure 4: Comparison of the impulse responses, in annual terms, for selected macroeconomic variables under a fixed exchange rate regime without money supply sterilization (full absorption) and with full sterilization (partial absorption). The responses are shown as percentage deviations from steady state, unless otherwise noted.

Figure 3. The real exchange rate appreciation is similar to that under a flexible regime, but because traded goods prices remain constant, non-traded inflation has to increase significantly more to bring about the same relative price change. This also means substantially higher overall inflation, because unlike the flexible regime case, there is no traded *deflation*. Without traded deflation, there are larger demand pressures in the non-traded sector, as reflected by a more pronounced short-run spike in GDP, relative to the one in the flexible regime scenario. Over the medium term, however, output responses are almost identical to the baseline.

With a fixed regime, the accumulation of international reserves is not a policy choice but is governed by the need to sell as much foreign exchange as needed to keep the nominal exchange rate constant. In contrast to the baseline scenario, where aid inflows were sold to bring about a nominal currency appreciation, under the fixed regime part of these inflows are accumulated as reserves. Absent sterilization, and provided the domestic currency counterpart is fully spent by the government, this reserve accumulation leads to a large increase in the money supply.[33] This money supply expansion is instrumental in accommodating the overall increase in inflation, which in turn brings about the real appreciation necessary for close-to-full absorption of the aid inflows. In fact, the dynamics

[33] This follows from the central bank's balance sheet in equation (22), where the reserve buildup increases the third term on the right hand side, whereas no sterilization and full government spending keep the first and second terms constant.

of private investment is broadly the same across regimes. The real short interest rate increases to help keep inflation expectations anchored, but this increase is moderate and short-lived, despite the accommodative monetary policy stance.

The central bank could prevent the money supply expansion through open market operations that sterilize the domestic currency counterpart of the foreign reserve accumulation.[34] In this case, the monetary policy stance would become much tighter, with real interest rates increasing by much more and remaining high for a longer period, as shown in Figure 4. This would lead to significant private-sector crowding out. The associated reduction in private sector import demand would limit economy-wide absorption, including private investment, as well as the real exchange rate appreciation. But once more, lower private investment would reduce the medium-term impact of aid on real GDP. These effects are very similar to those of the partial absorption scenario under the flexible exchange rate regime, and the corresponding policy considerations apply here as well.

C. Learning-by-Doing Externalities, The Efficiency of Public Investment, and Partial Absorption Policies

In this section we explore the interactions of the learning-by-doing (LBD) externalities, the efficiency of public investment, and partial absorption policies. We proceed in three steps. First, we discuss the implications of varying efficiency in our model. Second, we explore the consequences of increasing the LBD externalities and its interaction with low efficiency of public investment. And third, we examine the effects of partial absorption policies in the context of strong externalities and low efficiency.

C.1. The Efficiency of Public Investment

A significant change in the (relative) efficiency with which public investments translate into public capital may have a large impact on GDP. Figure 5 illustrates this by keeping the efficiency of the general public investment process at 40 percent ($\varepsilon_s = 0.4$), and comparing three scenarios: (i) a low-efficiency scenario where the efficiency of aid-surge-financed investment is reduced to 10 percent ($\varepsilon_A = 0.1$); (ii) the baseline scenario ($\varepsilon_A = 0.4$); and (iii) a high-efficiency scenario, reflecting 100 percent efficiency ($\varepsilon_A = 1$).

The difference in the GDP effect between the high- and low-efficiency scenarios is sizeable. In the high-efficiency scenario, the GDP effects are large and persistent, owing to public capital accumulation and the associated crowding in effect on private investment: the larger public capital accumulation

[34] An important caveat is that sterilization is feasible only with a sufficiently closed capital account, as is the case with the Uganda calibration used here. With an open capital account, the attempt to raise interest rates as part of the sterilization effort would attract private sector capital inflows. This would add to the foreign reserve buildup and, therefore, to the sterilization need, thereby quickly overwhelming the central bank's ability to control the money supply while maintaining a fixed exchange rate. In practice, many low-income country central banks seem to have some room to sterilize even with pegged regimes and de jure open capital accounts.

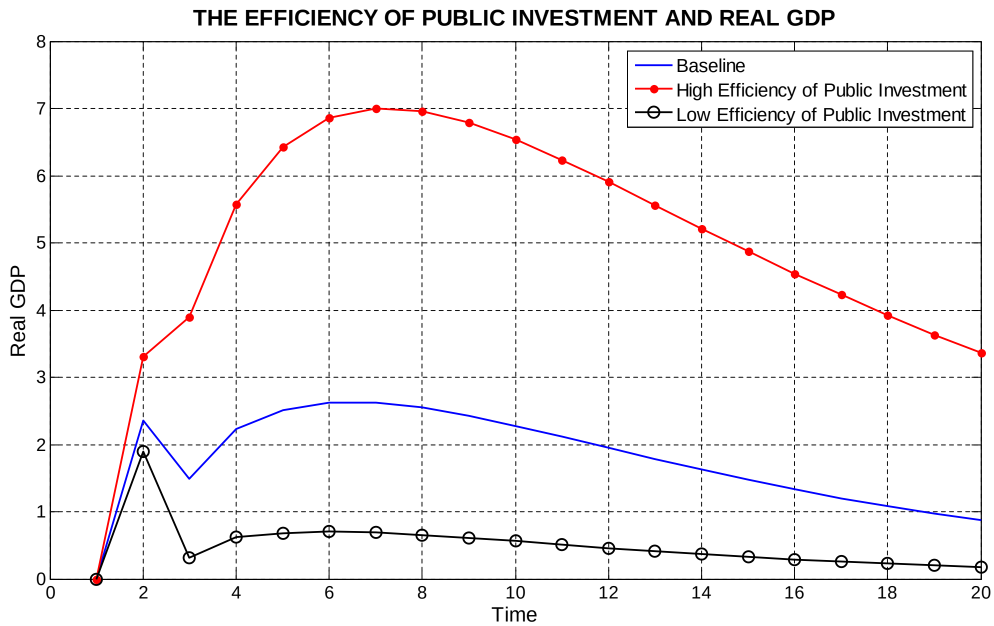

Figure 5: Comparison of the real GDP impulse responses, in annual terms, under different assumptions for the efficiency of the public investment. The responses are shown as percentage deviations from steady state.

raises the marginal value of private capital, which triggers an increase in private investment. In contrast, the low-efficiency scenario is characterized by a large but short-lived demand-driven boom and practically no GDP effects beyond the short term.[35]

C.2. The Learning-by-Doing (LBD) Externalities

The term "Dutch disease" in this paper is reserved to describe the potential negative effects of the smaller traded-goods sector on productivity, here modeled through powerful LBD externalities. But these externalities cut both ways: increases of traded output relative to its trend can also generate productivity gains in this sector and, therefore, amplify the positive effects of aid, especially over longer horizons. We will call this "Dutch vigor."

The LBD externalities are governed by the parameters $\mathfrak{v}$ and ρ_z of the specification in (15), which measure the strength and persistence of traded output changes on its TFP deviations from trend. To understand the role of these externalities, we compare the model dynamics under strong externalities ($\mathfrak{v} = 0.5$ and $\rho_z = 0.5$) with the baseline scenario ($\mathfrak{v} = 0.1$ and $\rho_z = 0.1$). Figure 6 shows this comparison, with the line marked with dots representing the strong externalities scenario. Relative to the baseline, strong externalities have the expected effect of amplifying the decline in the traded

[35] It should be noted that a change of these relative efficiencies is akin to changing the distribution between public investment and public consumption (μ_A). Therefore, given μ_s, fully investing the aid ($\mu_A = 1$) is comparable to the high-efficiency scenario, while fully consuming the aid ($\mu_A = 0$) is equivalent to the low-efficiency scenario.

