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 computable version of this model 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.

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1 Introduction

Recent global initiatives on debt relief and development assistance anticipate a significant increase in overall aid flows to the poorest countries and, at least in the medium term, a concentration of these flows on a small number of recipients.[1] Accompanying these pressures for a 'scaling-up' of aid, however, is a heightened anxiety amongst some donors and potential recipients that large increases in aid may jeopardize macroeconomic stability and growth.[2] Not surprisingly, these concerns are most acute in already aid-dependent countries, for example Uganda and Tanzania, whose recent track-records on growth, policy reform and poverty reduction mean they are best placed to take advantage of the donors' willingness to increase aid in support of higher levels of public expenditure but, arguably, where there might be most to lose if further aid increases were to 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 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 intertemporal productivity spillover for both tradable and non-tradable production, but in a potentially unbalanced manner.[3] 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 higher public investment expenditure tend to be the non-poor working in the ser-

[1] For example the UN Millennium Project (2005) and the Report of the Commission for Africa (2005).

[2] See, for example, Rajan and Subramanian (2005).

[3] 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 he does not explore specific mechanisms through which these externalities may emerge.

vices and manufacturing sectors as opposed to the poor who are predominantly engaged in food and cash crop production. The second is that if public expenditure is devoted to infrastructure that enhances productivity in non-tradable sectors, this may shift the domestic terms of trade 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 so that the income elasticity of demand for non-tradable output (in this case basic food) is low.[4]

The paper is organized as follows. In the next section we outline a simple two-sector, two-good model to highlight these Dutch disease effects in the presence of aid-financed public infrastructure investment and a learning-by-doing production externality. This model is highly stylized and so in Section 3 we present a more detailed calibrated simulation model, loosely based on data from Uganda, which allows us to examine the possible magnitudes likely to prevail in reality as well as the distributional pressures likely to arise under alternative aid-financed public expenditure strategies. We examine two core versions of the model – the first where public infrastructure represents the only dynamic externality and the second where this mechanism interacts with a learning-by-doing externality capturing productivity spillovers associated with increased non-traditional export production – and subject both to sensitivity analysis. Section 4 presents and discusses both the core simulation results and the sensitivity analysis 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, but rather are likely to be dominated in the medium term by the positive supply side effects of aid. Somewhat paradoxically, we show that growth in aggregate exports and total output in the medium term is strongest when the productivity effects of public investment expenditure are skewed in favour of non-tradable production, reflecting the aggregate dynamic gains arising from improvements in non-tradable supply. 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. 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.

[4] The implications of this combination are also 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 both the labour surplus and the declining price of the wage good (i.e. food) that fuel the process of industrialization.

2 A simple model of productivity spillovers

It is a difficult and rather tedious task to set out and give intuition to the characteristics of a full-scale simulation model. In this section, therefore, we take a short-cut by developing a simple stylized model which highlights a number of the key features embedded in the full-scale simulation model employed in remainder of the paper. Think of this as a 'model of the model'.

We consider a two-period Ricardo-Viner small open economy that produces and consumes one non-traded good and one traded good. Private capital stocks are fixed, sector-specific, and do not depreciate, while a fixed endowment of labour, L, 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, first-period market clearing in the non-traded goods market is given by

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

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.[5] Public investment takes place

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

in the first period (at first-period prices) but augments productive capacity in either or both the tradable and non-tradable sectors only in the second period.[6]

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,

[6] 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.

so that (γ/ϕ) is the non-tradable share in government expenditure; and η is its share in the total demand for non-tradables. Λ^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[7]

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

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, 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 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.[8] 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

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

[7] 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.

[8] 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.

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

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.[9]

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.[10] 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.[11]

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

[9] 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.

[10] 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.

[11] 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.

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 $(\sigma_{qq} - \delta_{qq}) > 0$ 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 the positive productivity spillovers from public infrastructure investment. As we noted in the introduction, however, an important strand in the debate about aid and the Dutch disease has been the concern that aid-induced appreciations of the real exchange rate dilute positive learning-by-doing externalities arising from tradable goods production. We reflect this by assuming that firms in the export sector benefit from learning-by-doing externality which, as with the effect of infrastructure, are not appropriable by individual firms.[12] Exports and income

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

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

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

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

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

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 model 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 production and 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, in particular, to unpack some first-order distributional consequences of the aid and public expenditure interaction, we now turn to our simulation model. This is a recursively dynamic real CGE model of a small open economy calibrated to a database representing the principal features of an archetypical low-income aid dependent economy.[13]

3.1 Private production and consumption

Producers and consumers are assumed to enjoy no market power in world markets, so that the terms of trade are independent of domestic policy choices and are, for convenience, held constant across all simulations. On the production side, firms in each of the four 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. Production in each sector i is determined by a Cobb-Douglas function of the form

$$X_i = A_i S_i^{\alpha s} L_i^{\alpha l} KP_i^{\alpha k} KG^{\alpha g}. \tag{25}$$

S, KP, and KG denote land, sector-specific private capital and infrastructure respectively, and L is a composite labour input. Only production in the rural sectors requires land which is fixed in perpetuity. Private sector-specific capital stocks are fixed in each period, but evolve over time through depreciation and gross investment. The labour composite, L, is constructed as a constant elasticity of substitution aggregation of skilled and unskilled labour, the supplies of which are fixed but inter-sectorally mobile. Labour markets are competitive so that composite labour is employed in each sector up to the point that it is paid the value of its marginal product. Skill- and sector-specific wages are derived as a function of the elasticity of substitution between skilled and unskilled labour and a vector of fixed sector-specific wage differentials. 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 involved in food-crop and cash-crop agriculture and owns the land and capital in these two sectors. This household is outside the direct tax net, and has zero net savings.[14] 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 and 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 capital in the economy. This household pays direct taxes to government, at a higher rate

[13] The underlying SAM is, in fact, loosely based on data from Uganda around the turn of the century, but offers a reasonable representation of many similar cash-crop agricultural-based economies. See Appendix II.

[14] The rural household's gross savings are constrained to be equal to the depreciation of agricultural capital.

than the unskilled household, earns interest on its net holdings of government domestic debt, and has a non-zero net saving in the initial equilibrium.

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 the income elasticity of demand for all other goods (manufactured goods and services) is greater than unity.[15]

3.2 Macroeconomic closure and dynamics

We adopt, as our default, a neoclassical closure in which total private investment is constrained by the level of total savings net of exogenous public investment, where household savings propensities are exogenous. This rule, which is broadly consistent with conditions in the poorest countries 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. There is a risk, however, that this closure rule exaggerates the private investment response to public investment (either positively or negatively). We therefore also run the simulation experiments under an alternative closure in which we define an independent, return sensitive, private aggregate investment function and allow for the marginal savings propensity of the urban skilled household to adjust endogenously. Our core results, generated under the neo-classical closure, are replicated under this alternative closure in Appendix Table 2. As we discuss in more detail in the next section, the key insights delivered by the simulation model are not greatly altered by the choice of closure rule.

