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Aid and the Supply Side: Public Investment, Export Performance and Dutch Disease in Low Income Countries*

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Abstract

Contemporary policy debates on the macroeconomics of aid often concentrate on short run Dutch disease effects, ignoring the possible supply side impact of aid financed public expenditure. We present a simple model of aid and public expenditure in which public infrastructure generates an inter-temporal productivity spillover which may exhibit a sector-specific bias. The model also provides for a learning-by-doing externality, through which total factor productivity in the tradable sector is an increasing function of past export volumes. We then use an extended version of this model, calibrated to contemporary conditions in Uganda, to simulate the effect of a step increase in net aid flows. Our simulations show that beyond the short-run, where conventional demand-side Dutch disease effects are present, the relationship between enhanced aid flows, real exchange rates, output growth and welfare is less straightforward than simple models of aid suggest. We show that public infrastructure investment which generates a productivity bias in favour of non-tradable production delivers the largest aggregate return to aid, but it does so at the cost of a deterioration in the income distribution. Income gains accrue predominantly to urban skilled and unskilled households, leaving the rural poor relatively worse off. Under plausible parameterizations of the model the rural poor may also be worse off in absolute terms.

Keywords: Aid, Dutch Disease, Public Expenditure, Africa.

JEL Code: O41.

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1 Introduction

In recent years patterns of aid allocations have begun to change in ways that anticipate a significant concentration of aid on a small number of recipients. These changes reflect a number of factors including the Highly Indebted Poor Countries (HIPC) debt relief initiative, pressures for increased country selectivity in aid allocations (for example, Collier and Dollar, 2002), as well as specific initiatives aimed at increasing net aid flows to selected low-income countries.[1] Hand in hand with these developments has come a heightened anxiety amongst both donors and potential recipients that such initiatives may jeopardize macroeconomic stability and growth. Not surprisingly, these concerns are most acute in already aid-dependent countries, such as Uganda, where their recent track-record on growth, policy reform and poverty reduction has ensured they are best placed to take advantage of the donors' willingness to increase aid in support of higher levels of public expenditure but, arguably, feel that they have most to lose from aid increases which might undermine long-run growth. In part this anxiety reflects reservations about the absorptive and managerial capacity of over-stretched public sectors to deliver higher public expenditure without a serious decline in quality, and in part it reflects deeper reservations about aid dependency and the impact of foreign aid on the domestic political economy (for example, Adam and O'Connell (1999), Svensson (2000)). However, more traditional concerns about the macroeconomics of aid still also figure large, and it is on these that this paper focuses.

Dominating these concerns is the fear that the Dutch disease effects of aid will inhibit development of the tradable goods sector and reduce growth in the recipient economy. Research in this area has tended to focus on the tax-like distortion of aid or resource discoveries on the competitiveness of the tradable sector, typically where the latter enjoys learning-by-doing (LBD) productivity effects (for example, van Wijnbergen,1984, Sachs and Warner,1995, Gylafson *et al*,1997, Elbadawi, 1999 and Adam and O'Connell, 2004). In this paper we show that this conventional perspective may be overturned when productivity spillovers accrue in both tradable and non-tradable sectors. Specifically we examine the case where public infrastructure investment generates an inter-temporal productivity spillover for both tradable and non-tradable production, but in a potentially unbalanced manner.[2] For example, public investment in rural roads is likely to impact more on the production of (non-tradable) food crops than on urban-based (tradable) manufactures and *vice versa* for, say, telecommunications infrastructure.

A second source of concern is that the distributional effects of higher public expenditure may run counter to inequality and poverty reduction objectives. There are two elements here. The first is that the immediate beneficiaries of

[1] For example the International Finance Facility and other 'Global Funds'.

[2] The notion that productivity externalities accruing to the production of non-tradables might reverse conventional Dutch disease results is not new. Torvik (2001), for example, makes the same point, although does not explore specific mechanisms through which these externalities may emerge.

higher public expenditure tend to be the non-poor working in the services and manufacturing sectors as opposed to the poor who are predominantly engaged in food and cash crop production. The second is that, even if public expenditure is devoted to infrastructure that enhances productivity in non-tradable sectors, the distribution of aggregate income may move against net producers of non-tradables and hence, to the extent that the poor are located in these sectors, worsen the distribution of income. We show that this is a distinct possibility in circumstances where preferences are non-homothetic and the income elasticity of demand for non-tradable output (in this case basic food) is low.[3]

The paper is organized as follows. In the next section we outline a simple two-sector, two-good model to analyze these Dutch disease effects in the presence of aid-financed public infrastructure investment. This model is highly stylized and so in Section 3 we present a simulation model, calibrated to Ugandan data, to offer a sense of the possible magnitudes likely to prevail in reality, and to focus on the distributional consequences arising from alternative assumptions about the characteristics of aid-financed public expenditure. To do so we disaggregate the production and consumption sides of the economy, bring in private savings and investment, and allow for differentiated households, to give meaning to distributional considerations which are not reflected in the stripped down model of Section 2. We then simulate the medium-term effects of alternative aid-financed increases in public expenditure based on recent experience in Uganda. We examine two versions of the model. In the first, public infrastructure represents the only dynamic externality, while in the second this mechanism interacts with a learning-by-doing externality capturing productivity spillovers associated with increased non-traditional export production. Section 4 discusses the simulation results and Section 5 concludes.

Our results suggest that for reasonable parameter values governing the supply-side response to public expenditure, traditional Dutch disease effects are not present beyond the short-run. Rather, it appears that for low-income countries with a structure similar to that of contemporary Uganda, public expenditure whose productivity effects are skewed towards the non-tradable sector delivers significant growth in exports and total output and sustains increased aggregate real income in the medium term. These effects remain even if we assume that the country is, in fact, well endowed with public infrastructure and that its productivity on the margin is relatively low. Moreover, we show that these results also remain qualitatively unchanged in the presence of plausibly scaled learning-by-doing externalities in non-traditional exporting. In both cases, however, the simulation model also highlights important distributional tensions which disadvantage rural households relative to urban households and which may even lead to an absolute decline in rural incomes.

[3]The implications of this combination are explored by Matsuyama (1992) in his analysis of industrial take-off where the low income elasticity of demand for agricultural output allows agricultural productivity growth to generate the labour surplus and declining price of the wage good that fuel the process of industrialization.

2 A simple model of productivity spillovers

We consider a two-period Ricardo-Viner model of a small open economy that produces and consumes a non-traded good and a traded good. Private capital stocks are fixed, sector-specific, and do not depreciate, while a fixed endowment L of labour moves freely between sectors to equalize real consumption wages. The economy faces fixed external terms of trade and there are no tariffs or taxes. Aid, represented by a fully fungible transfer of (tradable) resources, is the only international capital flow in the model. To focus on the mechanisms of interest, we assume that aid is received in the first period only, although in the simulation model in Section 3 we find it more appropriate to treat the aid flow as permanent. Total aggregate expenditure consists of private expenditure on tradable and non-tradable goods, and public expenditure on infrastructure.

All values are expressed in terms of tradable goods where $P_T = 1$. Hence defining the real exchange rate as $P_N/P_T = Q$, and using the superscripts P and G to denote private and government expenditure, the first period income-expenditure balance is given by

$$E^P(Q,U) + E^G(Q,K) = R(Q;L) + A \tag{1}$$

where A is aid, U is private utility and K is public infrastructure capital. $E^P(Q,U)$, $E^G(Q,K)$ and $R(Q;L)$ represent private and public expenditure functions and the revenue function respectively. Letting the supply and compensated demand functions for non-traded goods be R_Q, E^P_Q and E^G_Q respectively, the condition for first-period market clearing in the non-traded goods market is

$$E^P_Q(Q,U) + E^G_Q(Q,K) = R_Q(Q;L) \tag{2}$$

Equations (1) and (2) imply that the trade balance is equal to the exogenous aid flow, thus: $E^P_T(Q,U) + E^G_T(Q,K) - R_T(Q;L) = A$. Finally the government budget constraint is defined as

$$E^G(Q,K) = A \tag{3}$$

The government's role in this model is simply the conversion of donor aid into public infrastructure. Since infrastructure is composed of tradable and non-tradable goods, the actual quantity of public investment realized will depend on the real exchange rate and the elasticity of substitution between tradable and non-tradable goods in investment demand.[4] Public investment takes place in the first period (at first period prices) but augments productive capacity in both the tradable and non-tradable sectors only in the second period.[5]

[4] At this stage we impose no prior on this elasticity, although in the simulation model in Section 3 we assume a Leontief structure for investment demand.

[5] Notice that in this model the first-period equilibrium embodies a latent externality, in the sense that the public capital stock is not optimized. Implicitly, the government is assumed to lack access to the tax or borrowing instruments required to raise K sufficiently to exhaust the return from public capital.