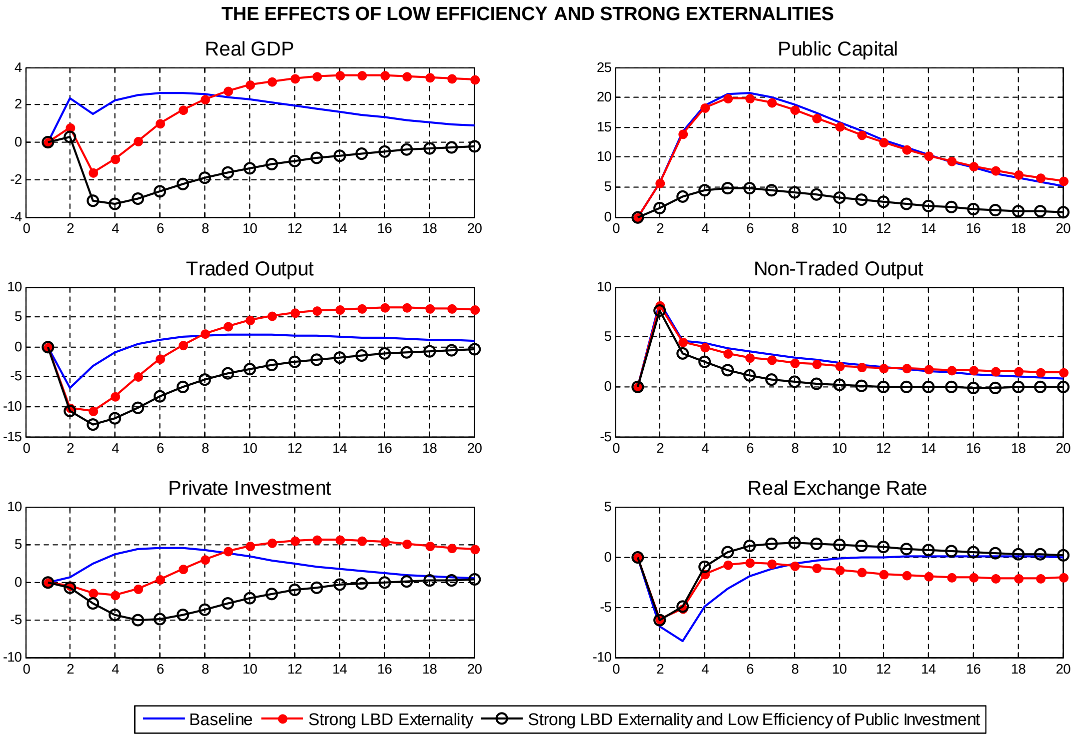

Figure 6: Impulse responses, in annual terms, for selected macroeconomic variables under full spending and absorption, assuming very low efficiency and strong learning-by-doing externalities. The responses are shown as percentage deviations from steady state, unless otherwise noted.

sector, which leads to a fall in GDP in the short-term and a lower economy-wide GDP effect over the first eight years. Moreover, the real exchange rate appreciation is less pronounced, reflecting a reverse Balassa-Samuelson effect due to the decline in productivity in the traded sector relative to that of the non-traded sector. The non-traded sector, in contrast, is broadly unaffected by varying the LBD externalities.

Looking beyond the first eight years, however, shows a stronger economic performance under the strong LBD externalities—the *Dutch vigor*. The key here is that higher public capital accumulation induces crowding in effects on private capital accumulation, as captured by the expansion of private investment in Figure 6. This eventually helps raise traded output above its steady state level. Once output exceeds the steady state, the externalities boost traded sector TFP, which amplifies the positive medium-term effect of public and private capital accumulation on this sector and the whole economy. Moreover, as predicted by the Balassa-Samuelson effect, the increase in the traded sector TFP causes and appreciation of the real exchange rate relative to the baseline scenario.

LBD externalities raise the stakes. They can amplify positive effects of aid, but they may also make aid harmful in terms of real GDP effects. The key determinant of whether they amplify or undermine aid's positive effects is the relative efficiency of public investment. The use of aid matters, because this will determine whether a shrinkage in the traded sector is temporary or protracted and thereby whether the externalities have positive or negative effects. The line marked with circles in

Figure 6 illustrates this point, by representing the combination of strong LBD externalities with low efficiency of public investment ($\varepsilon_A = 0.1$). In this case, strong externalities still lead to a short-term drop in GDP, and the brunt falls on the traded sector. But the low efficiency of public investment accentuates these negative effects, including the decline in private investment. In addition, over the medium term, the low efficiency of public investment precludes crowding in effects on private capital accumulation. Aid is harmful in this context, at least for growth.

C.3. Partial Absorption Policies

We now explore the macroeconomic implications of accumulating some of the additional aid flows in reserves, a partial absorption policy, in the context of strong LBD externalities and low efficiency of public investment.[36] This policy implies a trade-off. On the one hand, as Figure 7 shows, it does indeed succeed in diminishing some of the short-term appreciation pressures. On the other, it crowds out private investment (and consumption), as we saw in the baseline scenario. When efficiency is low and the externalities strong, however, the costs in terms of lower private investment are low and medium-term real GDP effects benign. The reason lies in the interaction of low efficiency and strong externalities. When efficiency is low, there is less public capital accumulation and thus less crowding-in. Indeed, the partial absorption policy encourages private investment insofar as it reduces mitigates the real appreciation and related negative effect on productivity growth. These two effects on private investment roughly counterbalance, as Figure 7 also shows.

These results lend some support to the notion that partial absorption policies may be an appropriate response to aid surges. It is important to underscore, though, that both the low efficiency and the strong externalities are important here. This is confirmed by the results presented in Figure 8, which shows the simulations for both partial and full absorption policies, in the context of strong externalities and fully efficient public investment ($\varepsilon_A = 1$). In this case, the GDP effect of scaled-up aid is always positive, and more so over time in the presence of full absorption. After five years, GDP exceeds that under partial absorption and maintains this trend in the longer term. An important part of the transmission mechanism is a large increase in private capital accumulation due to the TFP gains that are multiplied by strong externalities (the "Dutch Vigor" effect). In fact, traded-sector output overshoots its trend over the medium term, while the real exchange rate displays a persistent appreciation, in line with the Balassa-Samuelson effect.[37]

V. Discussion

A theme running through the paper is that efforts to suppress the real exchange rate appreciation pressures associated with aid surges may be misguided. The baseline simulation showed that the resulting real appreciation is a critical element of the transmission mechanism that shifts resources from

[36] Similar results to those in this section are obtained under a fixed exchange rate regime with money supply sterilization.

[37] Full absorption still yields higher GDP over the medium term even with strong LBD externalities when the efficiency of aid-related investment is the same as steady-state efficiency.

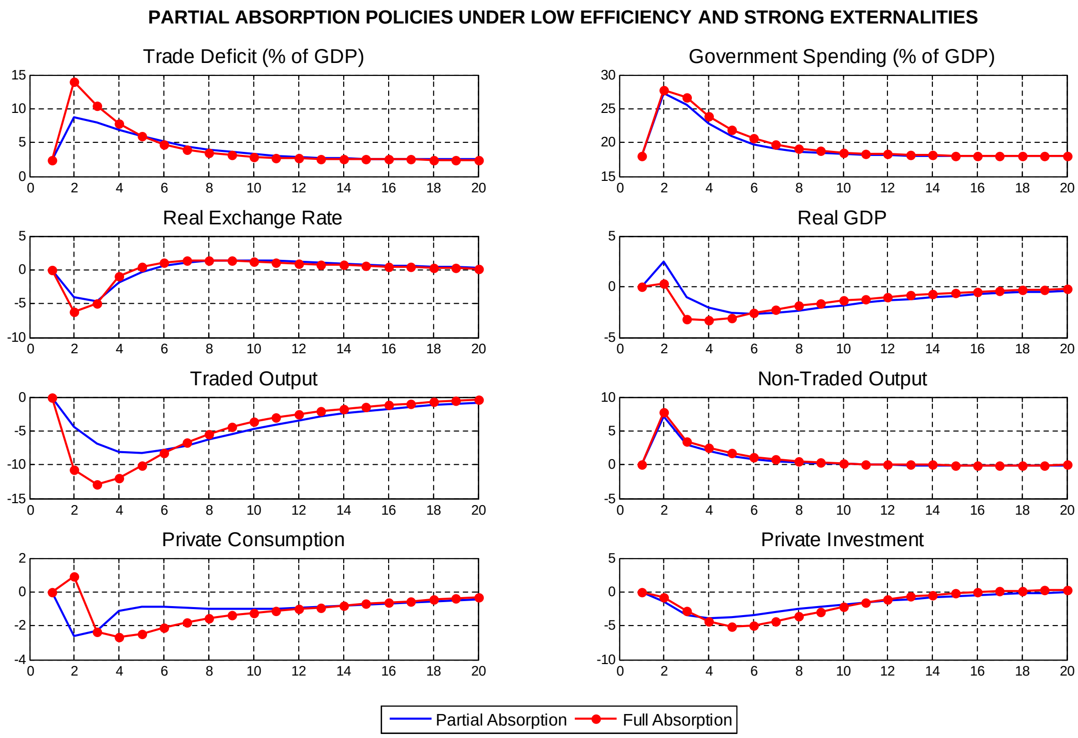

Figure 7: Comparison of impulse responses, in annual terms, for selected macroeconomic variables under full and partial absorption for an economy with low efficiency of public investment and strong learning-by-doing externalities. The responses are shown as percentage deviations from steady state, unless otherwise noted.