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 fixed and the model is solved given the parameters of the experiment (e.g. the increased aid flows and the corresponding public expenditure response). This solution defines a new vector of prices and quantities for the economy, including the level of public and private sector investment, which feed into the equations of motion for sectoral capital stocks

$$K_{i,t} = K_{i,t-1}(1 - \mu_i) + \Delta K_{i,t-j} \tag{26}$$

where $K_i = \{KP_i, KG\}$, μ_i denotes the sector-specific 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

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

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 static steady-state equilibrium for the economy.

The final dynamic 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

$$A_{st} = A_{s0}[1 + \phi \ln \left(\frac{E_t^p}{\bar{E}_t^p} \right)] \tag{27}$$

where $E_t^p = \sum_{j=1}^{\infty} \beta^j E_{t-j}$ 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, $\beta = (1+\rho)^{-1} < 1$ is the gross discount factor, and A_{s0} is the value of A_{st} in the baseline calibration. Hence the higher is ρ the lower the impact of past experience on current productivity. Since $\rho > 0$ 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.

3.3 Aid and government expenditure

To focus on the principal mechanisms of interest, we assume that aid accrues to government and is used exclusively to finance increased public investment expenditure.[16] We make two further assumptions.

The first assumption is that an increased public capital stock entails a higher level of operations and maintenance (O&M) expenditure. We calibrate this on the basis of evidence on the recurrent expenditure requirements of World Bank-financed capital projects compiled by Hood *et al* (2002). We set recurrent O&M equivalent to 3.5% of the additional capital stock (the Hood *et al* weighted average across all projects) but we also consider a higher O&M rate corresponding to Hood *et al's* highest estimated rate of 7.5% (that being for education). Our baseline assumption is that these additional O&M costs are financed out of the additional aid flow so that the domestic budget deficit is *(ex ante)* unchanged. In our sensitivity analysis we also examine the case where aid flows finance only

[16] Hence we do not examine the consequences of changes to the structure of taxation, the level of reserves, or the volume of real recurrent expenditure (other than those arising directly from the public investment, such as O&M - see below), all of which are kept constant across all simulations.

the installation of public capital, and O&M expenditures are met through increases in the domestic budget deficit.[17] In both 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. 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,* even when O&M costs are aid-financed.

The second assumption concerns the nature of investment expenditure. Public investment expenditure represents a source of demand for goods and services and hence entails derived demands for factors. In keeping with much of the evidence on PRSPs our baseline simulations assume that aid-financed increases in public investment expenditure are more intensive in non-tradable inputs on the margin than is the case for private investment and inframarginal government expenditure. 'Scaling up' is therefore assumed to skew aggregate demand towards non-tradables in the short run. In our sensitivity analysis, however, we consider two key variations. One allows for the possibility that public investment demand is *less* non-tradable intensive than the average (which may be the case when government infrastructure investment is geared towards, say, upgrading telecommunications technologies, or employing more technical assistance etc.). The other is that an aid-financed 'scaling up' of public investment entails an additional demand for labour, above and beyond that entailed by O&M requirements reflecting, for example, greater management and coordination burdens placed on the public sector.

Finally, although it is reasonable in practice to assume that public investment in areas such as health and education will augment human capital and thereby generate a source of extensive productivity growth, we do not include these effects in our simulations. We take the view that this feedback is relatively slow so that 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.[18].

4 Experiments and results

4.1 Simulation experiments

The data used to calibrate the CGE model are briefly described in Appendix II.[19] The policy experiment consists of an increase in public infrastructure in-

[17] There are of course other ways in which this issue could be handled. The first is through matching increases in domestic taxes, and the second is to set the level of O&M as a choice variable with the rate of effective depreciation of the public capital stock being a (negative) function of the level of O&M expenditure. In this case, failing to meet O&M requirements serves to accelerate the rate of depreciation of public infrastructure.

[18] The model by Agénor *et al* (2005), by contrast, provides an explicit treatment of the links between public investment and human capital formation.

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

vestment financed by a permanent 12.5 percent increase in the net (grant) aid inflow to the economy. This increase is equivalent to just under 2 percent of baseline GDP, a step increase roughly equivalent to the size of the increase in net aid flows to Uganda, Tanzania and Mozambique following HIPC-related reductions in external debt service obligations. In all cases, the aid flow is used exclusively to finance an increase in public infrastructure investment holding tax rates and all other components of public expenditure (with the exception of O&M expenditure) constant. Any consequent changes in the domestic budget balance after grants therefore reflect general equilibrium effects arising from the increased public spending and are accommodated through adjustments to private saving or investment depending on the macroeconomic closure rule.

Table 1. Simulation Experiments

Core Simulations	
1	No productivity spillover from infrastructure capital
2	Neutral productivity spillovers
3	Export-biased productivity spillovers
4	Domestic-biased productivity spillovers
5	As 4 with subsistence threshold for food
Variants	
a	LBD spillover = 0.20
b	LBD spillover = 0.45
c	LBD spillover = 0.00 with 3-year gestation lag on public investment
d	LBD spillover = 0.20 with 3-year gestation lag on public investment
e	Low elasticity of substitution between skilled and unskilled labour ($\sigma_L = 0.50$)
f	High elasticity of substitution between skilled and unskilled labour ($\sigma_L = 2.0$)
g	Public investment demand is tradable-goods intensive
h	High initial public capital ($KG = 75\%$ of optimal value) and $\alpha_G = 0.25$
i	O&M = 0.0%
j	O&M = 7.5%
k	O&M = 3.5% plus additional public sector labour demand
l	O&M = 3.5% financed through higher domestic budget deficit
m	As l with additional public sector labour demand
n	Kaldorian closure
o	As m with Kaldorian closure

Table 1 summarizes our core simulations and a set of variations around these. The potential simulation space is vast: in principle, each core simulation can be implemented under any of the variants and, indeed, many combinations of the variants. In what follows we present only a small number of simulations illustrating the key features of the results; the sensitivity analysis offers some support to their robustness.

Our core simulations, described in the top half of Table 1 and presented in Table 2, are denoted 1 to 5. Simulation 1 is 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 a balanced 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 export- or domestic-good 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. Simulation 3 considers the case of an export-bias in the productivity effects of government infrastructure, and Simulations 4 and 5 a domestic-goods bias. Simulations 1 through 4 assume that the subsistence component in consumption is zero so that the consumption is homothetic in income across all goods and households. In Simulation 5, however, we impose a subsistence component for food consumption so that the income elasticity of demand for food falls below one.

These baseline runs are all based on a common set of assumptions which are then varied in subsequent simulations in order to assess the robustness of our central findings. The core assumptions and principal variations are as follows, where each variation can be applied to any or all of the core simulations. The variations are reported in the bottom half of Table 1.

First, to reflect the idea that there is often a severe shortage of (functional) infrastructural capital in countries to which this model applies, we assume the public infrastructure capital stock is at only half its 'optimal' value.[20] Second, there is very little empirical consensus on the size of the productivity effects of infrastructure investment in low-income countries. We assume a value for this parameter of $\alpha_G = 0.50$, somewhat higher than values estimated in Hulten's (1996) study of infrastructure capital and economic growth. This higher baseline value reflects in part the previous point that for countries with a severely depleted capital stock we might expect a higher marginal product of public capital, and in part the likelihood that the contemporary marginal productivity of public infrastructure expenditure may in fact be higher than the historical point estimates suggest. Both the size of the initial public capital stock and its productivity are exogenous parameters of the model and both could be either high or low. Sensitivity analysis not reported here suggests that the variation in the behaviour of the economy between these points is fairly regular. In the sensitivity analysis here, therefore, we report only the robustness of the core

[20] In this setting we define the optimal public capital stock as that amount at which the marginal product of public capital is equal to the average marginal product of private capital given the initial endowments of private factors (Land, labour and capital) and the assumed parameters of the production function. At such a point the output gain from a tax- or deficit-financed increase in infrastructure capital would exactly offset the loss arising from the crowded-out private capital.

results to the case where the economy is endowed with a larger infrastructure capital stock and a lower return on the margin. This is denoted as variant h.