This completes the characterization of the first period. Using lower-case letters to denote second-period values, we assume that firms in both sectors may enjoy productivity gains from public infrastructure investment, and that, if forthcoming, these gains are sector specific but not appropriable by individual firms. Production in period two therefore depends on the real exchange rate, q, and the size of the public capital stock, K, installed from period 1. Second period GDP and sectoral equilibrium conditions are given by:

$$e(q, u) = r(q, K) \tag{4}$$

$$e_q(q, u) = r_q(q, K) \tag{5}$$

$$e_t(q, u) = r_t(q, K) \tag{6}$$

First Period Equilibrium Given the characterization of the government's behaviour, public capital formation is the only inter-temporal spillover in this simple model. Hence equations (1), (2), and (3) fully determine the first period equilibrium. Total differentiation of these three equations produces the following expressions for the proportional change in the real exchange rate, private utility and public infrastructure in terms of the increase in aid, where a hat ($\hat{}$) denotes a proportional change (see Appendix I)

$$\hat{Q} = \frac{dA}{QE_Q}\left[\frac{(\gamma/\phi)\Lambda^G}{B}\right] \tag{7}$$

$$\hat{U} = \frac{dA}{UE_U^P}\left[\frac{\eta(\gamma/\phi)\Lambda^G}{B}\right] \tag{8}$$

$$\hat{K} = \frac{dA}{KE_K^G}\left[1 - \frac{\eta(\gamma/\phi)\Lambda^G}{B}\right] \tag{9}$$

where

$$B = \Sigma_{QQ} - [(1-\eta)\Delta_{QQ}^P + \eta\Delta_{QQ}^G] - \gamma\left[\frac{(1-\eta)}{(1-\phi)}\Lambda^P - \frac{\eta}{\phi}\Lambda^G\right] \tag{10}$$

E_Q is total (private plus government) demand for non-tradables, and $\Sigma_{QQ} > 0, \Delta_{QQ}^P < 0$ and $\Delta_{QQ}^G < 0$ are the real-exchange rate elasticities of supply and (private and government) demand for non-tradables respectively. The three parameters, ϕ, γ and η describe the composition of government expenditure, as follows: ϕ is the share of government expenditure in total expenditure and γ is the share of government expenditure on non-tradables in total expenditure, so that (γ/ϕ) is the non-tradable share in government expenditure; and η is its share in the total demand for non-tradables. $\Lambda^P$and Λ^G denote the (uncompensated) income elasticities of demand for non-tradables of the public and private sectors respectively.

Expressions (7) to (9) deliver the standard demand-side Dutch disease results. First, notice that unless Λ^P is very large relative to Λ^G, Σ_{QQ} and Δ_{QQ} , the expression for B will be positive; letting $\Delta_{QQ} = (1-\eta)\Delta^P_{QQ} + \eta\Delta^G_{QQ}$ be the overall real exchange rate elasticity of demand for non-tradables, B will be positive provided[6]

$$\Lambda^P < \left(\frac{\eta}{1-\eta}\right)\left(\frac{1-\phi}{\phi}\right)\Lambda^G + \left(\frac{1-\phi}{\gamma(1-\eta)}\right)(\Sigma_{QQ} - \Delta_{QQ}) \tag{11}$$

Hence for reasonable values an increase in aid will appreciate the real exchange rate and will increase first period private welfare. The latter result may at first seem counter-intuitive but, as can be seen immediately from equation (A4) in the Appendix, it arises from the fact that the private sector is a net seller of the non-tradable good to the public sector so that the aid-induced real exchange rate appreciation generates a favourable movement in the private-public terms of trade. Finally, aid will succeed in increasing public infrastructure as long as $B > \eta(\gamma/\phi)\Lambda^G$, which requires that

$$\Lambda^P < \left(\frac{1-\phi}{\gamma(1-\eta)}\right)(\Sigma_{QQ} - \Delta_{QQ}) \tag{12}$$

Assuming $\Lambda^G > 0$, this is a stricter condition than that required for increased aid to appreciate the real exchange rate and increase private welfare although, for the reasons noted in footnote 4, this condition will be satisfied in most circumstances.

In all three cases the magnitude of these effects is determined by the behavioural structure of the economy. Consider, for example, the responsiveness of the real exchange rate to the aid inflow (equation (7)). Here the degree of appreciation moderates the higher are $\Sigma_{QQ}, \Delta^P_{QQ}$ and Δ^G_{QQ} (in absolute value) but increases with the private and government income elasticities of demand for non-tradables.[7] A similar set of comparative static results can be derived for the private welfare and public expenditure effects of aid. Since these are not of central importance in this paper we do not discuss them here.

Notice that if there is no public investment response to the aid inflow (so that $E^G(.) = 0$ in (1) and aid resources accrue directly to the private sector as an income transfer), equation (3) disappears and we obtain

$$\hat{U} = \frac{dA}{UE^P_U} \tag{13}$$

$$\hat{Q} = \frac{\Lambda^P dA}{E(\Sigma_{QQ} - \Delta^P_{QQ})} \tag{14}$$

[6] In the simulation model below $\gamma \approx 0.10$, $\eta \approx 0.125$ and $\phi \approx 0.20$, so that the first term on the right hand side scales the sum of the real exchange rate demand and supply elasticities by a factor of around 9. Since it is reasonable to expect that Λ^P will be less than unity, then even if Λ^G were very low B would still be positive.

[7] In the case of the private sector expenditure elasticity the effect is unambiguous; in the case of the government elasticity, the responsiveness of the real exchange rate elasticity is increasing in Λ^G provided condition (12) is satisfied.

which confirm the simple demand-side results of a pure consumption transfer which emerge from any standard model (for example Devarajan *et al*, 1993). In this case the aid flow is strictly welfare increasing and will, unambiguously, appreciate the real exchange rate, with the extent of the appreciation being determined by the income elasticity of demand and the elasticities of demand and supply in the non-tradable sector.[8]

Second-Period Equilibrium The second period equilibrium is derived in an analogous fashion by totally differentiating (4) and (5) to solve for dq and du in terms of dK and the productivity of investment in the two sectors as follows.[9] To do so, first notice that from the properties of (4), (5) and (6), the value of the marginal product of infrastructure capital is given by $r_K = qr_{qK} + r_{tK}$. Then, letting $\theta = qe_q/e$ be the share of non-tradables in total expenditure, we obtain the following expressions for the changes in second-period utility,

$$\hat{u} = \frac{r_K dK}{ue_u} \tag{15}$$

and in the second-period real exchange rate

$$\hat{q} = \frac{[(\theta\lambda^p - 1)qr_{qK} + \theta\lambda^p r_{tK}]dK}{qe_q(\sigma_{qq} - \delta_{qq})} \tag{16}$$

where, following the derivations in Appendix 1, λ^p is the second-period private sector income elasticity of demand for non-tradables, and $\sigma_{qq} > 0$ and $\delta_{qq} < 0$ are the second period real exchange rate elasticities of supply and (private sector) demand for non-tradables, respectively.[10]

Three key results emerge from the above. The first is that in this model the change in second period utility depends on the value of the *aggregate* product of public capital; it does not depend on the presence or absence of any bias in productivity. Second, and by contrast, the evolution of the real exchange depends on the scale of infrastructure investment and the relative bias in productivity spillover between the tradable and non-tradable sectors. Thus, noting that

[8] Notice, also, that if public investment is entirely composed of tradables so that $\gamma = \eta = \Lambda^G = 0$, we get the obvious result that $\frac{dQ}{dA} = \frac{dU}{dA} = 0$ and $\frac{dK}{dA} = \frac{1}{E_K}$, in other words that the aid inflow has no consequences for the first-period real exchange rate or private utility and that public capital increases in direct proportion to the aid inflow.

[9] We express the results which follow in terms of dK, the increase in public infrastructure, rather than solving out for dK from (9) since from the perspective of period 2 the relationship between the original aid flow and the volume of additional infrastructure it financed is immaterial. Though we choose not to do so, it would be a simple matter to to solve the donor's optimal aid allocation as a function of the second-period productivity given the donor's welfare function and budget constraint.

[10] Notice that we could derive the same result by solving (3) and (5). In this instance equation (16) would take the form

$$\hat{q} = \frac{[((1-\theta)\lambda^{pt} - 1)r_{tK} + (1-\theta)\lambda^{pt} qr_{qK}]dK}{e_t(\sigma_{tq} - \delta_{tq})}$$

where λ^{pt} is the second period income elasticity of demand for tradables, and $\sigma_{tq} < 0$ and $\delta_{tq} > 0$ the second-period real exchange rate elasticities of supply and demand for tradables.