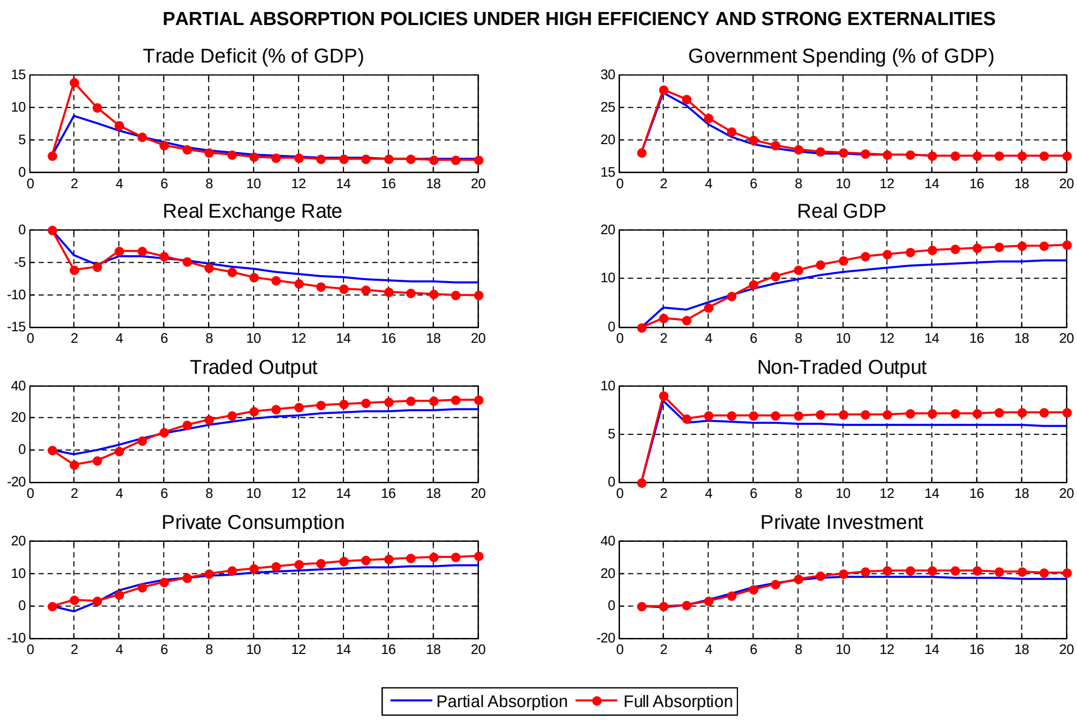

Figure 8: Comparison of impulse responses, in annual terms, for selected macroeconomic variables under full and partial absorption for an economy with high efficiency of public investment and strong learning-by-doing externalities. The responses are shown as percentage deviations from steady state, unless otherwise noted.

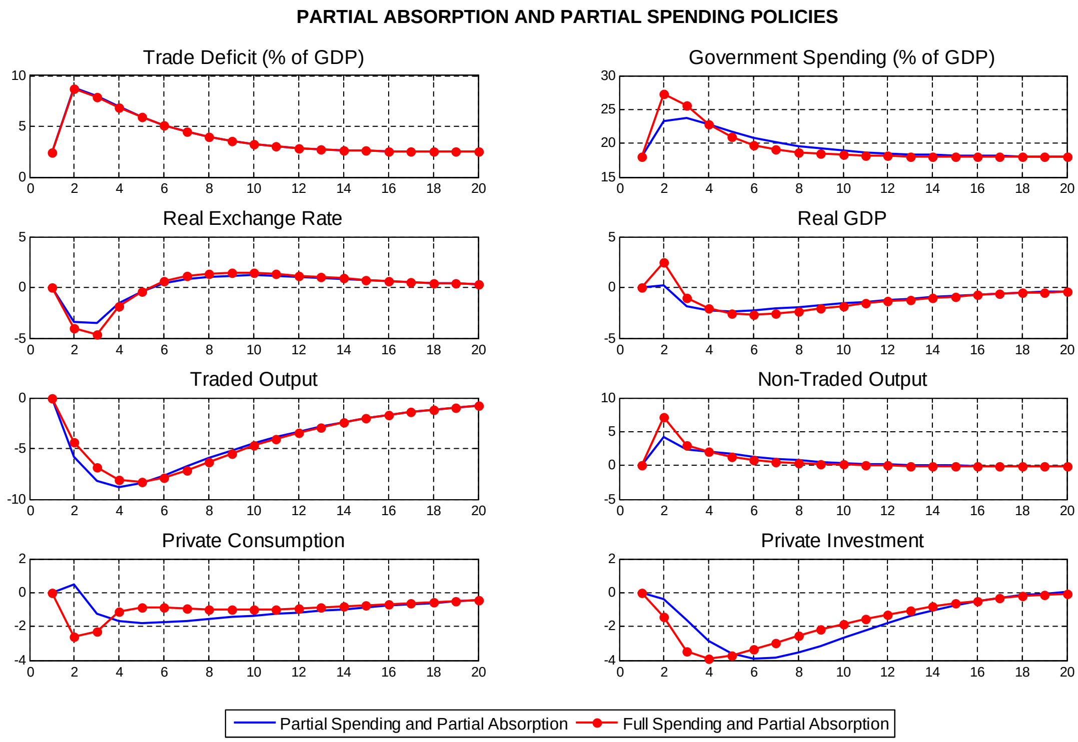

Figure 9: Comparison of the impulse responses, in annual terms, for selected macroeconomic variables under partial spending and partial absorption versus full spending and partial absorption of aid, assuming flexible exchange rates, strong learning-by-doing externalities, and low efficiency of public investment. Partial absorption is the result of accumulating some of the aid surge in reserves. The responses are shown as percentage deviations from steady state, unless otherwise noted.

the traded to the non-traded sector, thereby enabling a supply response to the government's increased demand for nontradables and reducing the traded sector output. More importantly our experiments show that partial absorption policies designed to choke off the real exchange rate appreciation in the short term can crowd out private consumption and investment, and have adverse real GDP effects over the medium term.

The question remains, why do policy-makers continue to consider such efforts? One answer is that, contrary to our baseline calibration, the relative efficiency of public investment, or the share of spending allocated to public investment, is low, while LBD externalities are strong. As explored above, fully spending and absorbing aid may be harmful in this context.

However, even with strong externalities and low efficiency, it is possible to do better than partial absorption policies—avoid the crowding out of the private sector—by combining them with partial spending policies. Figure 9 illustrates this, when only half of the aid inflows are initially spent by the government ($\gamma = 0.5$), and when half of the flows are accumulated as reserves by the central bank ($\omega = 0.5$). In this case, appreciation pressures can be diminished, ameliorating the short-term crowding out effect on private consumption and investment of fully spending and partially absorbing the aid. In practice, partial spending may face donor objections, given that they expect their scarce

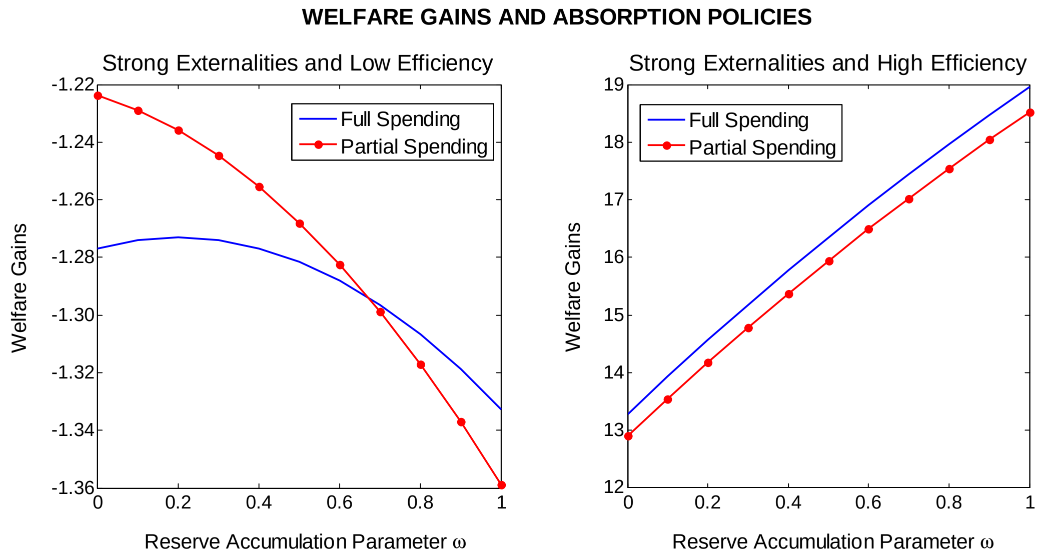

Figure 10: Welfare gains of different reserve accumulation policies (aid absorption policies), assuming LBD externalities are strong, and the efficiency of public investment is either low (left-hand side) or high (right-hand side). Full spending corresponds to $\gamma = 1$, while partial spending corresponds to $\gamma = 0.5$.