Third, we assume that scaling up entails additional O&M expenditure equivalent to 3.5% of the increase in the public capital stock but that this additional expenditure is met out of the aid inflow. In the sensitivity analysis we allow for lower and higher values of the O&M rate, for additional public labour demand in support of 'scaling up', and for an alternative mechanism for financing this additional expenditure. These possibilities are reflected in variants i to m.

Fourth, we initially assume that there are no dynamic externalities to exporting. The evidence base for the learning-by-doing spillover is far from conclusive and in our sensitivity analysis we 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 (27)) is set to $\phi = 0.20$. Since this value is highly contested we also consider a value of $\phi = 0.45$. (These are variants a and b).

Fifth, our initial simulations set the elasticity of substitution between skilled and unskilled labour to unity (so that (25) become Cobb-Douglas in all factors). We then relax this assumption by examining the cases where the elasticity of substitution is low ($\sigma_L = 0.50$) and where it is high ($\sigma_L = 2.00$) (Variants e and f).

Finally, we initially assume that infrastructure investment augments the capital stock with a lag of one year. The sensitivity analysis considers the case where public infrastructure investment has a longer gestation, taking 3 years to augment private productivity.(Variants c and d).

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 and composition of exports; real GDP; private investment; the fiscal balance; 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. Figures 1 to 4 also report the evolution of the real exchange rate, total exports, total real disposable income and the rural household's share in this.

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. 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.[21] However the main 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. 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 may be largely offset when the aid inflow is used productively, but may re-emerge and be 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.[22] As a consequence, while the impact effects on the real exchange rate and on exports are identical to experiment 1, because of the time lag before productivity effects kick in, they diverge sharply over time. Virtually all of the real exchange rate appreciation has been unwound by the end of the ten year period. Moreover, even though the real exchange rate remains somewhat appreciated relative to its baseline value, the initial 6.9 percent fall in export volumes is reversed, moving to a 8.7 percent increase over the baseline by the end of the simulation.

While the impact effects on household incomes are the same as in the previous experiment, so that rural income again initially falls, matters now improve over time. Not only is total real income 6.5 percent higher over the long run,

[21] 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.

[22] 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.

but rural households enjoy a similar increase in real income over time in this experiment, even though their proportionate gain is slightly lower than that of the urban households.

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 leads to a more appreciated path for the real exchange rate than in the neutral 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 more than offset the demand effects of the increased aid flows so that the initial real exchange rate appreciation is reversed within five years.[23] The effects on exports are symmetrical with experiment 3; cash-crop exports recovering more strongly than in earlier experiments, but the domestic bias in manufacturing productivity results in a more sluggish recovery in manufacturing exports. Interestingly, overall export performance is stronger with a domestic bias than with an export bias, reflecting the real depreciation induced by the former.

The domestic-biased supply response also leads to a larger improvement in the long-run fiscal balance (of 0.8 percentage points of GDP) reflecting favourable relative price movements (see footnote 22) 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 4.1 percent over its baseline compared to 6.5 percent when the supply response is neutral between exports and domestic production. However, the income gain is spread somewhat differently across household groups, with urban unskilled workers now doing less well than the other two groups. This contrasts sharply with the domestic-biased supply response which generates a markedly higher aggregate real income gain of 9.9 percent in the long-run but one that is disproportionately skewed in favour of the urban households.

As noted above, demand-side effects imply a tendency for urban households

[23] 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.

to gain disproportionately from aid-financed increases in infrastructure because of low backward linkages from government expenditure to the rural sector of the economy. The relative price movements underpinning experiment 4 exacerbate these weak 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 that they only partially 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, 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; after its impact appreciation, the real exchange rate depreciates sharply and becomes more depreciated over time. Similarly after their 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 10.6 percent over the baseline in the long-run.

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 food 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.[24]

4.3 Learning-by-doing and gestation lags

In Table 3 we introduce two factors that might be expected to modify the results presented in Table 2.

[24] 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.

*** Table 3 ***

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 also operates in reverse so that sluggish export performance reduces TFP growth relative to the baseline.[25] We retain the same five basic cases as displayed in Table 2, and combine them with four variations involving learning-by-doing and gestation lags, indexed by letters a to d. Thus letter a always refers to a variation with an LBD elasticity set at $\phi = 0.20$, but no other changes from the assumptions of Table 2. Variation b is similar, except that this elasticity is set at the very high level $\phi = 0.45$. Variation c reverts to setting the LBD spillover at zero, but increases the gestation lag on public investment to 3 years. Variation d combines an LBD elasticity of 0.2 with this three year lag.

The first point to note is that simply inserting learning-by-doing into the unproductive case (Experiment 1a) has fairly strong adverse effects. What was a relatively slow deterioration in the original unproductive case is now accelerated. The costs of accepting aid but then wasting it are raised markedly. Turning to the productive cases, 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 of $\phi = 0.20$, the 'positive' impact flowing from the aid-funded infrastructure investment still dominates. For example, when productivity effects are neutral the LBD effect lowers medium-term (ten year) GDP growth only from 7.6% to 7.3% and total real income growth from 6.5% to 6.2% (experiment 2a versus 2). Obviously, manufacturing exports bear most of the cost (falling from a medium-term growth of 8.6% to one of 5.1%) but this is partly offset by stronger growth in traditional exports.

As experiment 2b indicates, however, a substantially larger LBD elasticity ($\phi = 0.45$) would inhibit the recovery in manufacturing exports (still down by 3.1% after ten years and knock a further 1% off the growth in real GDP.

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 $t + 1$. Experiments c and d allow public investment in t to augment 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 (for example, in experiment 2d the growth in total exports is roughly halved relative to experiment 2).

[25] 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.

It is worth highlighting one important feature of the results for all variants of experiment 5, namely that the decline in rural incomes in these experiments 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 alter the pattern of rural incomes very little indeed.