$(\sigma_{qq} - \delta_{qq}) > 0$ it follows that the higher the impact on non-tradable (tradable) productivity the more likely is the real exchange rate to depreciate (appreciate). Third, these effects are moderated by the income elasticity of demand for non-tradables. For given values of r_{qK} and r_{tK}, the lower the income elasticity, λ^p, the weaker the tendency for the real exchange rate to appreciate. Specifically, solving (16) it follows that

$$\hat{q} \gtrless 0 \qquad \text{as } \lambda^p \gtrless \frac{1}{\theta}\left[\frac{qr_{qK}}{qr_{qK} + r_{tK}}\right] \tag{17}$$

If productivity is exactly balanced, in the sense that $qr_{qK} = r_{tK}$ condition (17) simplifies to

$$\hat{q} \gtrless 0 \qquad \text{as } \lambda^p \gtrless \frac{1}{2\theta} \tag{18}$$

In the simulation model in the following section we consider only 'extreme-bias' cases where alternately $qr_{qK} = 0$ and $r_{tK} = 0$. In the former case, where productivity gains are located exclusively in the tradable sector, the real exchange rate will unambiguously appreciate for any non-negative income elasticity, while in the latter (where productivity gains are located exclusively in the non-tradable sector) condition (17) becomes

$$\hat{q} \gtrless 0 \qquad \text{as } \lambda^p \gtrless \frac{1}{\theta} \tag{19}$$

These three results highlight the principal aggregate effects of aid we explore in the remainder of the paper. They indicate that in the presence of productivity effects the dynamic evolution of the equilibrium real exchange rate is ambiguous but that in the configuration which characterizes the current aid environment in low income countries – where substantial aid financed public expenditure is targeted to improving the productivity of the non-tradable sector and where income elasticities of demand for non-tradable goods such as basic food are low – then the initial appreciation is likely to be followed by a subsequent equilibrium depreciation of the real exchange rate.

Learning-by-doing So far the analysis has focused exclusively on positive productivity spillovers from public infrastructure investment. As we noted in the introduction, however, an important strand in the debate about aid and Dutch disease has been the concern that aid flows serve to weaken the positive learning-by-doing externalities arising from tradable goods production. To reflect this we assume that firms in the export sector benefit from learning-by-doing spillovers that are sector-specific but not appropriable by individual firms.[11] Exports and income in the second period now depend not only on the real exchange rate, q, and the level of infrastructure capital, K, but also on first period exports. Hence we re-define the second period equilibrium (4), (5), and (6) as

$$e(q, u) = r(q, K, R_T) \tag{20}$$

[11] This extension draws directly from the structure used in Adam and O'Connell (2004).

$$e_q(q,u) = r_q(q,K,R_T) \tag{21}$$

$$e_t(q,u) = r_t(q,K,R_T) \tag{22}$$

where R_T denotes the volume of first period exports. We assume that $r_R = qr_{qR} + r_{tR} > 0$ where $r_{qR} \leq 0$ and $r_{tR} > 0$. Spillovers therefore create their own biased shift in the production possibility frontier in period 2 so that at fixed relative prices the output of non-tradables will fall in absolute terms (the Rybczynski Theorem) in the face of higher first-period tradable production.

Accounting for this second externality, the second period equilibrium for private sector utility and the real exchange rate (and hence net exports) is given by

$$\hat{u} = \frac{1}{ue_u}\left[r_K dK + r_R dR_T\right] \tag{23}$$

and

$$\hat{q} = \frac{\left[(\theta\lambda^P - 1)qr_{qK} + \theta\lambda^p r_{tK}\right]dK - \left[(\theta\lambda^p - 1)qr_{qR} + \theta\lambda^p r_{tR}\right]dR_T}{qe_q[\sigma_{qq} - \delta_{qq}]} \tag{24}$$

In the natural case where $r_{qR} = 0$ (i.e learning-by-doing does not impact the productivity of the non-tradable sector), it follows that with $r_{tR} > 0$ an aid inflow which lowers first period net exports (so that $dR_T < 0$) will lower second period welfare relative to (15), and will lead to a more appreciated real exchange rate (and hence a lower level of net-exports), relative to (16). This effect is larger, other things equal, the higher the income elasticity of demand for non-tradables and the larger the share of non-tradables in total expenditure. Whether this second externality could reverse the sign of $\hat{u}$ or $\hat{q}$ will, of course, depend on the relative size of the two externalities, and the changes triggering them (i.e. dK and dR_T). As we show in Section 4, the positive effects flowing from public infrastructure investment dominate the negative learning-by-doing effects for reasonable calibrations of the simulation model. It is to this we now turn.

3 The simulation model

The analytical model is necessarily highly stylized. It assumes fixed private resource endowments, a highly simplified government structure, and focuses only on aggregate consumption. To give greater substance to its central mechanisms, to offer a sense of the magnitude of the possible effects policy makers are likely to confront, and to unpack some first-order distributional consequences of the aid and public expenditure interaction, we construct a small recursively dynamic computable general equilibrium model calibrated to reflect the principal features of contemporary Uganda. In this section we provide a brief sketch of the features of the simulation model; the properties of the data calibration employed in the simulations are summarized in Appendix II.[12]

[12] The full model and calibration data are available on request from the authors.

We use a real (barter) model of a small open economy enjoying no market power in world markets, either for its imports or exports, so that the terms of trade are independent of domestic policy choices, and are thus held constant across the range of experiments. The production side of the model is standard. Firms in each of the four productive sectors (food-crop agriculture, cash crops, manufacturing and services) are assumed to be perfectly competitive, producing a single good which can be sold to either the domestic or export markets. At any point in time, production in each sector i is determined by a Cobb-Douglas function of the form

$$X_i = A_i S_i^{\alpha s} \prod_{lc} L_{ilc}^{\alpha lc} KP_i^{\alpha k} KG^{\alpha g} \tag{25}$$

The factors S, L, KP, and KG denote land, labour (consisting of skilled and unskilled labour), sector-specific private capital and infrastructure respectively. Only production in the rural sectors requires land which is fixed in perpetuity. Private sector-specific capital is fixed in each period, but can be augmented over time, so that labour is the only variable factor in the short run. Labour is fixed in aggregate but is mobile across sectors and at the margin is paid the value of its marginal product. Private sector output is also determined by the level of infrastructure, KG, which is provided by government. Constant returns to scale prevail in the private factors of production, but increasing returns are possible in the presence of public infrastructure.

The distributional consequences of aid and public expenditure are tracked though their impact on three household types, differentiated by factor ownership and patterns of consumption and saving. The first is a 'rural' household, which is primarily involved in food-crop agriculture (it owns the land and capital in this sector) but it also supplies unskilled labour to the cash crop sector. This household is outside the direct tax net, and has zero net savings.[13] The second household is the 'urban unskilled' household whose only factor of production is unskilled labour which it supplies to the manufacturing, services and government sectors. It owns no capital or land, has zero (gross and) net savings, but in contrast to the rural household it does pay direct taxes. Finally the 'urban-skilled' household supplies skilled labour to the manufacturing, services and public sectors and owns the remainder of the land and capital in the economy. This household pays direct taxes to government, at a higher rate than the unskilled household, earns interest on its net holdings of government domestic debt, and has a non-zero but constant propensity to save out of disposable income.

Consumption for each household type is defined in terms of a constant elasticity of substitution linear expenditure system (CES-LES), which allows for the income elasticity of demand for different goods to deviate from unity. In the simulations reported in the next section, we restrict our attention to the case where only food consumption is subject to a subsistence threshold. This implies that the marginal income elasticity of demand for food is less than unity and

[13] Gross savings in this sector are exactly equal to the depreciation of agricultural capital.

the income elasticity of demand for all other goods (manufactured goods and services) is greater than unity.[14]

Government policy decisions impact the private sector through a number of channels, only some of which we consider in this paper. For example, we do not examine the consequences of changes to the structure of taxation or the volume of real recurrent expenditure, both of which are kept constant across all simulations. Instead we focus entirely on changes to government infrastructure investment, allowing the productivity effects of this investment to vary across sectors [15]

We adopt a neoclassical closure constraining total investment to equal the level of domestic savings. This rule, which is broadly consistent with conditions in Uganda where unrationed access to world capital markets is virtually zero and domestic private saving is relatively interest inelastic, means that the shortfall (excess) of government savings relative to the cost of government capital formation, net of exogenously-given foreign savings, directly crowds-out (crowds-in) private investment.