budgetary resources to be used for development and not to be saved by the recipient government. This adds the need for donor coordination to the policy mix. In principle, donors could scale up their aid at a pace that takes macroeconomic concerns into account or allow the government to smooth aid-financed expenditures over time by saving initially part of the flows.[38]

A welfare analysis confirms that partial absorption policies may indeed induce welfare gains relative to full absorption policies, in the context of low efficiency and strong externalities. To see this, we calculate the welfare gains of different reserve accumulation policies (aid absorption policies). We define the welfare gain as the *difference* between the government life-time utility function $\mathfrak{U}_o^g$ and *its steady-state value*. In turn, $\mathfrak{U}_o^g$ is defined as the weighted average of the life-time utility functions of the two types of households.[39] Specifically,

$$\mathfrak{U}_o^g = \mathfrak{p}\mathcal{U}_o^a + (1-\mathfrak{p})\mathcal{U}_o^h$$

where $\mathcal{U}_o^j = \sum_{t=0}^{\infty}(\beta^a)^t \left[u^j(c_t^j, m_t^j) - \frac{\varkappa^j}{1+\psi}(l_t^j)^{1+\psi} \right]$ for the asset holders ($j = a$) and hand-to-mouth consumers ($j = h$).

Figure 10 presents the results of this welfare analysis. Consider first the left-hand side, which

[38] Figure 9 that represents a scenario of limiting initial spending of aid is an example of such expenditure smoothing, because the fiscal spending rule in equation (21) ensures that all aid is eventually fully spent.

[39] Note that since our model is *non-stochastic*, the spirit of our analysis differs from that of the recent optimal policy analysis of the New-Keynesian literature. This literature studies the optimal fiscal and monetary policies in the context of *stochastic* models in which the volatility of the shocks plays a crucial role (see for instance Schmitt-Grohé and Uribe, 2007, among others). Here we abtract from these issues.

shows the welfare gains for different reserve accumulation policies (aid absorption) as measured by the parameter ω in equation (23), assuming efficiency is *low*. The solid line shows the results for the baseline case of full spending. Welfare gains are maximized for $\omega \approx 0.25$ implying a quite significant reserve accumulation and, therefore, a partial absorption policy. Note also that with low efficiency, a better approach would be to partially spend the aid ($\gamma = 0.5$) as well. As the line with dots shows, this raises welfare relative to the full-spending case.[40]

But the same welfare analysis also reveals that a better approach than implementing partial absorption policies might be to redirect efforts to quickly increase the efficiency of public investment to enjoy the benefits of aid surges.[41] The right-hand side of Figure 10 confirms the existence of very large gains of fully absorbing the aid ($\omega = 1$), relative to not absorbing it ($\omega = 0$), when externalities are strong and public investment is highly efficient. In fact, it can be shown that these gains increase with the efficiency of public investment. The same figure shows that, in this case, partially spending the aid is a mistake from a welfare perspective, contrary to the low-efficiency case.

Our previous analysis does not capture other concerns that may explain partial absorption policies. For instance concerns that may be related to volatility in relative prices, which is particularly relevant if a surge in aid is perceived to be temporary or of uncertain duration. If a temporary spike in aid is fully spent and absorbed, resources have to be shifted from the non-traded to the traded sector and then back again as the aid inflows recede. This process introduces considerable volatility into the economy, including large swings in the real exchange rate and other relative prices. This is likely to be a costly process involving considerable turmoil in the traded and non-traded sector, as companies in both sectors are buffeted by large swings in prices and contract or expand rapidly. Ideally, these costs would be avoided by reducing the volatility of aid inflows, but this is mostly a task for donors; aid-recipient countries could address aid volatility on the fiscal side through expenditure smoothing accompanied by central bank foreign exchange sales that are limited to the amount of aid spent, in line with the discussion above.

Furthermore, countries may simply wish to accumulate international reserves, for reasons outside we have not modeled, such as a need for buffers against capital account shocks. The lesson of this paper is that, while this may of course be a valid goal, policymakers need to carefully consider the interactions of discretionary policies by the government and the central bank in this context. An effort to accumulate international reserves without a corresponding tightening of fiscal policy is like spending but not absorbing aid. In particular, it calls for an increase in private savings to finance the reserve accumulation and may thus require crowding out of private sector investment and consumption.

Finally, it is important to mention that besides the efficiency of public investment and the intensity of LBD externalities, there are other features of the model that matter for the implications of partial absorption policies. These features include the share of hand-to-mouth consumers, the access to

[40] The optimal degree of spending in general may also depend on the degree of absorption. A full welfare analysis of alternative optimal and implementable reserve accumulation and fiscal spending rules in response to unpredictable and volatile aid shocks is outside the scope of this paper and is addressed in Portillo and Zanna (2010).

[41] In fact, public management capacity constraints in themselves may call for further investments in capacity, i.e. "to invest in investing" in the words of Collier (2007). It has been notoriously difficult for aid donors to improve public management, however, as discussed for example in Berg (1993).

international capital markets, and the mobility of productive factors across sectors. The presence of hand-to-mouth consumers can give fiscal policy and aggregate demand larger real effects, including appreciation effects, in the short run; the degree of access to international capital markets controls the effectiveness of sterilized interventions; and the degree of factor mobility affects the degree of real exchange rate appreciation. We refer the interested reader to Berg et al. (2010) that discuss in detail the role of all these features in a *short-run* analysis of policy responses to aid shocks.

VI. Conclusions

Our approach in this paper—and in our contribution to the broader "Gleneagles aid scaling-up scenarios" project—is to build and calibrate a dynamic micro-founded structural economic model to construct scenarios that can help us understand the short- and medium-term issues associated with large aid surges. Our model captures at best only crudely most of what is most important about aid. Purely real CGE models such as the World Bank's MAMS (Maquette for MDG Simulations) address a much richer set of sectoral issues.[42] Our purpose here is to capture the key microeconomic issues efficiently in a way that informs a macroeconomic analysis, such as that required in the context of IMF-supported programs. We believe there has been underinvestment in this sort of analysis and view it as complementary to, rather than a substitute for, other approaches.

We also see our contribution as complementary to the empirical work that has examined the issues we study here, such as Arslanalp et al. (2010). From the perspective of a policy maker or IMF country team conducting an analysis for a particular country, such empirical results are helpful background but can only be useful if understood in a structural sense, that is, in terms of fully articulated causal channels. The outcome of an aid surge depends on a number of country-specific factors, such as the macroeconomic policy response, the uses to which the aid is put, the efficiency of public investment, and various parameters of the economy. This, in fact, has been one of the overarching lessons of the macroeconomic assessments in the "Gleneagles aid scaling-up scenarios" project.

The model we present here—like any such model—is incomplete and indeed incorrect in many ways. We do not expect that on its own it will produce good forecasts. But we believe that it can help organize thinking; provide a way to systematically incorporate various sorts of empirical evidence; and provide a vehicle for transparently producing alternative scenarios and comparing results across countries. In this regard, the calibration here is only a first step, and the quantitative properties of the model need to be more systematically compared to evidence. In particular, the application of variants of the model to historical episodes should help provide more reliable calibrations.

Nonetheless, a few critical themes emerge that we believe transcend a particular calibration. These include:

- It is the efficiency of aid-related public investment relative to steady-state investment efficiency

[42] See the applications of Bourguignon and Sundberg (2006) and Gottschalk et al. (2009), for instance.

that determines the growth impact of aid-finance public investment; rather surprisingly, changing assumptions about both steady-state and aid-surge-related efficiency has offsetting effects.

- The LBD externality raises the stakes for aid efficiency: if aid is invested well, the interaction of both can produce even greater gains—producing Dutch vigor. If it is not, aid can be harmful for growth.
- Partial absorption policies such as accumulating aid in reserves while spending the local counterpart can succeed in narrow terms in resisting appreciation, but at a cost to private investment and medium-term growth.
- As a specific example of partial absorption, resisting "inflation" in a fixed exchange rate regime may be a bad idea, if the inflation is part of the relative price adjustment required to absorb aid.
- When efficiency is low and externalities strong, and thus aid is bad for growth, partial absorption policies may be better than full absorption, but even better would be partial spending. Efforts to increase efficiency would have potentially the greatest impact.