4.4 Sensitivity and robustness checks

Appendix Tables 1 and 2 subject these central results to a battery of robustness checks. Four variations are considered in Appendix Table 1, assessing, in turn, the effects of: altering the elasticity of substitution between skilled and unskilled labour; varying the non-tradable intensity of public investment; altering the assumed initial endowment and productivity of public infrastructure capital; and changing the assumptions concerning O&M expenditures. First, columns $2e$ and $2f$ suggest that the elasticity of substitution between labour types has very little impact on the aggregate response of the economy, acting only to alter the trajectory or real wages and the export response, and then only marginally. Second, column $3g$ considers the case where public investment is relatively intensive in tradable inputs. The comparison with column 3 confirms the standard intuition that the strength of the demand-side Dutch disease effects of aid are mitigated when public investment is relatively intensive in tradable goods. Moreover, the more tradable-intensive is public expenditure the more the rural household benefits relative to urban households. Third, columns 4 and $4h$ show that when the economy is initially relatively well endowed with public capital and the marginal productivity of public investment is relatively low, the positive supply-side effects of aid are significantly weaker, even in the domestic bias case, but are not completely overturned. Real GDP growth over the 10-year horizon falls from 8% to 3.4% with total exports rising by only 1.2% as opposed to 10.1% in the baseline case, 4. Finally, columns 4 and $4i$ to $4m$ highlight the importance of anticipating the O&M implications of an aid-financed increase in public investment. The comparison of $4l$ which assumes that O&M costs are domestically financed with 4 (where O&M costs are aid-financed) offers a measure of the direct recurrent fiscal costs of maintaining a higher public capital stock: at a rate of 3.5%, increased O&M obligations add an additional 0.3% of GDP to the domestic fiscal deficit (twice this amount if O&M runs at 7.5% of GDP). If, on the other hand, 'scaling up' entails additional demands for skilled labour (columns $4k$ and $4m$) the effects are much more dramatic, both in terms of the increasing direct fiscal costs (under $4m$ the domestic deficit is increased by 2.6% of GDP) but also through its effects on the real wage for skilled labour which, in turn, significantly reduces export growth and GDP.

Finally, Appendix Table 2 investigates the sensitivity of our core results to the macroeconomic closure rule. Compared to the neo-classical closure, the response is generally more sluggish in the medium term when simulated under a Kaldorian closure. With changes in net public savings no longer crowding-in (or out) private investment so directly, the medium-term export and output elasticities with respect to the public expenditure increase are weaker. As with Appendix Table 1, the qualitative characteristics of the simulations remain unchanged.

5 Summary and conclusions

Six key conclusions emerge from the simulations presented in this paper. First, when public infrastructure augments the productivity of private factors, and 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 most experiments, but 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 a domestic bias in productivity is combined 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 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 circumstances 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 so that improved productivity in traditional agriculture becomes problematic, condemning rural households to declining real incomes rather than stimulating migration into the urban tradable sectors.. 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

The social accounting matrix underpinning our simulation model is loosely based on national accounts data for Uganda, supplemented by additional assumptions concerning the structure of the economy. Together these data allows us to define a representative economy sharing the principal structural features of many low-income aid-dependent Sub Saharan African countries such as Uganda. Thus, 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. 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 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	2	3	4	5
Productivity Bias [3]				Neutral	Export	Domestic	Domestic
Alphag [4]			0	0.5	0.5	0.5	0.5
EPSL [5]			0.99	0.99	0.99	0.99	0.99
O&M [6]			3.5%	3.5%	3.5%	3.5%	3.5%
Initial public capital as percent of 'optimal' public capital [7]			50%	50%	50%	50%	50%
Subsistence food share in consumption [8]			0.00	0.00	0.00	0.00	0.90
Change in KG (at initial prices)		**t=2**	2.4%	2.4%	2.4%	2.4%	2.4%
		t=10	14.0%	14.3%	14.2%	14.3%	14.1%
PRICES AND QUANTITIES		**Time Period**					
Export Weighted RER [9]		**to t=1**	-2.8%	-2.8%	-2.8%	-2.8%	-2.4%
		to t=5	-2.1%	-1.1%	-2.1%	0.5%	1.7%
		to t = 10	-2.2%	-0.2%	-1.3%	1.3%	3.0%
Total Exports		**to t=1**	-6.9%	-6.9%	-6.9%	-6.9%	-6.4%
		to t=5	-7.3%	1.4%	0.7%	2.4%	8.5%
		to t = 10	-7.7%	8.7%	7.7%	10.1%	18.5%
Manufacturing Exports		**to t=1**	-6.6%	-6.6%	-6.6%	-6.6%	-6.5%
		to t=5	-7.3%	1.2%	1.9%	0.3%	-1.5%
		to t = 10	-8.0%	8.6%	9.1%	8.1%	5.3%
Cash crop Exports		**to t=1**	-7.7%	-7.7%	-7.7%	-7.7%	-7.0%
		to t=5	-8.0%	1.1%	-0.8%	3.7%	12.6%
		to t = 10	-8.2%	8.7%	6.4%	11.9%	24.2%
Real GDP		**to t=1**	0.08%	0.08%	0.08%	0.08%	0.10%
		to t=5	-0.08%	4.16%	4.01%	4.37%	4.71%
		to t = 10	-0.26%	7.64%	7.37%	8.01%	8.57%
Private Investment		**to t=1**	-3.7%	-3.7%	-3.7%	-3.7%	-3.4%
		to t=5	-4.1%	7.4%	5.1%	10.4%	14.7%
		to t = 10	-4.3%	16.8%	14.2%	20.3%	26.2%
Domestic Budget Balance [2]		**to t=1**	-0.47%	-0.47%	-0.47%	-0.47%	-0.44%
		to t=5	-0.48%	0.17%	0.04%	0.35%	0.76%
		to t = 10	-0.48%	0.66%	0.52%	0.84%	1.41%
REAL DISPOSABLE INCOME							
	Rural	**to t=1**	-1.6%	-1.6%	-1.6%	-1.6%	-2.0%
		to t=5	-1.8%	2.3%	0.8%	4.4%	-6.2%
		to t = 10	-2.1%	6.0%	4.2%	8.5%	-5.6%
	Urban - Unskilled	**to t=1**	2.7%	2.7%	2.7%	2.7%	3.1%
		to t=5	2.5%	5.2%	1.8%	10.1%	20.1%
		to t = 10	2.4%	6.9%	3.4%	11.9%	25.2%
	Urban -Skilled	**to t=1**	2.0%	2.0%	2.0%	2.0%	2.4%
		to t=5	2.0%	4.8%	2.2%	8.5%	17.3%
		to t = 10	2.0%	6.9%	4.2%	10.7%	22.3%
	Total	**to t=1**	0.5%	0.5%	0.5%	0.5%	0.6%
			0.4%	3.8%	1.5%	7.0%	7.5%
		to t = 10	0.3%	6.5%	4.1%	9.9%	10.6%
FACTOR MARKETS							
Average Real Wage	**Skilled**	**to t=1**	2.7%	2.7%	2.7%	2.7%	3.2%
(wa/cpi)		**to t=5**	2.8%	5.6%	2.3%	10.1%	24.4%
		to t = 10	3.2%	7.7%	4.4%	12.4%	31.9%
	Unskilled	**to t=1**	0.9%	0.9%	0.9%	0.9%	1.0%
		to t=5	0.7%	4.7%	2.0%	8.7%	13.2%
		to t = 10	0.5%	8.3%	5.5%	12.3%	18.9%

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 (Neutral) or biased towards domestic production (Domestic) or export production (Export).

[4] Elasticity of public infrastructure in private production.

[5] Elasticity of substitution between skilled and unskilled labour.

[6] Operations and Maintenance costs (as percentage of additional capital stock)

[7] Size of initial infrastructure capital stock relative to optimal given initial private capital stocks and labour.

[8] Indicates the presence of a sector-specific subsistence level of consumption (as percentage of baseline consumption) .