The final element is the learning-by-doing externality. We assume that learning-by-doing generates a Hicks-neutral innovation to total factor productivity in the manufacturing sector (i.e. our non-traditional export sector). Specifically, in (25) we assume that $A_{it} = A_i$ for all time periods t for non-spillover sectors, while for the spillover sector, denoted s, the total factor productivity evolves according to

$$A_{st} = A_{s0}[1 + \phi \ln \left(\frac{E_t^p}{\bar{E}_t^p} \right)] \tag{26}$$

where $E_t^p = \sum_{j=1}^{\infty} \Gamma^j E_{t-j}$ is the (discounted) sum of exports in the spillover sector up to and including $t-1$ under the simulation experiment, and $\bar{E}_t^p$ is the correspondingly defined cumulative exports under the baseline trajectory for the economy. $\phi \geq 0$ measures the extent of the spillover, $\Gamma = (1+\gamma)^{-1} < 1$ is the gross discount factor, and A_{s0} is the value of A_{st} in the baseline calibration. Hence the higher is γ the lower the impact of past experience on current productivity. Since $\gamma > 0$ there will always be some persistence in $\left(\frac{E^p}{\bar{E}^p}\right)$ so that temporary policy reforms will have at least some permanent consequence for productivity.

The model has a simple recursively dynamic structure. Each solution run tracks the economy over 10 periods from the initial policy change, and each period may be thought of as a fiscal year. Within each year public and private capital stocks are taken as given and the model is solved given the parameters of the experiment (e.g. the increased aid flows and the corresponding public

[14] Since cash crops are produced solely for export, final household consumption is defined over food, manufactures and services only.

[15] It is reasonable to assume that there are long-run returns to recurrent public expenditure on health and education so that the value of this expenditure is also felt on the supply side. The simulation model does not, however, reflect this feedback. We take the view that this feedback is relatively slow. Accordingly our simulations reflect a "medium-term" in which adjustment to the physical capital stock takes place but where changes to the human capital stock have not yet materialized.

expenditure decision being analyzed). This solution defines a new vector of prices and quantities for the economy, including the level of public and private sector investment. This feeds into the dynamic equation for investment

$$K_{i,t} = K_{i,t-1}(1-\mu_i) + \Delta K_{i,t-j} \tag{27}$$

where μ_i denotes the rate of depreciation and j measures the gestation lag on investment. In the simulations presented below, our default setting is $j = 1$ although we examine the effects of assuming that public investment augments the stock of infrastructure capital only with a longer lag. In order to focus exclusively on the impact of increased aid flows on the economy we calibrate the model to an initial equilibrium in which net public and private investment is zero (i.e. gross investment exactly matches depreciation) and there is no growth in the labour supply. The baseline therefore represents a steady-state equilibrium for the economy.

4 Experiments and Results

4.1 Simulation Experiments

The data used to calibrate the CGE model are described in Appendix II and summarized in Appendix Table 1. The policy experiment is concerned with the consequences of a permanent 12.5 percent increase in the net (grant) aid inflow to the economy, equivalent to just under 2 percent of GDP, roughly the size of the increase in net aid flows to Uganda between 2000 and 2002. In all cases, the aid flow is used exclusively to finance an increase in public infrastructure investment. Hence although in practice the government may decide to respond to the aid flow by increasing other components of its expenditure programme or altering the rate of revenue mobilization, our simulations take the tax structure and the recurrent expenditure programme (in real terms) as given; any consequent changes in the domestic budget balance after grants is financed through a direct crowding-out or crowding-in of private investment.

Table 1. Simulation Experiments

	Experiments	
1	No productivity spillover from infrastructure capital	
2	Productivity spillover with no bias	
3	Productivity spillover with export-production bias	
4	Productivity spillover with domestic production bias	
5	As 4 with subsistence threshold for food	
	Variants	
a		$\alpha_G = 0.50$; $KG/KG^* = 0.50$
b		$\alpha_G = 0.25$; $KG/KG^* = 0.75$
	(i)	LBD spillover = 0.20
	(ii)	LBD spillover = 0.45
	(iii)	Gestation lag for public investment = 3 years

Table 1 summarizes the full set of experiments. Simulation 1 provides our benchmark, where the infrastructure investment has no effect on private sector productivity: the economy's total capital stock is increased but the increased public capital does not sustain higher private output. This allows us to isolate the pure demand side effects of the aid flow. Simulation 2 examines the case where the investment does enhance private sector productivity but these effects are uniform across all sectors of the economy and are represented by an outward shift in each sector's production possibility frontier between domestic (non-tradable) and export (tradable) variants of the good. The remaining permutations on the basic experiment (simulations 3 to 5) examine three central cases where the productivity impact is still felt across all sectors but now embodies a bias such that within each sector the shift in the production possibility frontier is skewed in favour of either tradable or non-tradable production. Specifically, we consider only the 'extreme-bias' cases described in equations (17) and (19) above which are represented by a rotation in the frontier around either end-point. Simulations 1 through 4 assume that the subsistence component in consumption is zero so that the consumption side of the economy is homothetic in income. In Simulation 5, however, we impose a subsistence component for food consumption so that the income elasticity of demand for food falls below one.

We then analyse variants of these core experiments in order to examine the robustness of our results to alternative assumptions about the level and productivity effects of public infrastructure expenditure, private consumption behaviour, and the nature of the learning-by-doing spillover. First, we consider two alternative initial calibrations for the economy, the first where the public capital stock is only 50% of is optimal value, conditional on the initial endowments of private factors and the assumed parameters of the production function, and the second where the economy is initially endowed with 75% of the optimal stock. Second, given the lack of a strong empirical consensus on the size of the infrastructure productivity in low-income countries, we vary the spillover parameter. We use Hulten's (1996) estimates which are based on estimated production functions for 43 developing countries over the period 1970-1990 in which he derives an average value of $\alpha_G = 0.25$. We use this value in our simulations but also consider a larger value ($\alpha_G = 0.50$) to reflect the possibility that at the margin the productivity of public infrastructure expenditure may in fact be higher than the historical averages suggest. Varying the spillover parameter and initial infrastructure capital stock independently gives us four initial permutations for each experiment. Since the variation in behaviour of the economy between these points is fairly regular we report only the two extreme values; the first, labelled variant a, is the case where the returns to infrastructure are high and the initial stock is far from its optimal value ($\alpha_G = 0.50$ and $KG/KG^* = 0.50$). Variant b corresponds to the case where returns are low and the initial stock is close to its optimal value ($\alpha_G = 0.25$ and $KG/KG^* = 0.75$).

The evidence base for the learning-by-doing spillover is even weaker and so we are forced to experiment with plausible alternative values. Our central value for the elasticity of manufacturing sector TFP with respect to non-traditional exports (the parameter ϕ in equation (26)) is set to $\phi = 0.20$. Since this value is highly contested we also consider a value of $\phi = 0.45$. These are reported as variants (*i*) and (*ii*). In the interests of keeping the number of reported simulations manageable, these variants are combined with variant *b* only. Finally, we also allow for infrastructure investment expenditure to augment the capital stock with a lag of 3 years rather than the one year lag assumed in the baseline experiments. This is variant (*iii*) and is reported in combination with 5*b* only.

In all cases, it is assumed that the government takes into account price changes in determining the volume of expenditure which can be financed with the additional aid. Hence it sets out to behave in a way which is (domestic) budget neutral. Second-order changes in the level of household income, demand, and relative price effects arising from infra-marginal government activities are not, however, internalized in the government's decisions so that the experiments are not necessarily budget neutral *ex post.*

For each experiment we report the impact effect (year 1) and the cumulative evolution of the economy after 5 and 10 years. In order to simplify our presentation we focus only on changes in a small number of key aggregates. These are: the export-weighted real exchange rate; the volume of exports and imports and the domestic good supply; real GDP; private investment; the fiscal accounts; and the real disposable income of our three household types, measured in terms of the household-specific consumption price index. For a given level of government expenditure real disposable income is a direct measure of household welfare.

4.2 Results

*** Table 2 here ***

Unproductive Infrastructure Experiment 1 provides a benchmark for what follows. Here the infrastructure investment confers no benefits on private productivity so that in terms of the model in Section 2, $qr_{qK} = r_{tK} = 0$. Hence the aid flow has little initial impact on GDP, but it does lead to an appreciation of the export real exchange rate and a sizeable contraction in exports in favour of higher production of domestic goods. The higher permanent level of aid necessarily implies an increased current account deficit, so that total imports rise despite the decline in private export earnings. In contrast to the endowment model of Section 2, the evolution of the simulated economy over the medium-term points to a progressive deterioration in overall economic performance as a result of the decline in real private sector investment. In part this reflects a decline in total savings as the fiscal balance deteriorates, which in turn reflects the adverse effects of the real exchange rate on the budget.[16] However the main

[16] Since government in this model is a net seller of foreign exchange, the real exchange rate appreciation reduces the domestic value of the budget balance and therefore increases the domestic financing requirement.

reason for the decline in real investment is that the real exchange rate appreciation raises the cost of capital goods (since capital formation is intensive in non-tradable services). This means that although the real exchange rate appreciation moderates over time, the deterioration of the capital stock ensures that the decline in export performance does not reverse and hence the initial welfare gains weaken over time. Finally, while total real income increases, rural households actually suffer a decline in their income, absolutely in this case and also relative to urban households. This relative decline is an important result which recurs across all simulations to a greater or lesser degree. In experiment 1, the principal reason for this is that the demand effects from increased government expenditure fall disproportionately on urban skilled and unskilled labour and on intermediate goods from the manufacturing and services sectors. In other words, backward linkages from the formal urban sectors (manufacturing, services and government) to the rural sectors (food and cash-crops) are extremely weak. As later results show, these demand effects are exacerbated in circumstances when relative price effects turn against the rural sector, and the income elasticity of demand for food is low.