Much work remains to be done. Optimal fiscal spending and reserve accumulation reactions to aid shocks and volatility, including the appropriate degree of smoothing, deserve more work. The experiments studied here demonstrate that the mixture of these responses interact with all the features of the model to drive growth as well as private consumption and hence welfare. Portillo and Zanna (2010) considers a range of assumptions about these factors looking for simple and implementable fiscal spending and reserve accumulation rules that maximize welfare in the context of unpredictable and volatile aid shocks. We also defer to future work the question of endogenizing other policies responses, or for that matter those of aid donors, believing that such analyses would benefit from a clear understanding of the underlying economics.

A number of model design issues and assumptions could be investigated to move forward from here. A semi-closed capital account is key to many of our results. Human capital would seem worth incorporating, at least for longer-term analyses. Public capital could be made sector-specific to permit the analysis of another policy option in the face of Dutch disease concerns: directing public investment towards the traded sector would presumably promote that sector's expansion, even as Balassa-Samuelson effects cause a real appreciation.

Variations of the model could shed light on a number of important shocks. Natural resource booms and terms of trade shocks in resource-rich countries have many similar features to the aid shocks examined here.[43] For example, the management of resource booms involve similar decisions regarding spending and absorbing the capital inflows associated with these booms. Similarly, the model could be extended to investigate debt-financed public investment shocks and their implications for debt sustainability. The IMF and the World Bank conduct debt sustainability analysis roughly every year for each low-income country. In principle, the framework of this paper could provide economic structure to these assessments and facilitate scenario analysis and stochastic simulations. We are currently working on such an extension.

[43] See for instance Dagher et al. (2010).

Appendix

A. Writing the Model in Stationary Terms

In this part of the Appendix, we show how the model is transformed in stationary terms. As mentioned above, there is exogenous growth of the labor-augmenting type, which is the same across sectors. The productive units of labor that are used in the production of the traded and non-traded goods correspond to $\mathcal{T}_t l_t^T$ and $\mathcal{T}_t l_t^N$, respectively, where $\mathcal{T}_t$ is the productivity level that grows at the constant factor $\mathfrak{n}$, and l_t^k corresponds to the amount of raw labor used in the production of the good $k = T, N$. Presenting the model in stationary terms involves rescaling variables by the productivity level $\mathcal{T}_t$, when required. To show how the model is transformed in stationary terms, it suffices to show the transformation of a few equations. For instance, to obtain the objective function (4) of the asset holders' representative agent we manipulate the original function

$$\sum_{t=0}^{\infty} (\beta^a)^t \left[u^a \left(C_t^a, \frac{M_t^a}{P_t} \right) - \frac{\varkappa^a (l_t^a)^{1+\psi}}{1+\psi} \right]$$

to obtain

$$\sum_{t=0}^{\infty} (\beta^a)^t \left[u^a \left(\frac{\mathcal{T}_t C_t^a}{\mathcal{T}_t}, \frac{\mathcal{T}_t M_t^a}{\mathcal{T}_t P_t} \right) - \frac{\varkappa^a (l_t^a)^{1+\psi}}{1+\psi} \right] = \sum_{t=0}^{\infty} (\beta^a)^t \left[u^a \left(\frac{C_t^a}{\mathcal{T}_t}, \frac{M_t^a}{\mathcal{T}_t P_t} \right) - \frac{\varkappa^a (l_t^a)^{1+\psi}}{1+\psi} + \log(\mathcal{T}_t) \right],$$

where the last expression corresponds to (4). Similarly the original budget constraint of the asset holder can be written in nominal terms as

$$P_t C_t^a + M_t^a + B_t^{ac} + S_t B_t^{a*} = (1-\tau) W_t l_t^a + M_{t-1}^a + i_{t-1} B_{t-1}^{ac} + S_t i_{t-1}^* B_{t-1}^{a*} + \Theta_t^a + S_t R M_t^{a*},$$

where for simplicity we have ignored the portfolio adjustment costs and transfers. Dividing both sides by $P_t \mathcal{T}_t$ and manipulating it we obtain

$$\begin{aligned} \frac{C_t^a}{\mathcal{T}_t} + \frac{M_t^a}{P_t \mathcal{T}_t} + \frac{B_t^{ac}}{P_t \mathcal{T}_t} + \frac{s_t B_t^{a*}}{P_t^* \mathcal{T}_t} &= (1-\tau) \left(\frac{W_t}{P_t \mathcal{T}_t} \right) l_t^a + \left(\frac{1}{\mathfrak{n}\pi_t} \right) \frac{M_{t-1}^a}{P_{t-1} \mathcal{T}_{t-1}} + \left(\frac{i_{t-1}}{\mathfrak{n}\pi_t} \right) \frac{B_{t-1}^{ac}}{P_{t-1} \mathcal{T}_{t-1}} \\ &\quad + s_t i_{t-1}^* \frac{B_{t-1}^{a*}}{P_t^* \mathcal{T}_t} + \frac{\Theta_t^a}{P_t \mathcal{T}_t} + s_t \frac{R M_t^{a*}}{P_t^* \mathcal{T}_t}, \end{aligned}$$

where $s_t = \frac{S_t P_t^*}{P_t}$ and $\mathfrak{n}\pi_t = \frac{\mathcal{T}_t P_t}{\mathcal{T}_{t-1} P_{t-1}}$. Using appropriate definitions for the stationary variables, the equivalence between this constraint and constraint (8), where $\Omega_t^a = \frac{\Theta_t^a}{P_t \mathcal{T}_t}$, becomes evident.

The production function of the representative monopolist in the non-traded sector

$$Y_{it}^N = z^N \left[\left(K_{it-1}^N \right)^{\phi_N} \left(Q_{t-1} \right)^{1-\phi_N} \right]^{1-\alpha_N} \left(\mathcal{T}_t l_{it}^N \right)^{\alpha_N},$$

can be also transformed into stationary terms by dividing both sides by $\mathcal{T}_t$. Then

$$\frac{Y_{it}^N}{\mathcal{T}_t} = z^N \left[\left(\frac{K_{it-1}^N}{\mathcal{T}_t} \right)^{\phi_N} \left(\frac{Q_{t-1}}{\mathcal{T}_t} \right)^{1-\phi_N} \right]^{1-\alpha_N} \left(\frac{\mathcal{T}_t}{\mathcal{T}_t} l_{it}^N \right)^{\alpha_N},$$

which corresponds to equation (10). Note the timing convention for capital stocks, i.e., $k^N_{it-1} \equiv \frac{K^N_{it-1}}{\mathcal{T}_t}$.

Finally the equation of accumulation of capital for each firm in the non-traded sector is

$$K^N_{it} = (1-\delta_N)K^N_{it-1} + \left[1 - \frac{\kappa_N}{2}\left(\frac{X^N_{it}}{\mathfrak{n}X^N_{it-1}} - 1\right)^2\right] X^N_{it},$$

which can be written as

$$\left(\frac{\mathcal{T}_{t+1}}{\mathcal{T}_t}\right)\frac{K^N_{it}}{\mathcal{T}_{t+1}} = (1-\delta_N)\frac{K^N_{it-1}}{\mathcal{T}_t} + \left\{1 - \frac{\kappa_N}{2}\left[\frac{\mathcal{T}_t\left(X^N_{it}/\mathcal{T}_t\right)}{\mathfrak{n}\mathcal{T}_{t-1}\left(X^N_{it-1}/\mathcal{T}_{t-1}\right)} - 1\right]^2\right\}\frac{X^N_{it}}{\mathcal{T}_t},$$

which is equivalent to equation (11).