[9] The real exchange rate is defined as (pe/pd) so that negative values indicate an appreciation.

TABLE 3: LEARNING BY DOING AND GESTATION LAGS

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

Experiment			1a	2a	2b	2d	3a	4a	5a	5c	5d
Productivity Bias [3]				Neutral	Neutral	Neutral	Export	Domestic	Domestic	Domestic	Domestic
Alphag [4]			0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
EPSL [5]			0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
O&M [6]			3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%
Initial public capital as percent of 'optimal' public capital [7]			50%	50%	50%	50%	50%	50%	50%	50%	50%
Subsistence food share in consumption [8]			0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.90	0.90
Public capital gestation lag [10]			1 year	1 year	1 year	3 year	1 year	1 year	1 year	3 years	3 years
LBD Spillover [11]			0.20	0.20	0.45	0.20	0.20	0.20	0.20	0.00	0.20
Change in KG (at initial prices)		**t=2**	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%
		t=10	14.0%	14.3%	14.3%	12.7%	14.2%	14.3%	14.1%	12.7%	12.7%
PRICES AND QUANTITIES		**Time Period**									
Export Weighted RER [9]		**to t=1**	-2.8%	-2.8%	-2.8%	-2.8%	-2.8%	-2.8%	-2.4%	-2.4%	-2.4%
		to t=5	-2.3%	-1.2%	-1.5%	-1.7%	-2.3%	0.3%	1.6%	1.0%	0.8%
		to t = 10	-3.0%	-0.6%	-1.3%	-1.2%	-1.6%	0.8%	2.5%	2.6%	2.0%
Total Exports		**to t=1**	-6.9%	-6.9%	-6.9%	-6.9%	-6.9%	-6.9%	-6.4%	-6.4%	-6.4%
		to t=5	-7.9%	0.9%	0.3%	-3.2%	0.3%	1.9%	7.8%	3.5%	2.7%
		to t = 10	-10.3%	7.7%	5.3%	4.3%	6.9%	8.7%	16.4%	15.6%	12.6%
Manufacturing Exports		**to t=1**	-6.6%	-6.6%	-6.6%	-6.6%	-6.6%	-6.6%	-6.5%	-6.5%	-6.5%
		to t=5	-9.5%	-0.5%	-2.8%	-4.9%	0.4%	-1.6%	-3.6%	-4.8%	-7.3%
		to t = 10	-16.9%	5.1%	-3.1%	-1.0%	6.4%	3.5%	-0.9%	3.2%	-6.0%
Cash crop Exports		**to t=1**	-7.7%	-7.7%	-7.7%	-7.7%	-7.7%	-7.7%	-7.0%	-7.0%	-7.0%
		to t=5	-7.2%	1.7%	2.5%	-2.3%	-0.3%	4.4%	13.2%	6.9%	7.7%
		to t = 10	-5.2%	9.9%	12.6%	8.8%	7.3%	13.4%	25.9%	21.0%	23.5%
Real GDP		**to t=1**	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%	0.10%	0.10%	0.10%
		to t=5	-0.31%	3.99%	3.75%	2.03%	3.86%	4.17%	4.48%	2.76%	2.49%
		to t = 10	-1.25%	7.26%	6.36%	5.82%	7.07%	7.52%	7.84%	7.48%	6.40%
Private Investment		**to t=1**	-3.7%	-3.7%	-3.7%	-3.7%	-3.7%	-3.7%	-3.4%	-3.4%	-3.4%
		to t=5	-5.0%	6.8%	5.8%	1.4%	4.6%	9.7%	13.8%	8.7%	7.6%
		to t = 10	-8.1%	15.4%	12.1%	11.2%	13.2%	18.6%	23.4%	22.9%	18.8%
TFP (Manufacturing) [12]		**to t=1**	-0.2%	-0.8%	-0.8%	-0.8%	-0.8%	-0.8%	-0.8%	0.0%	-0.8%
		to t=5	-1.6%	-1.6%	-3.2%	-1.6%	-1.6%	-1.6%	-1.6%	0.0%	-2.4%
		to t = 10	-6.3%	-2.4%	-7.2%	-4.8%	-1.6%	-3.2%	-4.0%	0.0%	-5.6%
Domestic Budget Balance [2]		**to t=1**	-0.47%	-0.47%	-0.47%	-0.47%	-0.47%	-0.47%	-0.44%	-0.44%	-0.44%
		to t=5	-0.53%	0.14%	0.10%	-0.16%	0.02%	0.31%	0.71%	0.39%	0.33%
		to t = 10	-0.68%	0.60%	0.46%	0.40%	0.48%	0.77%	1.27%	1.23%	1.02%
REAL DISPOSABLE INCOME											
	Rural	**to t=1**	-1.6%	-1.6%	-1.6%	-1.6%	-1.6%	-1.6%	-2.0%	-2.0%	-2.0%
		to t=5	-2.1%	2.1%	1.7%	0.1%	0.6%	4.1%	-6.3%	-6.2%	-6.3%
		to t = 10	-3.5%	5.5%	4.4%	3.8%	3.9%	7.9%	-5.9%	-5.9%	-6.3%
	Urban - Unskilled	**to t=1**	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%	3.1%	3.1%	3.1%
		to t=5	2.3%	5.0%	4.7%	3.8%	1.6%	9.9%	19.7%	17.1%	16.6%
		to t = 10	1.5%	6.5%	5.6%	5.7%	3.1%	11.4%	23.9%	23.9%	21.8%
	Urban -Skilled	**to t=1**	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.4%	2.4%	2.4%
		to t=5	2.0%	4.8%	4.8%	3.6%	2.2%	8.5%	17.1%	14.4%	14.3%
		to t = 10	2.1%	6.9%	6.9%	6.3%	4.2%	10.7%	21.8%	21.0%	20.2%
	Total	**to t=1**	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.6%	0.6%	0.6%
			0.3%	3.6%	3.5%	2.1%	1.4%	6.9%	7.3%	5.9%	5.7%
		to t = 10	-0.4%	6.2%	5.6%	5.1%	3.9%	9.6%	10.1%	9.7%	8.9%
FACTOR MARKETS											
Average Real Wage (wa/cpi)	**Skilled**	**to t=1**	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%	3.2%	3.2%	3.2%
		to t=5	3.2%	5.7%	5.9%	4.5%	2.4%	10.2%	24.5%	20.4%	20.5%
		to t = 10	4.4%	8.0%	8.8%	7.8%	4.6%	12.8%	31.7%	30.0%	29.8%
	Unskilled	**to t=1**	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	1.0%	1.0%	1.0%
		to t=5	0.5%	4.5%	4.3%	2.7%	1.8%	8.5%	12.9%	10.4%	10.0%
		to t = 10	-0.6%	7.5%	6.7%	6.3%	4.6%	11.6%	17.9%	17.3%	15.8%

NOTES

[1] - [9] See Table 2.
[10] Gestation lag for public infrastructure investment
[11] Learning-by-doing parameter ϕ (see Equation (27).
[12] Percentage change in Ast (see equation (27)).