Productive Infrastructure By contrast, in experiments 2 to 5 government infrastructure investment raises private-sector productivity. In experiment 2 this productivity effect is uniform across sectors and between production for the domestic and export markets. There is now a fairly substantial cumulative growth in GDP over the ten years, some improvement in the fiscal balance, and a marked increase in private investment.[17] This is true both for experiment 2*a*, where public capital is relatively scarce and its returns are high, and also, in a more muted fashion, at the other extreme (2*b*) where the economy is close to its optimum and returns are low. As a consequence, while the impact effects on the real exchange rate and on exports are very similar to experiment 1, they diverge sharply over time. In the case of experiment 2*a*, over the medium-term, most of the real exchange rate appreciation has been reversed. Moreover, even though the real exchange rate remains appreciated relative to its baseline value, the initial 6.2 percent fall in export volumes is reversed, moving to a 3.8 percent increase over the baseline by the end of the simulation. For experiment 2*b*, the recovery is slower so that even after 10 years total exports have not quite returned to their pre-aid level.

While the impact effects on household incomes are the same as in the previous experiment, matters improve over time so that not only is total real income more than 4 percent higher over the long run but the previously poor and declining position of rural households has been reversed. Rural households enjoy an increase in real income over time in this experiment, even though their gain is lower than that of the urban households.

[17] Government revenue grows as real incomes and expenditures grow while, after the initial step change, real government spending does not. Savings available for private investment grow partly with GDP but also because of 'crowding-in' from the improvement in the fiscal balance. It is a consequence of the closure rule mentioned earlier that these resources are duly invested.

Experiments 3 and 4 consider the outcome if the productivity gains witnessed in experiment 2 are biased either towards the production of tradable (exportable) or non-tradable (domestic) goods. In the former case, considered in experiment 3, while the productivity effect is again positive and uniform across sectors, it is now biased within the food and manufacturing sectors in favour of export production. As expected, when there is no increase in the productivity of non-tradable production, this more than doubles the real exchange rate appreciation relative to experiment 2. Hence, although manufacturing export performance is stronger as a result of the productivity bias traditional cash-crop exports are hit relatively hard, some 2.3 percentage points lower than when productivity gains are neutral.

When the productivity gain is biased entirely towards the production of the domestic good, as shown in experiment 4, outcomes are markedly different. The bias in production (which increases the supply of non-tradable goods) is sufficiently strong to almost entirely offset the demand effects of the increased aid flows so that the real exchange rate movement is more or less neutral (a mild depreciation in experiment 4*a* and a very mild appreciation in 4*b*).[18] The effects on exports are symmetrical with experiment 3; cash-crop exports fall by less initially and recover more strongly than in earlier experiments, but the domestic bias in manufacturing productivity results in a greater initial decline and more sluggish recovery in manufacturing exports. In the case where the marginal productivity of infrastructure is relatively low, manufacturing exports fail to return to their initial level after 10 years.

The domestic-biased supply response also leads to a larger improvement in the long-run fiscal balance (of 0.5 percentage points of GDP) reflecting favourable relative price movements (see footnote 16) as well as the effects of higher growth and investment than in either the neutral or export-biased forms of productivity growth.

The most striking difference between these two experiments, though, is the effect on real household disposable incomes. Compared to the case of a neutral supply response, a strong export bias in the productivity gain induced by infrastructure expenditure sharply moderates real income growth in the economy. Long-run total income rises by only 1.9 percent over its baseline compared to 4.3 percent when the supply response is neutral between exports and domestic production. However, the income gain is spread relatively equally across household groups. This contrasts sharply with the domestic-biased supply response which generates a markedly higher aggregate real income gain of 6.8 percent in the long-run but one that is disproportionately skewed in favour of the urban households.

As noted above, the tendency for urban households to gain disproportionately from aid-financed increases in infrastructure partly reflects the low backward linkages from government expenditure to the rural sector of the economy. The relative price movements underpinning experiment 4 exacerbate these weak

[18] The model in Section 2 predicts that the real exchange rate change should be exactly zero. That it is not so in the simulation model reflects its richer structure including the fact that the government budget is not invariant to changes in the real exchange rate.

linkages. As the economy's increased ability to produce domestic goods reverses the real exchange rate appreciation this shifts the domestic terms of trade in favour of those consuming the now relatively cheaper domestic goods (all households) and against those producing them (the rural household). Rural households thus share more or less equally in the consumption gain from lower-cost domestic goods but share disproportionately in the income loss from producing them.

In experiments 2 and 4 these adverse distributional effects are weak enough not to fully offset the rural household's share in the aggregate income gain for the economy. This is not the case, however, in Experiment 5. This experiment repeats the previous one, but assumes that there is a high subsistence requirement in food consumption for all households. The implication of this is that having met this requirement, positive income gains will be allocated disproportionately *away* from food expenditure so that on the margin the income elasticity of demand for food will be less than unity, and increasingly so the higher is the subsistence threshold, and *vice versa* for the other sectors. The effect of this adjustment to assumed consumer behaviour is dramatic; the real exchange rate now initially depreciates sharply and, in the case of experiment $5a$, remains more depreciated than the baseline throughout the simulation. Similarly after a small initial fall, export volumes increase substantially, as does the fiscal balance, private investment and real GDP. In all cases the gains are greater than in any of the other experiments. The same holds for aggregate real income which increases by 7.5 percent over the baseline in the long-run in experiment $5a$ and 5.9% in experiment $5b$.

The distributional impact in this experiment is rather unpleasant, though. Urban households enjoy substantial real income gains as a result of the decline in food prices, while rural households experience large income falls. The reason is simple; the adverse shift in the internal terms of trade against rural households noted in experiment 4 is magnified by the low income elasticity of demand in consumption from all households. As net producers, rural households suffer twice over; the fall in food prices caused by the increase in supply is exacerbated by the weakness in the demand for food as a result of the low income elasticity.[19]

4.3 Learning-by-doing and robustness

In Table 3 we subject the results presented in Table 2 to a range of robustness checks, focusing in particular on three key parameters.

*** Table 3 ***

[19] The size of these effects clearly reflects the subsistence threshold; the lower the subsistence food share in private consumption the larger the local income elasticity of food and the smaller the quantitative difference between Experiment 5 and Experiment 4. Although the effects are not everywhere proportional, reducing the subsistence share in food consumption from 90 percent to 45 percent produces a simulated outcome which lies roughly mid-way between 4 and 5 regardless of which variants we examine.

We first introduce a learning-by-doing externality from non-traditional (i.e. manufactured) exports. This externality is assumed to be symmetric, in the sense that while cumulative growth in exports relative to the no-aid baseline augments manufacturing TFP, this effect operates in reverse so that sluggish export performance reduces TFP growth relative to the baseline.[20] To keep things manageable we restrict our attention here to the case where the externality augments the 'b' experiments from Table 2. We label these experiments $2b(i)$ to $5b(i)$. The impact of the externality on the 'a' experiments has qualitatively the same properties. Two features stand out. The first is that, as the model in Section 2 anticipates, this second spillover pulls in the opposite direction to the infrastructure effect, at least over the horizon of these simulations. Second, however, even at what is arguably a rather high LBD elasticity value of $\phi = 0.20$, the 'positive' impact flowing from the aid-funded infrastructure investment still dominates (even in the low-returns, high infrastructure case considered here). For example, when productivity effects are neutral the LBD effect lowers medium-term GDP growth from 3.0% to 2.3% and total real income growth from 2.8% to 2.3% (experiment $2b$ versus $2b(i)$). Obviously, manufacturing exports bear most of the cost (falling from a medium-term decline of -0.3% to one of -6.5%) but this is partly offset by stronger growth in traditional exports.

As experiment $2b(ii)$ indicates, however, a substantially larger LBD elasticity ($\phi = 0.45$) would induce a sharp fall in manufacturing exports and almost completely overturns the real GDP and real income gains accruing from the positive infrastructure effects.