B. The Equations of the Model and Definition of Equilibrium

B.1. The First Order Conditions of the Households' Problem

The first order conditions of the asset holders' optimization problem correspond to (8) and

$$u^a_{c_t} = \beta^a\left(\frac{u^a_{c_{t+1}} i_t}{\mathfrak{n}\pi_{t+1}}\right) \qquad \text{with} \qquad u^a_{c_t} \equiv \left[\vartheta^a\left(c^a_t\right)^{\frac{\eta-1}{\eta}} + (1-\vartheta^a)\left(m^a_t\right)^{\frac{\eta-1}{\eta}}\right]^{-1}\vartheta^a\left(c^a_t\right)^{-\frac{1}{\eta}}, \tag{27}$$

$$u^a_{m_t} = \left[\vartheta^a\left(c^a_t\right)^{\frac{\eta-1}{\eta}} + (1-\vartheta^a)\left(m^a_t\right)^{\frac{\eta-1}{\eta}}\right]^{-1}(1-\vartheta^a)\left(m^a_t\right)^{-\frac{1}{\eta}} = u^a_{c_t}\left(\frac{i_t - 1}{i_t}\right), \tag{28}$$

$$u^a_{c_t}\left[1 + \upsilon(b^{a*}_t - \bar{b}^{a*})\right] = \beta^a\left[u^a_{c_{t+1}}\left(\frac{i^*_t}{\mathfrak{n}\pi^*}\right)\left(\frac{s_{t+1}}{s_t}\right)\right], \tag{29}$$

$$u^a_{lt} = \varkappa^a (l^a_t)^\psi = u^a_{c_t} w_t(1-\tau), \tag{30}$$

$$l^{aN}_t = \delta\left(\frac{w^N_t}{w_t}\right)^\varrho l^a_t, \tag{31}$$

and

$$l^{aT}_t = (1-\delta)\left(\frac{w^T_t}{w_t}\right)^\varrho l^a_t. \tag{32}$$

When $\beta^h = 0$, the first order conditions of the hand-to-mouth consumers optimization problem correspond to (9) and

$$u^h_{m_t} = \left[\vartheta^h\left(c^h_t\right)^{\frac{\eta-1}{\eta}} + (1-\vartheta^h)\left(m^h_t\right)^{\frac{\eta-1}{\eta}}\right]^{-1}(1-\vartheta^h)\left(m^h_t\right)^{-\frac{1}{\eta}} = u^h_{c_t} \tag{33}$$

with $u^h_{c_t} \equiv \left[\vartheta^h\left(c^h_t\right)^{\frac{\eta-1}{\eta}} + (1-\vartheta^h)\left(m^h_t\right)^{\frac{\eta-1}{\eta}}\right]^{-1}\vartheta^h\left(c^h_t\right)^{-\frac{1}{\eta}}$,

$$u^h_{lt} = \varkappa^h (l^h_t)^\psi = u^h_{c_t} w_t(1-\tau), \tag{34}$$

$$l_t^{hN} = \delta \left(\frac{w_t^N}{w_t} \right)^{\varrho} l_t^h, \tag{35}$$

and

$$l_t^{hT} = (1-\delta) \left(\frac{w_t^T}{w_t} \right)^{\varrho} l_t^h. \tag{36}$$

B.2. The First Order Conditions of the Firms' Problem

In a symmetric equilibrium (dropping the sub-indices), the first order conditions of the representative monopolist in the non-traded sector are equations (10)-(12) and:

$$\beta^a \left\{ \frac{u^a_{c_{t+1}}}{u^a_{c_t}} \left((1-\delta_N)\lambda^N_{t+1} + \frac{\phi_N(1-\alpha_N)}{\alpha_N} w^N_{t+1} \frac{l^N_{t+1}}{k^N_t} \right) \right\} = \mathfrak{n}\lambda^N_t, \tag{37}$$

$$\frac{1}{\lambda^N_t} = 1 - \mathcal{F}^N \left(\frac{x^N_t}{x^N_{t-1}} \right) - \kappa_N \frac{x^N_t}{x^N_{t-1}} \left(\frac{x^N_t}{x^N_{t-1}} - 1 \right) + \beta^a \kappa_N \left[\frac{u^a_{c_{t+1}}}{u^a_{c_t}} \frac{\lambda^N_{t+1}}{\lambda^N_t} \left(\frac{x^N_{t+1}}{x^N_t} - 1 \right) \left(\frac{x^N_{t+1}}{x^N_t} \right)^2 \right], \tag{38}$$

and

$$\Pi^N_t = \beta^a \left[\left(\frac{u^a_{c_{t+1}}}{u^a_{c_t}} \right) \left(\frac{p^N_{t+1}}{p^N_t} \right) \left(\frac{y^N_{t+1}}{y^N_t} \right) \Pi^N_{t+1} \right] + \frac{\theta-1}{\zeta} \left[\frac{\theta}{(\theta-1)(1-\varpi)(1+\iota_N)\alpha_N} \left(\frac{w^N_t l^N_t}{p^N_t y^N_t} \right) - 1 \right], \tag{39}$$

where λ^N_t is related to Tobin's Q and $\Pi^N_t \equiv \frac{\pi^N_t}{\pi^N_{t-1}} \left(\frac{\pi^N_t}{\pi^N_{t-1}} - 1 \right)$.

On the other hand, in a symmetric equilibrium (dropping the sub-indices), the optimizing conditions for the firm in the traded sector correspond to (13), (14), and

$$l^T_t = \left(\frac{s_t \alpha_T (1-\varpi) z^T_t}{w^T_t} \right)^{\frac{1}{1-\alpha_T}} \left(k^T_{t-1} \right)^{\phi_T} (q_{t-1})^{1-\phi_T}, \tag{40}$$

$$\beta^a \left\{ \frac{u^a_{c_{t+1}}}{u^a_{c_t}} \left((1-\delta_T)\lambda^T_{t+1} + \phi_T(1-\alpha_T)(1-\varpi) s_{t+1} \frac{y^T_{t+1}}{k^N_t} \right) \right\} = \mathfrak{n}\lambda^T_t, \tag{41}$$

and

$$\frac{1}{\lambda^T_t} = 1 - \mathcal{F}^T \left(\frac{x^T_{it}}{x^T_{it-1}} \right) - \kappa_T \frac{x^T_t}{x^T_{t-1}} \left(\frac{x^T_t}{x^T_{t-1}} - 1 \right) + \beta^a \kappa_T \left[\frac{u^a_{c_{t+1}}}{u^a_{c_t}} \frac{\lambda^T_{t+1}}{\lambda^T_t} \left(\frac{x^T_{t+1}}{x^T_t} - 1 \right) \left(\frac{x^T_{t+1}}{x^T_t} \right)^2 \right]. \tag{42}$$

B.3. Demand Functions, Aggregation, Market Clearing Conditions, and Other Equations

For consumption of traded and non-traded goods the demand functions are

$$c^{jN}_t = \varphi \left(p^N_t \right)^{-\chi} c^j_t \qquad \text{and} \qquad c^{jT}_t = (1-\varphi) {s_t}^{-\chi} c^j_t \qquad \text{for } \; j = a, h, \tag{43}$$

while the demand of investment of traded goods in the traded and non-traded sectors correspond to

$$x_t^{NT} = (1-\varphi)\,(s_t)^{-\chi}\,x_t^N \qquad \text{and} \qquad x_t^{TT} = (1-\varphi)\,(s_t)^{-\chi}\,x_t^T. \tag{44}$$

Public investment at steady state and that financed by the aid surge are determined by

$$x_t^{gs} = \mu_s \bar{g} \qquad \text{and} \qquad x_t^{gA} = \mu_A (g_t - \bar{g}). \tag{45}$$

By the definitions of the CPI, the government price index, the nominal depreciation rate, and the inflation of non-traded goods we have

$$1 = \left[\varphi\left(p_t^N\right)^{1-\chi} + (1-\varphi)(s_t)^{1-\chi}\right]^{\frac{1}{1-\chi}}, \tag{46}$$

$$p_t^g = \left[\nu\left(p_t^N\right)^{1-\chi} + (1-\nu)(s_t)^{1-\chi}\right]^{\frac{1}{1-\chi}} \tag{47}$$

$$\pi_t^S = \frac{s_t}{s_{t-1}}\frac{\pi_t}{\pi^*}, \tag{48}$$

and

$$\pi_t^N = \frac{p_t^N}{p_{t-1}^N}\pi_t. \tag{49}$$

Finally the aggregation equations and the market clearing conditions for bonds, labor, and money imply

$$\mathfrak{a}_t = \mathfrak{p}\mathfrak{a}_t^a + (1-\mathfrak{p})\mathfrak{a}_t^h \tag{50}$$

for $\mathfrak{a}_t = c_t,\, c_t^N,\, c_t^T,\, m_t,\, l_t,\, b_t^*,\, b_t^c,\, l_t^T,\, l_t^N$, where $b_t^{h*} = b_t^{hc} = 0$, and

$$b_t = b_t^c + b_t^{cb}. \tag{51}$$

B.4. Definition of Equilibrium

The simulations of the paper conform with the following definition of equilibrium.