Appendix Table 1
Sensitivity Analysis

Experiment			**2**	**2e**	**2f**	**3**	**3g**	**4**	**4h**	**4i**	**4j**	**4k**	**4l**	**4m**
Productivity Bias [3]			Neutral	Neutral	Neutral	Export	Export	Domestic	Neutral	Domestic	Domestic	Domestic	Domestic	Domestic
Alphag [4]			0.5	0.5	0.5	0.5	0.5	0.5	0.25	0.5	0.5	0.5	0.5	0.5
EPSL [5]			0.99	0.5	2.00	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
O&M [6]			3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	0.0%	7.5%	3.5%	3.5%	3.5%
LPUB [13]			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	0.0%	5.0%
O&M closure [14]			Aid	Aid	Aid	Aid	Aid	Aid	Aid	Aid	Aid	Aid	Deficit	Deficit
Initial public capital as percent of 'optimal' public capital [7]			50%	50%	50%	50%	50%	50%	75%	50%	50%	50%	50%	50%
Subsistence food share in consumption [8]			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Public capital gestation lag [10]			1 year	1 year	1 year	1 year	1 year	1 year	1 year	1 year	1 year	1 year	1 year	1 year
LBD Spillover [11]			0.00	0.00	0.00	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%	12.5%	12.5%	12.5%
Change in KG (at initial prices)		**t=2**	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	1.6%	2.4%	2.4%	2.4%	2.4%	2.4%
		t=10	14.3%	14.3%	14.3%	14.2%	14.3%	14.3%	10.6%	16.0%	12.6%	9.9%	16.0%	15.8%
PRICES AND QUANTITIES		**Time Period**												
Export Weighted RER [8]		**to t=1**	-2.8%	-2.9%	-2.8%	-2.8%	-2.2%	-2.8%	-2.8%	-2.8%	-2.8%	-2.8%	-2.8%	-2.8%
		to t=5	-1.1%	-1.1%	-1.0%	-2.1%	-1.8%	0.5%	-0.1%	0.5%	0.4%	0.1%	0.6%	0.9%
		to t = 10	-0.2%	-0.2%	-0.2%	-1.3%	-1.0%	1.3%	0.2%	1.5%	1.1%	0.2%	1.7%	2.1%
Total Exports		**to t=1**	-6.9%	-6.9%	-6.9%	-6.9%	-4.6%	-6.9%	-6.9%	-6.9%	-6.9%	-6.9%	-6.9%	-6.9%
		to t=5	1.4%	1.4%	1.4%	0.7%	3.0%	2.4%	-2.7%	2.7%	2.0%	-0.3%	2.4%	-0.3%
		to t = 10	8.7%	8.7%	8.7%	7.7%	10.0%	10.1%	1.2%	12.0%	8.1%	2.5%	11.0%	3.6%
Manufacturing Exports		**to t=1**	-6.6%	-7.1%	-6.3%	-6.6%	-4.6%	-6.6%	-6.6%	-6.6%	-6.6%	-6.6%	-6.6%	-6.6%
		to t=5	1.2%	1.0%	1.4%	1.9%	4.1%	0.3%	-4.7%	0.8%	-0.3%	-4.2%	0.3%	-4.7%
		to t = 10	8.6%	8.7%	8.6%	9.1%	11.5%	8.1%	-0.2%	10.3%	5.9%	-2.1%	8.7%	-3.9%
Cash crop Exports		**to t=1**	-7.7%	-7.3%	-8.1%	-7.7%	-4.9%	-7.7%	-7.7%	-7.7%	-7.7%	-7.7%	-7.7%	-7.7%
		to t=5	1.1%	1.3%	1.0%	-0.8%	1.7%	3.7%	-1.7%	4.0%	3.4%	2.5%	3.8%	2.8%
		to t = 10	8.7%	8.6%	8.8%	6.4%	8.8%	11.9%	1.9%	13.7%	10.0%	6.2%	13.0%	9.2%
Real GDP		**to t=1**	0.08%	0.08%	0.08%	0.08%	0.00%	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%	0.08%
		to t=5	4.16%	4.15%	4.17%	4.01%	4.02%	4.37%	1.88%	4.53%	4.18%	3.07%	4.48%	3.35%
		to t = 10	7.64%	7.63%	7.65%	7.37%	7.47%	8.01%	3.42%	8.94%	7.06%	4.34%	8.62%	5.61%
Private Investment		**to t=1**	-3.7%	-4.0%	-3.6%	-3.7%	-1.9%	-3.7%	-3.7%	-3.7%	-3.7%	-3.7%	-3.7%	-3.7%
		to t=5	7.4%	7.3%	7.5%	5.1%	6.7%	10.4%	3.7%	11.6%	9.2%	5.0%	8.2%	-5.9%
		to t = 10	16.8%	16.8%	16.8%	14.2%	15.9%	20.3%	8.1%	23.3%	17.5%	9.8%	16.3%	-13.6%
Domestic Budget Balance [2]		**to t=1**	-0.47%	-0.50%	-0.45%	-0.47%	-0.28%	-0.47%	-0.47%	-0.47%	-0.47%	-0.47%	-0.47%	-0.47%
		to t=5	0.17%	0.16%	0.18%	0.04%	0.20%	0.35%	-0.03%	0.43%	0.26%	-0.07%	0.16%	-0.96%
		to t = 10	0.66%	0.66%	0.65%	0.52%	0.67%	0.84%	0.21%	1.00%	0.69%	0.19%	0.51%	-1.76%
REAL DISPOSABLE INCOME														
	Rural	**to t=1**	-1.6%	-1.6%	-1.5%	-1.6%	-1.1%	-1.6%	-1.6%	-1.6%	-1.6%	-1.6%	-1.6%	-1.6%
		to t=5	2.3%	2.3%	2.3%	0.8%	1.3%	4.4%	1.9%	4.6%	4.2%	3.3%	4.4%	3.2%
		to t = 10	6.0%	6.0%	6.0%	4.2%	4.8%	8.5%	3.6%	9.5%	7.5%	5.0%	8.8%	5.1%
	Urban - Unskilled	**to t=1**	2.7%	2.2%	3.0%	2.7%	1.5%	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%
		to t=5	5.2%	5.0%	5.3%	1.8%	0.8%	10.1%	8.5%	10.2%	10.0%	9.5%	10.3%	10.2%
		to t = 10	6.9%	7.0%	6.8%	3.4%	2.5%	11.9%	9.2%	12.5%	11.3%	9.9%	12.6%	12.4%
	Urban -Skilled	**to t=1**	2.0%	2.3%	1.7%	2.0%	1.5%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
		to t=5	4.8%	4.9%	4.7%	2.2%	1.8%	8.5%	6.9%	8.6%	8.5%	9.4%	8.7%	10.1%
		to t = 10	6.9%	6.8%	6.9%	4.2%	3.9%	10.7%	7.8%	11.2%	10.2%	10.6%	11.4%	14.1%
	Total	**to t=1**	0.5%	0.5%	0.5%	0.5%	0.4%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
			3.8%	3.8%	3.8%	1.5%	1.4%	7.0%	5.0%	7.1%	6.9%	6.7%	7.1%	7.1%
		to t = 10	6.5%	6.5%	6.5%	4.1%	4.1%	9.9%	6.2%	10.7%	9.2%	8.0%	10.5%	9.9%
FACTOR MARKETS														
Average Real Wage (wa/cpi)	**Skilled**	**to t=1**	2.7%	3.4%	2.0%	2.7%	2.2%	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%
		to t=5	5.6%	5.8%	5.4%	2.3%	2.2%	10.1%	8.5%	9.9%	10.3%	14.1%	10.3%	15.2%
		to t = 10	7.7%	7.4%	7.7%	4.4%	4.2%	12.4%	9.6%	12.2%	12.1%	16.5%	13.0%	23.1%
	Unskilled	**to t=1**	0.9%	0.5%	1.1%	0.9%	0.4%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%
		to t=5	4.7%	4.6%	4.8%	2.0%	1.7%	8.7%	6.2%	8.8%	8.5%	7.7%	8.8%	8.1%
		to t = 10	8.3%	8.3%	8.3%	5.5%	4.9%	12.3%	7.6%	13.7%	10.9%	8.9%	12.7%	11.0%