One final reason why the results in Table 2 may be seen as painting a relatively positive picture is the assumption that public infrastructure investment in period t augments the public capital stock in $t+1$. Experiment $5b(iii)$ therefore allows for a longer gestation period for public investment so that investment in t augments the capital stock only in $t+3$. This rather naturally elongates the 'J-curve' effects seen throughout these simulations for exports and lowers the rate of GDP and real income growth, but does not eliminate the recovery in total exports or the growth in income (experiment $5b(iii)$ versus $5b(i)$). However this final experiment does highlight one important feature of the results for experiment 5, namely that the decline in rural incomes in this experiment is immediate and persistent. In contrast to what is happening elsewhere in the economy, it is the demand effects rather than supply factors which drive rural incomes in both the short- and medium term. This is seen very clearly from the fact that changes in supply side factors across all variants of experiment 5 alters the pattern of rural incomes very little indeed.

[20] Since we assume zero TFP growth in the baseline this relative decline manifests itself as a (rather unrealistic) absolute decline in TFP. This has, however, no material bearing on the qualitative nature of our results.

5 Summary and Conclusions

Six key conclusions emerge from Tables 2 and 3. First, when public infrastructure augments the productivity of private factors, and especially when there is an initial scarcity of public infrastructure, there are potentially large medium-term welfare gains from aid-funded increases in public investment, despite the presence of short-run Dutch disease effects of aid. Second, however, the dynamic and distributional consequences of this investment are highly sensitive to: (i) the location of productivity effects; and (ii) the characteristics of demand. Third, the presence of a domestic-bias in the aggregate supply response (experiments 4 and 5) is broadly beneficial to the economy, in terms of aggregate growth and investment, welfare, exports and in moderating the appreciation of the real exchange rate. Fourth, in general across all experiments, and particularly when there is a domestic-good bias in the supply response, the rural household does not share proportionately in the aggregate income gains to the economy. In particular, if the domestic bias in production combines with a high subsistence requirement in food (experiment 5) the economy as a whole enjoys a large supply response which dominates the other cases, but at the cost of falling rural incomes and a sharp worsening in the income distribution. Fifth, there are potentially substantial payoffs via an improved fiscal balance and increased private investment, regardless of the presence or absence of bias (experiments 2-5). Finally, the results in Table 3 suggest that while it is certainly possible to identify configurations of parameters such that aid funded increases in public investment leave the economy worse off than without aid, this requires very low values for the productivity of public expenditure in circumstance where the public capital stock is already very close to its optimum and high values of the learning-by-doing externality.

These conclusions must, of course, be qualified by a number of caveats. First, our modelling of the labour market has been vestigial. In particular it permits no migration from rural to urban sectors in response to the shift in relative incomes. Hence improved productivity in traditional agriculture becomes problematic. Similarly, there is no scope in the model for rural households to shift to tradable forms of production. Second, the model does not allow for any form of human capital formation. We plan to extend the model to address both these shortcomings in future work.

However we feel confident in drawing one rather general conclusion, which is that serious analysis of the impact of aid must pay close attention to supply side issues, and that these are likely to be quite specific to the uses to which aid is put. It should not seem paradoxical that a proper assessment of the macroeconomic impact of aid depends intimately on the underlying microeconomics of the associated public expenditures it finances.

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Appendix I. Derivation of Conditions (7) to (9).

Totally differentiating (1) to (3) and noting from (2) that $(E^P_Q + E^G_Q - R_Q)dQ = 0$ we get

$$E^P_U dU + E^G_K dK = dA \tag{A1}$$

$$(R_{QQ} - E^P_{QQ} - E^G_{QQ})dQ = E^P_{QU} dU + E^G_{QK} dK \tag{A2}$$

and

$$E^G_Q dQ + E^G_K dK = dA \tag{A3}$$

Substituting from (A3) we derive the following expression for dU from (A1)

$$dU = \frac{E^G_Q}{E^P_U} dQ \tag{A4}$$

Substituting (A3) and (A4) into (A2) we obtain

$$(R_{QQ} - E^P_{QQ} - E^G_{QQ})dQ = \left(\frac{E^P_{QU} E^G_Q}{E^P_U} - \frac{E^G_{QK} E^G_Q}{E^G_K} \right) dQ + \frac{E^G_{QK}}{E^G_K} dA \tag{A5}$$

From the market clearing condition for the non-tradable sector we know that $E_Q = E^P_Q + E^G_Q = R_Q$. From this we can define $\eta = \frac{E^G_Q}{E^P_Q + E^G_Q}$ as the government share in the total demand for non-tradables. We also define $\gamma = \frac{QE^G_Q}{E}$ as the share of government expenditure on non-tradables as a proportion of total (national) expenditure, and $\phi = \frac{E^G}{E}$ as the share of total government expenditure in national expenditure. Finally we define the following quantities: $\Sigma_{QQ} = \frac{QR_{QQ}}{R_Q} > 0$ is the elasticity of supply of non-tradables with respect to the real exchange rate; $\Delta^P_{QQ} = \frac{QE^P_{QQ}}{{E^P}_Q} < 0$ is the private sector's elasticity of demand for non-tradables with respect to the real exchange rate; $\Delta^G_{QQ} = \frac{QE^G_{QQ}}{{E^G}_Q} < 0$ is the corresponding public sector elasticity of demand; $\Lambda^P = \frac{E^P E^P_{QU}}{E^P_Q E^P_U} > 0$ is the private sector's income elasticity of demand for non-tradables; and $\Lambda^G = \frac{E^G E^G_{QK}}{E^G_Q E^G_K} > 0$ the corresponding elasticity for the public sector (see Dixit and Norman (1980), chapter 2).

Multiplying and dividing by $QR_Q = Q(E^P_Q + E^G_Q)$ allows us to express the left hand side of (A5) as

$$\frac{E_Q}{Q} \left[\Sigma_{QQ} - ((1-\eta)\Delta^P_{QQ} + \eta \Delta^G_{QQ}) \right] dQ \tag{A6}$$

Turning to the right hand side of (A5), using the definitions of the income elasticities, collecting terms and multiplying and dividing by QE_Q the terms in dQ can be expressed as

$$E^G_Q \left[\frac{E^P_Q}{E^P} \Lambda^P - \frac{E^G_Q}{E^G} \Lambda^G \right] dQ = \frac{\gamma E_Q}{Q} \left[\frac{(1-\eta)}{(1-\phi)} \Lambda^P - \frac{\eta}{\phi} \Lambda^G \right] dQ \tag{A7}$$

The term in dA follows from the expression for Λ^G Substituting this, (A6) and (A7) into (A5) gives (7). Conditions (8) and (9) follow by simple substitution.

Appendix II. Data and parameter calibration

No official social accounting matrix currently exists for Uganda. Hence, drawing on a range of official sources, we have created a representative baseline SAM, calibrated to the fiscal-year 2000/01. Despite its synthetic character this SAM is a reasonable representation of the principal structural features of the Ugandan economy. The cash-crop sector is a pure export sector, and private services completely non-tradable. By contrast, there is two-way trade in both the food and manufacturing sectors. Both are net importers, although the latter is significantly more import-intensive than the former. We take the view that in both sectors the export share in current output is low relative to its optimum (as a result of two decades or more of anti-export biases in trade policy) so that the elasticity of substitution between supplying domestic and export markets should be set relatively high, and certainly greater than unity. We experimented initially with a range of values between 1 and 5 settling eventually on a value of 2.

Aggregate investment demand is more or less equally intensive in services (construction) and manufactured goods, although government infrastructure investment is rather more service-intensive than is private sector investment. As discussed in Section 3, output is characterized by constant returns to scale in private factors (land, labour and capital), but increasing returns in the presence of public infrastructure capital, measured by αg. There are no reliable empirical estimates, either for Uganda or elsewhere, with which to calibrate this parameter. We therefore choose values of $\alpha g = 0.5$ and $\alpha g = 0.25$.

As expected, given Uganda's level of income, private final consumption is dominated by food (58 percent) with the balance spread across manufactured goods (including petroleum products) and services. This balance is similar across the three household types although the food share in consumption is highest in the rural household (67 percent) and lowest in the urban-skilled household (42 percent). Consumers are assumed to have relatively low elasticities of substitution in consumption (the elasticities are set to 0.5 for each good), implying that the income effect of relative price movements dominates the substitution effect. Thus adverse terms of trade movements, for example, will lead to a depreciation of the import real exchange rate and vice versa for a positive terms of trade movements.

Government expenditure spans three broad categories. In the baseline approximately 40 percent is recurrent expenditure; a further 50 percent is categorized as infrastructure investment, and the balance as sector-specific public-sector capital formation.

TABLE 2: SIMULATION RESULTS OF THE EFFECT OF A 12.5 PERCENT INCREASE IN NET AID FLOWS [1,2].