Definition 1 *Given* $\{m_{-1}^a,\, b_{-1}^{ac},\, b_{-1}^{a*},\, m_{-1}^h,\, k_{-1}^N,\, k_{-1}^T,\, z_{-1}^T,\, q_{-1},\, A_{-1}^*,\, d_{-1}^g,\, R^*_{-1},\, b_{-1}^*,\, \bar{b}^{a*},\, \tau^h,\, \tau^a,\, \bar{z}^T\}$[44], *the external variables* $\{i_t^*,\, \pi^*,\, \bar{A}^*,\, rm^*\}$, *the target and policies* $\{\tau,\, \varpi,\, \iota_N,\, \bar{\pi},\, \bar{\pi}^S,\, \bar{b},\, \bar{g},\, \bar{d}^g,\, \bar{R}^*\}$ *and the exogenous increase in aid* $\{\epsilon_t^A\}_{t=0}^{\infty}$, *a symmetric equilibrium is a set of sequences* $\{c_t^a,\, c_t^{aN},\, c_t^{aT},\, c_t^h,\, c_t^{hN},\, c_t^{hT},\, c_t,\, c_t^T,\, c_t^N,\, l_t^a,\, l_t^{aN},\, l_t^{aT},\, l_t^h,\, l_t^{hN},\, l_t^{hT},\, l_t,\, m_t^a,\, m_t^h,\, m_t,\, b_t^{ca},\, b_t^{a*},\, b_t^c,\, A_t^*,\, g_t,\, g_t^N,\, g_t^T,\, q_t,\, x_t^{gs},\, x_t^{gA},\, d_t^g,\, b_t,\, R_t^*,\, b_t^{cb},\, b_t^*,\, k_t^N,\, l_t^N,\, y_t^N,\, x_t^N,\, k_t^T,\, z_t^T,\, l_t^T,\, y_t^T,\, x_t^T,\, x_t^{NT},\, x_t^{TT},\, y_t,\, \lambda_t^N,\, \lambda_t^T,\, w_t^N,\, w_t^T,\, w_t,\, \pi_t^N,\, \pi_t^S,\, \pi_t,\, p_t^g,\, p_t^N,\, i_t,\, s_t\}_{t=0}^{\infty}$ *satisfying (i) the price indices and definitions (1), and (46)-(49); (ii) the processes (15) and (16); (iii) the optimal conditions for consumers (7), (9), (27)-(36), and (43); (iv) the optimal conditions for firms (10), (11), (13), (14), (37)-(42), and (44); (v) the government rules and constraint (18)-(21), (45),* $b_t = \bar{b}$*; (vi) the central bank rules and constraint (22)-(24); and (vii) the aggregation and equilibrium market conditions for labor, non-traded goods, traded goods, money and assets (25), (26), (50), and (51).*

[44] Note that m_{-1}, b_{-1}, b_{-1}^{cb}, b_{-1}^*, and b_{-1}^c can be calculated using equations listed in (50)-(51).

C. The Efficiency of Public Investment and GDP

In this part of the Appendix, we prove that the percentage increase in GDP that results from a percentage increase in government spending depends on the *ratio* of the efficiency of the aid-surge financed public investment and the efficiency of the steady-state public investment. To do this, it is sufficient to simplify the model to one sector and consider the production function

$$y_t = z\left[(k_{t-1})^{\phi}(q_{t-1})^{1-\phi}\right]^{1-\alpha}(l_t)^{\alpha}, \tag{52}$$

and the public capital accumulation equation

$$\mathfrak{n}q_t = (1-\delta_g)q_{t-1} + \varepsilon_s\mu_s\bar{g} + \varepsilon_A\mu_A(g_t - \bar{g}). \tag{53}$$

Linearizing these equations around the steady state yields

$$\hat{y}_t = (1-\alpha)\phi\hat{k}_{t-1} + (1-\alpha)(1-\phi)\hat{q}_{t-1} + \alpha\hat{l}_t \tag{54}$$

and

$$\hat{q}_t = \frac{(1-\delta_g)}{\mathfrak{n}}\hat{q}_{t-1} + \left(\frac{\varepsilon_A\mu_A}{\mathfrak{n}}\right)\left(\frac{\bar{g}}{\bar{q}}\right)\hat{g}_t,$$

where $\hat{x}_t = \frac{x_t - \bar{x}}{\bar{x}}$ denote percentage deviations from steady state for $x_t = y_t,\ k_t,\ q_t,\ l_t,\ g_t$. But since at the steady state $\frac{\bar{g}}{\bar{q}} = \frac{(\mathfrak{n}+\delta_g-1)}{\varepsilon_s\mu_s}$, then the last equation can be re-written as

$$\hat{q}_t = \frac{(1-\delta_g)}{\mathfrak{n}}\hat{q}_{t-1} + \frac{(\mathfrak{n}+\delta_g-1)}{\mathfrak{n}}\left(\frac{\mu_A}{\mu_s}\right)\left(\frac{\varepsilon_A}{\varepsilon_s}\right)\hat{g}_t. \tag{55}$$

We are interested in finding $\frac{\partial\hat{y}_t}{\partial\hat{g}_{t-1}}$, to see how it depends on the efficiencies. Note that

$$\frac{\partial\hat{y}_t}{\partial\hat{g}_{t-1}} = \frac{\partial\hat{y}_t}{\partial\hat{q}_{t-1}}\frac{\partial\hat{q}_{t-1}}{\partial\hat{g}_{t-1}}. \tag{56}$$

Using (54), (55), and (56) we obtain

$$\frac{\partial\hat{y}_t}{\partial\hat{g}_{t-1}} = (1-\alpha)(1-\phi)\frac{(\mathfrak{n}+\delta_g-1)}{\mathfrak{n}}\left(\frac{\mu_A}{\mu_s}\right)\left(\frac{\varepsilon_A}{\varepsilon_s}\right),$$

which underscores the role of the *relative* efficiency $\frac{\varepsilon_A}{\varepsilon_s}$.

It should be noted that this result depends on the Cobb-Douglas production function assumption. By assuming a CES production function

$$y_t = z\left\{(1-\alpha)\left[(k_{t-1})^{\phi}(q_{t-1})^{1-\phi}\right]^{\sigma} + \alpha(l_t)^{\sigma}\right\}^{\frac{1}{\sigma}}.$$

we would obtain

$$\frac{\partial\hat{y}_t}{\partial\hat{g}_{t-1}} = (1-\alpha)(1-\phi)z^{\sigma}\frac{(\mathfrak{n}+\delta_g-1)^{1-(1-\phi)\sigma}}{\mathfrak{n}}\left[\frac{\bar{k}^{\phi}\bar{g}^{(1-\phi)}}{\bar{y}}\right]^{\sigma}(\mu_s\varepsilon_s)^{(1-\phi)\sigma}\left(\frac{\mu_A}{\mu_s}\right)\left(\frac{\varepsilon_A}{\varepsilon_s}\right),$$

where we have used $\frac{\bar{q}}{\bar{g}} = \frac{\varepsilon_s\mu_s}{\mathfrak{n}+\delta_g-1}$. But note that the Cobb-Douglas result is not fragile, in the sense that if the CES function is close to Cobb-Douglas ($\sigma \approx 0$), then the result holds approximately.

References

Adam, C. and D. Bevan, 2006, "Aid and the Supply Side: Public Investment, Export Performance, and Dutch Disease in Low-Income Countries," *The World Bank Economic Review*, Vol. 20(2), pp. 261-290.

Adam, C., S. O'Connell, E. Buffie and C. Pattillo, 2009, "Monetary Policy Rules for Managing Aid Surges in Africa," *Review of Development Economics*, Vol. 13(3), pp. 464-490.

Agénor, P., N. Bayraktar, and K. El Aynaoui, 2008, "Roads Out of Poverty? Assessing the Links Between Aid, Public Investment, Growth and Poverty Reduction, " *Journal of Development Economics*, Vol. 86(2), pp. 277-295.

Agénor, P. and D. Yilmaz, 2008, "Aid Allocation, Growth and Welfare with Productive Public Goods," Centre for Growth and Business Cycle Research Discussion Paper Series 95, Economics, The Univeristy of Manchester.

Arellano, C., A. Bulir, T. Lane, and L. Lipschitz, 2009, "The Dynamic Implications of Foreign Aid and Its Variability," *Journal of Development Economics*, Vol. 88, pp. 87–102.

Arestoff, F. and C. Hurlin, 2006, "Estimates of Government Net Capital Stocks for 26 Developing Countries, 1970-2002," World Bank Policy Research Working Paper 3858.

Arslanalp S., F. Bornhorst, S. Gupta, and E. Sze, 2010, "Growth Differences Across Countries: Public Capital or Public Investment?," IMF Manuscript.

Aschauer, D.A., 1989, "Is Public Expenditure Productive?," *Journal of Monetary Economics*, Vol. 23(2), pp. 177-200.

Berg, E., 1993, "Rethinking Technical Cooperation - Reforms for Capacity Building in Africa," UNDP, New York.

Berg, A., S. Aiyar , M. Hussain, S. Roache, T. Mirzoev, and A. Mahone, 2007, "The Macroeconomics of Scaling Up Aid: Lessons from Recent Experience," IMF Occasional Paper 253. (Washington: International Monetary Fund).