NOTES
[1] - [12] See Tables 2 and 3
[13] Additional 'scaling up' public sector employment of skilled labour (as percent of initial demand for skilled labour).
[14] Fiscal closure rule for O&M expenditure (Aid = O&M expenditure met from aid inflows; Domestic = from domestic sources)

Appendix Table 2
Varying the Macroeconomic Closure

Experiment			1	1n	2	2n	3	3n	4	4n	4o	5	5n
Macroeconomic closure [15]			nc	Kaldor	nc	Kaldor	nc	Kaldor	nc	Kaldor	Kaldor	nc	Kaldor
Productivity Bias [3]					Neutral	Neutral	Export	Export	Domestic	Domestic	Domestic	Domestic	Domestic
Alphag [4]			0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
EPSL [5]			0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
O&M [6]			3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%
LPUB [13]			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.0%	0.0%	0.0%
O&M closure [14]			Aid	Aid	Aid	Aid	Aid	Aid	Aid	Aid	Deficit	Aid	Aid
Initial public capital as percent of 'optimal' public capital [7]			50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Subsistence food share in consumption [8]			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.90
Public capital gestation lag [10]			1 year	1 year	1 year	1 year	1 year	1 year	1 year	1 year	1 year	1 year	1 year
LBD Spillover [11]			0.00	0.00	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%	12.5%	12.5%
Change in KG (at initial prices)		**t=2**	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%
		t=10	14.0%	14.1%	14.3%	14.3%	14.2%	14.2%	14.3%	14.3%	15.8%	14.1%	14.1%
PRICES AND QUANTITIES		**Time Period**											
Export Weighted RER [8]		**to t=1**	-2.8%	-2.7%	-2.8%	-2.7%	-2.8%	-2.7%	-2.8%	-2.7%	-2.7%	-2.4%	-2.4%
		to t=5	-2.1%	-2.2%	-1.1%	-0.7%	-2.1%	-1.8%	0.5%	0.9%	0.5%	1.7%	2.5%
		to t = 10	-2.2%	-2.2%	-0.2%	0.3%	-1.3%	-0.8%	1.3%	1.9%	1.2%	3.0%	3.9%
Total Exports		**to t=1**	-6.9%	-6.9%	-6.9%	-6.9%	-6.9%	-6.9%	-6.9%	-6.9%	-6.9%	-6.4%	-6.4%
		to t=5	-7.3%	-7.1%	1.4%	1.1%	0.7%	0.5%	2.4%	1.9%	0.1%	8.5%	8.0%
		to t = 10	-7.7%	-7.4%	8.7%	7.2%	7.7%	6.5%	10.1%	8.3%	5.5%	18.5%	15.9%
Manufacturing Exports		**to t=1**	-6.6%	-6.7%	-6.6%	-6.7%	-6.6%	-6.7%	-6.6%	-6.7%	-6.7%	-6.5%	-6.5%
		to t=5	-7.3%	-7.1%	1.2%	1.1%	1.9%	1.9%	0.3%	0.1%	-4.4%	-1.5%	-2.1%
		to t = 10	-8.0%	-7.6%	8.6%	7.2%	9.1%	7.9%	8.1%	6.2%	-2.1%	5.3%	2.4%
Cash crop Exports		**to t=1**	-7.7%	-7.7%	-7.7%	-7.7%	-7.7%	-7.7%	-7.7%	-7.7%	-7.7%	-7.0%	-7.0%
		to t=5	-8.0%	-7.7%	1.1%	0.7%	-0.8%	-1.1%	3.7%	3.2%	3.3%	12.6%	12.1%
		to t = 10	-8.2%	-7.8%	8.7%	7.1%	6.4%	5.1%	11.9%	10.0%	11.3%	24.2%	21.6%
Real GDP		**to t=1**	0.08%	0.09%	0.08%	0.09%	0.08%	0.09%	0.08%	0.09%	0.09%	0.10%	0.10%
		to t=5	-0.08%	0.00%	4.16%	4.08%	4.01%	3.97%	4.37%	4.23%	3.49%	4.71%	4.48%
		to t = 10	-0.26%	-0.11%	7.64%	7.11%	7.37%	6.93%	8.01%	7.35%	8.30%	8.57%	7.55%
Private Investment		**to t=1**	-3.7%	-2.0%	-3.7%	-2.0%	-3.7%	-2.0%	-3.7%	-2.0%	-2.0%	-3.4%	-1.9%
		to t=5	-4.1%	-2.2%	7.4%	1.3%	5.1%	0.2%	10.4%	2.7%	1.3%	14.7%	2.5%
		to t = 10	-4.3%	-2.5%	16.8%	4.1%	14.2%	5.9%	20.3%	5.7%	3.1%	26.2%	5.2%
FISCAL ACCOUNTS [2]													
Domestic Budget Balance		**to t=1**	-0.47%	-0.48%	-0.47%	-0.48%	-0.47%	-0.48%	-0.47%	-0.48%	-0.48%	-0.44%	-0.45%
		to t=5	-0.48%	-0.48%	0.17%	0.18%	0.04%	0.06%	0.35%	0.38%	-0.98%	0.76%	0.80%
		to t = 10	-0.48%	-0.47%	0.66%	0.64%	0.52%	0.51%	0.84%	0.82%	-1.75%	1.41%	1.39%
REAL DISPOSABLE INCOME													
	Rural	**to t=1**	-1.6%	-1.7%	-1.6%	-1.7%	-1.6%	-1.7%	-1.6%	-1.7%	-1.7%	-2.0%	-2.0%
		to t=5	-1.8%	-1.8%	2.3%	2.7%	0.8%	1.1%	4.4%	4.8%	2.9%	-6.2%	-6.3%
		to t = 10	-2.1%	-2.0%	6.0%	6.1%	4.2%	4.4%	8.5%	8.4%	5.1%	-5.6%	-6.2%
	Urban - Unskilled	**to t=1**	2.7%	2.8%	2.7%	2.8%	2.7%	2.8%	2.7%	2.8%	2.8%	3.1%	3.1%
		to t=5	2.5%	2.7%	5.2%	4.7%	1.8%	1.4%	10.1%	9.5%	10.8%	20.1%	19.8%
		to t = 10	2.4%	2.5%	6.9%	5.9%	3.4%	2.6%	11.9%	10.8%	13.7%	25.2%	24.2%
	Urban -Skilled	**to t=1**	2.0%	2.1%	2.0%	2.1%	2.0%	2.1%	2.0%	2.1%	2.1%	2.4%	2.4%
		to t=5	2.0%	2.1%	4.8%	4.3%	2.2%	1.8%	8.5%	8.0%	10.6%	17.3%	16.8%
		to t = 10	2.0%	2.1%	6.9%	6.0%	4.2%	3.4%	10.7%	9.7%	15.3%	22.3%	21.0%
	Total	**to t=1**	0.5%	0.6%	0.5%	0.6%	0.5%	0.6%	0.5%	0.6%	0.6%	0.6%	0.6%
			0.4%	0.5%	3.8%	3.7%	1.5%	1.4%	7.0%	6.8%	7.3%	7.5%	7.2%
		to t = 10	0.3%	0.4%	6.5%	6.0%	4.1%	3.7%	9.9%	9.3%	10.6%	10.6%	9.7%
FACTOR MARKETS													
Average Real Wage (wa/cpi)	**Skilled**	**to t=1**	2.7%	2.8%	2.7%	2.8%	2.7%	2.8%	2.7%	2.8%	2.8%	3.2%	3.2%
		to t=5	2.8%	3.1%	5.6%	5.1%	2.3%	1.8%	10.1%	9.5%	16.0%	24.4%	24.3%
		to t = 10	3.2%	3.2%	7.7%	6.6%	4.4%	3.5%	12.4%	11.2%	24.7%	31.9%	30.5%
	Unskilled	**to t=1**	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	1.0%	1.0%
		to t=5	0.7%	0.8%	4.7%	4.5%	2.0%	1.8%	8.7%	8.3%	8.4%	13.2%	12.9%
		to t = 10	0.5%	0.6%	8.3%	6.8%	5.5%	4.0%	12.3%	10.8%	11.6%	18.9%	17.4%