Experiment		1	2a	2b	3a	3b	4a	4b	5a	5b
Productivity Bias [3]			Neutral	Neutral	E-bias	E-bias	D-bias	D-bias	D-bias	D-bias
Alphag [4]		0	0.5	0.25	0.5	0.25	0.5	0.25	0.5	0.25
KG0 as percent of KG* [5]		50%	50%	75%	50%	75%	50%	75%	50%	75%
Subsistence food share in consumption [6]									0.9	0.9
LBD Spillover (tau) [7]		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Change in grant aid		12.5%	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%
Change in KG (at initial prices)	t=2	1.2%	1.2%	1.6%	1.2%	1.6%	1.2%	1.6%	1.2%	1.6%
	t=10	9.1%	9.2%	11.6%	9.1%	11.6%	9.2%	11.6%	9.1%	11.6%
PRICES AND QUANTITIES	**Time Period**									
Export Weighted RER [8]	to t=1	-2.6%	-2.6%	-2.6%	-5.8%	-5.8%	0.9%	0.9%	5.0%	5.0%
	to t=5	-2.0%	-1.6%	-1.7%	-2.6%	-2.8%	-0.5%	-0.6%	0.2%	-0.1%
	to t = 10	-2.1%	-0.8%	-1.3%	-1.9%	-2.4%	0.3%	-0.1%	1.3%	0.6%
Total Exports	to t=1	-6.2%	-6.2%	-6.2%	-6.7%	-6.7%	-5.7%	-5.7%	-2.8%	-2.8%
	to t=5	-6.4%	-2.8%	-4.1%	-3.5%	-4.7%	-2.1%	-3.4%	2.0%	0.3%
	to t = 10	-6.8%	3.8%	-0.2%	2.8%	-1.2%	4.8%	0.8%	11.1%	6.0%
Manufacturing Exports	to t=1	-6.0%	-6.0%	-6.0%	-5.2%	-5.2%	-6.8%	-6.8%	-7.3%	-7.3%
	to t=5	-6.3%	-2.8%	-4.0%	-2.1%	-3.4%	-3.5%	-4.7%	-4.3%	-5.4%
	to t = 10	-6.9%	3.7%	-0.3%	4.1%	0.1%	3.4%	-0.7%	1.8%	-1.6%
Cash crop Exports	to t=1	-6.9%	-6.9%	-6.9%	-8.6%	-8.6%	-5.2%	-5.2%	-1.0%	-1.0%
	to t=5	-7.0%	-3.3%	-4.6%	-5.2%	-6.4%	-1.4%	-2.7%	4.6%	2.8%
	to t = 10	-7.3%	3.5%	-0.5%	1.2%	-2.8%	5.9%	1.8%	15.3%	9.6%
Total Imports	t=1	1.9%	1.9%	1.9%	1.7%	1.7%	2.1%	2.1%	3.3%	3.3%
	t=5	1.8%	3.2%	2.7%	2.9%	2.5%	3.4%	2.8%	5.1%	4.5%
	to t = ss	1.7%	5.6%	4.1%	5.2%	3.8%	6.0%	4.5%	8.6%	6.6%
Total Domestic Goods Supply	to t=1	0.6%	0.6%	0.6%	-0.6%	-0.6%	1.9%	1.9%	2.0%	2.0%
	to t=5	0.5%	2.1%	1.6%	0.8%	0.3%	3.5%	2.9%	3.7%	3.1%
	to t = 10	0.4%	4.9%	3.2%	3.5%	1.8%	6.5%	4.7%	6.8%	5.0%
Real GDP	to t=1	0.1%	0.1%	0.1%	0.0%	0.0%	0.1%	0.1%	0.3%	0.3%
	to t=5	0.0%	1.7%	1.1%	1.6%	1.0%	1.9%	1.3%	2.2%	1.5%
	to t = 10	-0.2%	4.9%	3.0%	4.6%	2.7%	5.2%	3.3%	5.7%	3.7%
Private Investment	to t=1	-3.2%	-3.2%	-3.2%	-5.3%	-5.3%	-1.1%	-1.1%	0.8%	0.8%
	to t=5	-2.7%	2.1%	0.5%	-0.1%	-1.7%	4.4%	2.7%	7.1%	5.2%
	to t = 10	-2.9%	10.7%	5.6%	8.1%	3.1%	13.3%	8.1%	17.7%	11.8%
FISCAL ACCOUNTS [2]										
Total Revenue	to t=1	-0.01%	-0.01%	-0.01%	-0.13%	-0.13%	0.12%	0.12%	0.80%	0.80%
	to t=5	0.00%	0.02%	0.00%	-0.09%	-0.10%	0.14%	0.13%	1.09%	0.99%
	to t = 10	0.01%	0.04%	0.03%	-0.06%	-0.07%	0.15%	0.14%	1.53%	1.28%
Domestic Budget Balance	to t=1	-0.41%	-0.41%	-0.41%	-0.54%	-0.54%	-0.28%	-0.28%	-0.11%	-0.11%
	to t=5	-0.36%	-0.08%	-0.18%	-0.15%	-0.31%	0.05%	-0.05%	0.31%	0.19%
	to t = 10	-0.37%	0.39%	0.11%	0.25%	-0.03%	0.53%	0.25%	0.93%	0.58%
REAL DISPOSABLE INCOME										
Rural	to t=1	-1.4%	-1.4%	-1.4%	-2.7%	-2.7%	-0.1%	-0.1%	-4.8%	-4.8%
	to t=5	-1.5%	0.1%	-0.4%	-1.3%	-1.9%	1.7%	1.1%	-5.1%	-5.0%
	to t = 10	-1.7%	3.4%	1.5%	1.6%	-0.2%	5.2%	3.2%	-4.9%	-4.9%
Urban - Unskilled	to t=1	2.3%	2.3%	2.3%	-1.0%	-1.0%	5.9%	5.9%	10.4%	10.4%
	to t=5	2.2%	3.4%	3.0%	0.0%	-0.4%	7.0%	6.6%	13.5%	12.4%
	to t = 10	2.2%	5.0%	3.9%	1.6%	0.6%	8.7%	7.6%	18.7%	15.6%
Urban -Skilled	to t=1	1.8%	1.8%	1.8%	-0.7%	-0.7%	4.5%	4.5%	8.5%	8.5%
	to t=5	1.8%	3.0%	2.6%	0.4%	0.0%	5.7%	5.3%	11.5%	10.5%
	to t = 10	1.8%	5.0%	3.7%	2.3%	1.2%	7.8%	6.5%	16.4%	13.6%
Total	to t=1	0.5%	0.5%	0.5%	-1.7%	-1.7%	2.7%	2.7%	3.0%	3.0%
	to t=5	0.4%	1.8%	1.3%	-0.4%	-0.9%	4.2%	3.7%	4.6%	4.1%
	to t = 10	0.3%	4.3%	2.8%	1.9%	0.5%	6.8%	5.3%	7.5%	5.9%

NOTES

[1] All experiments consider a permanent increase in net aid inflows of 12.5%, equivalent to 1.97% of initial GDP.
[2] Values reported as changes relative to baseline except for fiscal measures which are reported as percentage points of GDP.
[3] Denotes whether the productivity enhancement is neutral or biased towards domestic production (D-bias) or export production (E-bias).
[4] Elasticity of public infrastructure in private production (assumed common across all sectors).
[5] Size of initial infrastructure capital stock relative to optimal given Alphag and initial private capital and labour.
[6] Indicates the presence of a sector-specific subsistence level of consumption (as percentage of baseline consumption) .
[7] Learning by doing spillover in manufacturing exports.
[8] The real exchange rate is defined as (pe/pd) so that negative values indicate an appreciation.

TABLE 3: SIMULATION RESULTS OF THE EFFECT OF A 12.5 PERCENT INCREASE IN NET AID FLOWS IN PRESENCE OF LBD SPILLOVER [1,2].