Berg, A., T. Mirzoev, R. Portillo, and L.F. Zanna, 2010, "The Short-Run Macroeconomics of Aid Inflows: Understanding the Interaction of Fiscal and Reserve Policy," IMF Working Paper 10/65.

Bouakez, H., E. Cardia and F. Ruge-Murcia, 2009, "The Transmission of Monetary Policy in a Multi-Sector Economy," *International Economic Review*, Vol. 50(4), pp. 1243-1266.

Bourguignon, F. and M. Sundberg, 2006, "Absorptive Capacity and Achieving the MDGs," Working Papers RP2006/47, World Institute for Development Economic Research.

Buffie, E., C. Adam, S. O'Connell, and C. Pattillo, 2008, "Riding the Wave: Monetary Responses to Aid Surges in Low-Income Countries," *European Economic Review*, Vol. 52, pp. 1378–1395.

Bu, Y., 2004, "Fixed Capital Stock Depreciation in Developing Countries: Some Evidence from Firm Level Data," Liberty Mutual Group, Manuscript.

Chatterjee, S. and S. Turnovsky, 2007, "Foreign Aid and Economic Growth: The Role of Flexible Labor Supply," *Journal of Development Economics*, Vol. 84(1), pp. 507–533.

Calvo, G., C. Reinhart, and C. Vegh, 1995, "Targeting the Real Exchange Rate: Theory and Evidence," *Journal of Development Economics*, 47(1), pp. 97-133.

Cerra, V., S. Tekin, and S. Turnovsky, 2008, "Foreign Aid and Real Exchange Rate Adjustments in a Financially Constrained Dependent Economy," IMF Working Paper 08/204.

Chakraborty S. and E. Dabla-Norris, 2009, "The Quality of Public Investment," IMF Working Paper 09/154.

Christiano, L., M. Eichenbaum, and C. Evans, 2005, "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy," *Journal of Political Economy*, Vol. 113(1), pp. 1-45.

Clemens, M., S. Radelet, and R. Bhavnani, 2004, "Counting Chickens When They Hatch: The Short-term Effect of Aid on Growth," Working Papers 44, Center for Global Development.

Collier, P., 2006, "African Growth: Why a 'Big Push'?," *Journal of African Economies*, Vol. 15(2), pp. 188-211.

Collier, P., 2007, "The Bottom Billion: Why the Poorest Countries are Failing and What Can Be Done About It," Oxford University Press, New York.

Cordella, T. and G. Dell'Ariccia, 2007, "Budget Support versus Project Aid: a Theoretical Appraisal," *Economic Journal*, Vol. 117(523), pp. 260-1279.

Dagher, J., J. Gottschalk and R. Portillo (2010), "Oil Windfalls in a DSGE Model: The Case of Ghana," IMF Manuscript.

Farah, A., E. Sacerdoti, and G. Salinas, 2009, "The Macroeconomic Impact of Scaled-up Aid: The Case of Niger," IMF Working Paper 09/36.

Galí, J., D. López-Salido, and J. Vallés, 2007, "Understanding the Effects of Government Spending on Consumption," *Journal of the European Economic Association*, Vol. 5(1), pp. 227–270.

Gottschalk, J., V. Le, H. Lofgren, and K. Nouve, 2009, "Analizing Fiscal Space Using MAMS: An Application to Burkina Faso," IMF Working Paper 09/227.

Gupta, S. and M. Verhoeven, 2001, "The Efficiency of Government Expenditure Experiences from Africa," *Journal of Policy Modeling*, Vol. 23(4), pp. 433–467.

Heller P., M. Katz, X. Debrun, T. Thomas, T. Koranchelian, and I. Adenauer, 2006, "Making Fiscal Space Happen: Managing Fiscal Policy in a World of Scaled-Up Aid," IMF Working Paper 06/270.

Hicks, J. R., 1939, *Value and Capital, An Inquiry Into Some Fundamental Principles of Economic Theory*, Oxford: Clarendon Press.

Hulten, C., 1990, "The Measurement of Capital, " in Ernst R. Berndt and E. Triplett, eds. Fifty Years of Economic Measurement, Studies in Income and Wealth, Volume 54: Chicago: Chicago University Press and National Bureau of Economic Research, 119-152.

Horvath, M., 2000, "Sectoral Shocks and Aggregate Fluctuations," *Journal of Monetary Economics*, Vol. 45(1), pp. 69-106.

Hulten, C., 1996, "Infrastructure Effectiveness as a Determinant of Economic Growth: How Well You Use it May Be More Important than How Much You Have," NBER Working Paper 5847.

International Monetary Fund, (2008a), "The Macroeconomics of Scaling-up Aid: The Cases of Benin, Niger, and Togo," IMF Manuscript Prepared by Staff of the African Department.

International Monetary Fund, (2008b), "The Macroeconomics of Scaling-up Aid Scenarios: The Cases of Central African Republic, Rwanda, and Sierra Leone," IMF Manuscript Prepared by Staff of the African Department.

International Monetary Fund and UNDP (2010), "The Gleneagles Scenarios: Scaling Up to Achieve the Millennium Development Goals," Forthcoming.

Isgut, A. and A. Fernandes, 2007, "Learning-by_Exporting Effects: Are They for Real?," Munich Personal RePEc Archive Paper No. 3121.

Johnson, S., J. Ostry, and A. Subramanian, 2007, "The Prospects for Sustained Growth in Africa: Benchmarking the Constraints," IMF Working Paper 07/52.

Keynes, J.M., 1936, *The General Theory of Employment, Interest, and Money*, New York: Macmillan.

Krugman, P., 1987, "The Narrow Moving Band, the Dutch Disease, and the Competitive Consequences of Mrs. Thatcher: Notes on Trade in the Presence of Dynamic Scale Economies," *Journal of Development Economics*, Vol. 27(1-2), pp. 41-55.

Kydland, F. and E. Prescott, 1982, "Time to Build and Aggregate Fluctuations," *Econometrica*, Vol. 50(6), pp. 1345-70.

Matsuyama, K., 1992, "Agricultural Productivity, Comparative Advantage and Economic Growth," *Journal of Economic Theory*, Vol. 58(2), pp. 317-334.

Mengistae, T. and C. Pattillo, 2004, "Export Orientation and Productivity in Sub-Saharan Africa," *IMF Staff Papers*, Vol. 51(2), pp. 327-353.

Portillo R. and L.F. Zanna, 2010, "Optimal and Implementable Reserve Accumulation and Fiscal Spending Rules in the Context of Aid Shocks," IMF Manuscript.

Prati, A. and T. Tressel, 2006, "Aid Volatility and Dutch Disease: Is There a Role for Macroeconomic Policies?" IMF Working Paper 06/145.

Pritchett, L., 2000, "The Tyranny of Concepts: CUDIE (Cumulated, Depreciated, Investment Effort) Is Not Capital," *Journal of Economic Growth*, Vol. 5(4), pp. 361-84.

Rajan, R. and A. Subramanian, 2010, "Aid, Dutch Disease, and Manaufacturing Growth," *Journal of Development Economics*, forthcoming.

Rodrik, D., 2008, "The Real Exchange Rate and Economic Growth," *Brookings Papers on Economic Activity*, Vol. 2, pp. 365-412.

Rotemberg, J., 1982, "Sticky Prices in the United States," *Journal of Political Economy,* Vol. 90, pp. 1187-1211.

Sarte, P., 2001, "Rent-seeking bureaucracies and oversight in a simple growth model," *Journal of Economic Dynamics and Control*, Vol. 25(9), pp. 1345-1365.

Steadman Group, 2009, "Financial Access Survey for Financial Sector Deepening," Presentation.

Schmitt-Grohé, S. and M. Uribe, 2003, "Closing Small Open Economy Models," *Journal of International Economics*, Vol. 61(1), pp. 163–185.

Schmitt-Grohé, S. and M. Uribe, 2007, "Optimal Simple and Implementable Monetary and Fiscal Rules," *Journal of Monetary Economics*, Vol. 54(6), pp. 1702–1725.

Tokarick, S., 2009, "A Method For Calculating Export Supply and Import Demand Elasticities," IMF Manuscript.

Torvik, R., 2001, "Learning by Doing and the Dutch Disease," *European Economic Review*, Vol. 45(2), pp. 285–306.

Van Biesebroeck, J., 2005, "Exporting Raises Productivity in Sub-Saharan African Manufacturing Firms," *Journal of International Economics*, Vol. 67(2), pp. 373-391.

Warner, A., 2010, "Cost-Benefit Analysis in World Bank Projects," Independent Evaluation Group, Washington, DC: World Bank.