Experiment		1(i)	2b(i)	2b(ii)	3b(i)	4b(i)	5b(i)	5b(ii)	5b(iii)
Productivity Bias [3]			Neutral	Neutral	E-bias	D-bias	D-bias	D-bias	D-bias
Alphag [4]		0	0.25	0.25	0.25	0.25	0.25	0.25	0.25
KG0 as percent of KG* [5]			75%	75%	75%	75%	75%	75%	75%
Subsistence food share in consumption [6]							0.9	0.9	0.9
Public capital gestation lag (private cap lag =1)		1 year	1 year	1 year	1 year	1 year	1 year	1 year	3 years
LBD Spillover (tau) [7]		0.20	0.20	0.45	0.20	0.20	0.20	0.45	0.20
Change in grant aid		12.5%	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%
Change in KG (at initial prices)	t=2	1.2%	1.6%	1.6%	1.6%	1.6%	1.6%	1.6%	1.6%
	t=10	9.1%	11.6%	11.6%	11.6%	11.6%	11.6%	11.6%	9.4%
PRICES AND QUANTITIES	Time Period								
Export Weighted RER [8]	to t=1	-2.6%	-2.6%	-2.6%	-5.8%	0.9%	5.0%	5.0%	5.0%
	to t=5	-2.1%	-2.9%	-2.0%	-2.9%	-0.8%	-0.2%	-0.3%	-0.5%
	to t = 10	-2.8%	-2.9%	-2.7%	-2.8%	-0.8%	0.0%	-0.7%	-0.3%
Total Exports	to t=1	-6.2%	-6.2%	-6.2%	-6.7%	-5.7%	-2.8%	-2.8%	-2.8%
	to t=5	-6.8%	-4.4%	-4.8%	-5.0%	-3.7%	-0.1%	-0.7%	-2.1%
	to t = 10	-9.1%	-2.1%	-5.5%	-2.8%	-1.3%	3.3%	-1.7%	1.2%
Manufacturing Exports	to t=1	-6.0%	-6.0%	-6.0%	-5.2%	-6.8%	-7.3%	-7.3%	-7.3%
	to t=5	-7.5%	-5.2%	-6.7%	-4.4%	-6.0%	-6.8%	-8.7%	-8.2%
	to t = 10	-14.8%	-6.5%	-18.2%	-5.2%	-7.8%	-9.7%	-24.5%	-12.0%
Cash crop Exports	to t=1	-6.9%	-6.9%	-6.9%	-8.6%	-5.2%	-1.0%	-1.0%	-1.0%
	to t=5	-6.6%	-4.2%	-3.6%	-6.1%	-2.2%	3.2%	3.8%	1.0%
	to t = 10	-4.7%	1.5%	5.4%	-1.1%	4.1%	11.8%	15.8%	10.1%
Total Imports	t=1	1.9%	1.9%	1.9%	1.7%	2.1%	3.3%	3.3%	3.3%
	t=5	1.7%	2.6%	2.4%	2.4%	2.8%	4.3%	4.1%	3.6%
	to t = ss	0.8%	3.5%	2.2%	3.2%	3.7%	5.6%	3.8%	4.8%
Total Domestic Goods Supply	to t=1	0.6%	0.6%	0.6%	-0.6%	1.9%	2.0%	2.0%	2.0%
	to t=5	0.4%	1.4%	1.2%	0.1%	2.8%	2.9%	2.6%	2.2%
	to t = 10	-0.7%	2.4%	0.7%	1.1%	3.8%	3.9%	1.6%	3.1%
Real GDP	to t=1	0.1%	0.1%	0.1%	0.0%	0.1%	0.3%	0.3%	0.3%
	to t=5	-0.2%	1.0%	0.9%	0.9%	1.1%	1.4%	1.2%	0.7%
	to t = 10	-1.0%	2.3%	1.0%	2.2%	2.5%	2.8%	0.9%	2.0%
Private Investment	to t=1	-3.2%	-3.2%	-3.2%	-5.3%	-1.1%	0.8%	0.8%	0.8%
	to t=5	-3.2%	0.0%	-0.6%	-2.1%	2.2%	4.6%	3.8%	2.2%
	to t = 10	-6.3%	3.1%	-2.1%	1.0%	5.2%	8.1%	0.5%	5.6%
TFP (Manufacturing)	to t=1	-0.2%	-0.2%	-0.4%	0.0%	-0.2%	-0.2%	-0.2%	-0.2%
	to t=5	-1.4%	-1.3%	-3.0%	-1.1%	-1.5%	-1.6%	-3.8%	1.7%
	t= t = 10	-6.8%	-4.9%	-14.3%	-4.1%	-5.6%	-6.3%	-18.2%	-7.2%
FISCAL ACCOUNTS [2]									
Total Revenue	to t=1	-0.01%	-0.01%	-0.01%	-0.13%	0.12%	0.80%	0.80%	0.80%
	to t=5	0.01%	0.03%	0.04%	-0.09%	0.15%	1.00%	1.00%	0.88%
	to t = 10	0.10%	0.10%	0.23%	-0.02%	0.22%	1.29%	1.31%	1.21%
Domestic Budget Balance	to t=1	-0.41%	-0.41%	-0.41%	-0.54%	-0.28%	-0.11%	-0.11%	-0.11%
	to t=5	-0.39%	-0.20%	-0.23%	-0.32%	-0.07%	0.16%	0.11%	0.01%
	to t = 10	-0.54%	0.00%	-0.27%	-0.12%	0.12%	0.39%	-0.05%	0.24%
REAL DISPOSABLE INCOME									
Rural	to t=1	-1.4%	-1.4%	-1.4%	-2.7%	-0.1%	-4.8%	-4.8%	-4.8%
	to t=5	-1.7%	-0.6%	-0.8%	-2.0%	0.9%	-5.1%	-5.2%	-4.9%
	to t = 10	-3.0%	0.5%	-1.3%	-1.0%	2.2%	-5.4%	-6.6%	-5.5%
Urban - Unskill	to t=1	2.3%	2.3%	2.3%	-1.0%	5.9%	10.4%	10.4%	10.4%
	to t=5	2.1%	2.8%	2.7%	-0.5%	6.4%	12.1%	11.8%	10.8%
	to t = 10	1.3%	3.3%	2.1%	0.1%	6.8%	14.0%	10.9%	12.8%
Urban -Skilled	to t=1	1.8%	1.8%	1.8%	-0.7%	4.5%	8.5%	8.5%	8.5%
	to t=5	1.8%	2.6%	2.6%	0.0%	5.3%	10.4%	10.3%	9.2%
	to t = 10	1.9%	3.8%	4.0%	1.2%	6.6%	13.0%	12.1%	12.0%
Total	to t=1	0.5%	0.5%	0.5%	-1.7%	2.7%	3.0%	3.0%	3.0%
	to t=5	0.3%	1.2%	1.1%	-1.0%	3.6%	3.9%	3.8%	3.3%
	to t = 10	-0.3%	2.3%	1.4%	0.1%	4.7%	5.1%	3.7%	4.5%

NOTES
See Table 2.

Appendix Table 1: Representative Uganda SAM Fiscal Year 2000/01

Macro-Aggregates (Factor Cost)

	Ush bn	%GDP
GDP	8036	100.0%
GNY	9409	117%
Exports		17.4%
Imports		47.0%
Trade		64.4%
Net Factor Income from abroad		15.5%
Current Account (before aid)		-14.1%
Aid		15.8%
Reserve Accumulation		1.7%
Private Consumption		103.5%
Private Investment		8.1%
Depreciation		8.1%
Private Savings		5.7%
Government Revenue		13.6%
Government Current Expenditure		18.4%
Current Budget Balance		-4.8%
Government Investment		7.0%
Overall Deficit (before Aid)		-11.7%

Sectoral Data

Sectors	X	XD	E	M	Import Duties	Net Exports	ND	ID	CD	ITAX
Food Crops	5107	4984	123	631	13	-508	780	30	4818	80
Cash Crops	640	30	610	0	0	610	20	10	0	0
Manufacturing	3647	2982	665	3146	447	-2481	4184	549	1842	100
Services	5612	5612	0	0	0	0	3331	621	1660	175
Public Services	1345	1345	0	0	0	0	0	0	0	0
Total	16351	14953	1398	3777	460	-2379	8315	1210	8320	355

As share of Total

Sectors	X	XD	E	M	Import Duties	Net Exports	ND	ID	CD	ITAX
Food Crops	31.2%	33.3%	8.8%	16.7%	2.8%	21.4%	9.4%	2.5%	57.9%	22.5%
Cash Crops	3.9%	0.2%	43.6%	0.0%	0.0%	-25.6%	0.2%	0.8%	0.0%	0.0%
Manufacturing	22.3%	19.9%	47.6%	83.3%	97.2%	104.3%	50.3%	45.4%	22.1%	28.2%
Services	34.3%	37.5%	0.0%	0.0%	0.0%	0.0%	40.1%	51.3%	20.0%	49.3%
Public Services	8.2%	9.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

As share of X by sector (factor cost)

Sectors	X	XD	E	M	Import Duties	Net Exports	ND	ID	CD	ITAX
Food Crops	100.0%	97.6%	2.4%	12.6%		-10.2%	15.3%	0.6%	94.3%	
Cash Crops	100.0%	4.7%	95.3%	0.0%		95.3%	3.1%	1.6%	0.0%	
Manufacturing	100.0%	81.8%	18.2%	98.5%		-80.3%	114.7%	15.1%	50.5%	
Services	100.0%	100.0%	0.0%	0.0%		0.0%	59.4%	11.1%	29.6%	
Public Services	100.0%	100.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%	

Notes:

- **X** Total Domestic Production (at factor cost)
- **XD** Domestic Sales to Domestic Economy (X-E) (at factor cost)
- **E** Exports (fob)
- **M** Imports (cif)
- **CD** Private consumption demand (factor cost)
- **ND** Intermediate demand (factor cost)
- **ID** Investment demand (factor cost)
- **ITAX** Taxes paid on final consumption

The SAM is specified in billions of Shillings with a nominal exchange rate ofUsh1750 per US$