NOTES
[1] - [14] See Tables 2, 3 and Appendix Table 1
[15] Macroeconomic closure: (nc = 'neo-classical' savings driven closure; Kaldor= 'Kaldorian' investment driven closure).

Figure 1
Export Weighted Real Exchange Rate Response to Aid-Financed Public Investment

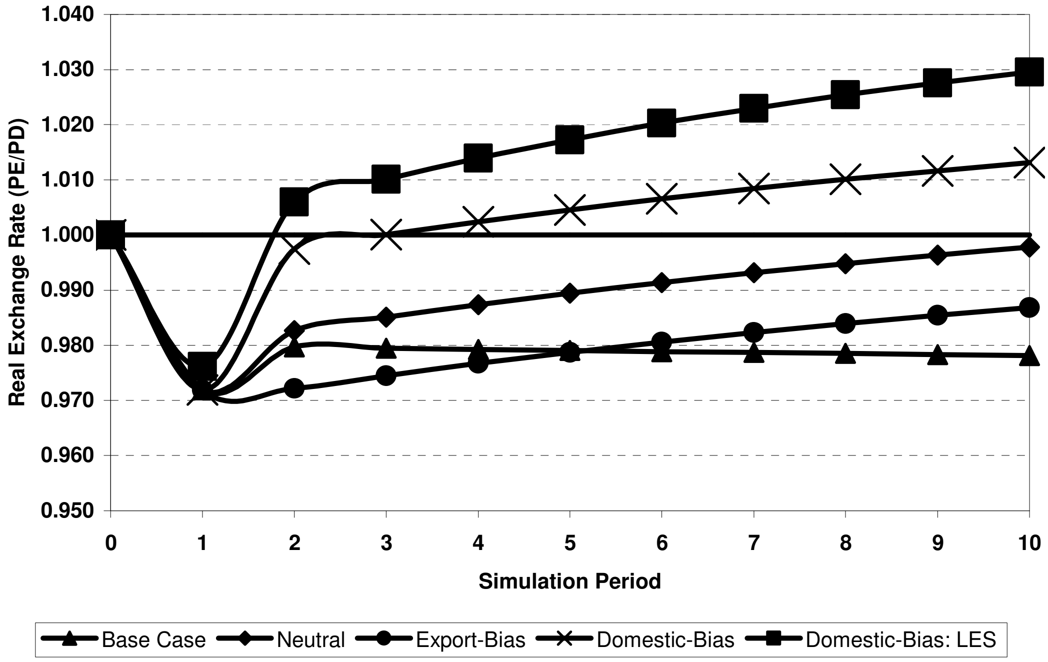

Figure 2
Total Export Response to Aid-Financed Public Investment

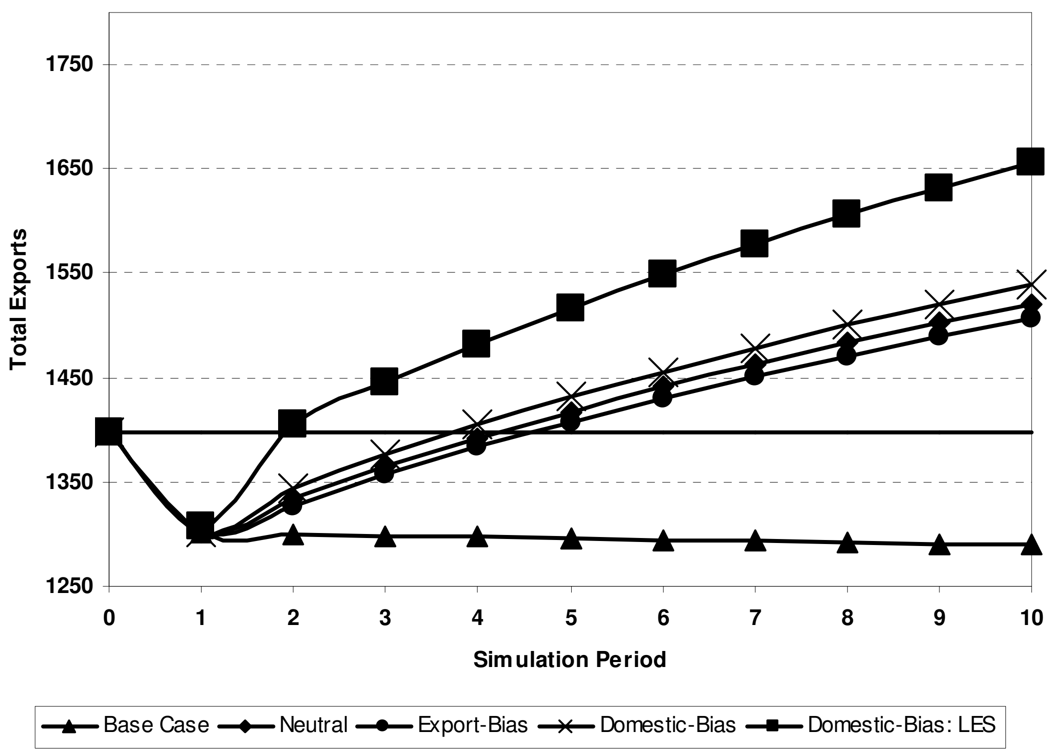

Figure 3
Real Household Disposable Incomes in Response to Aid-Financed Public Investment

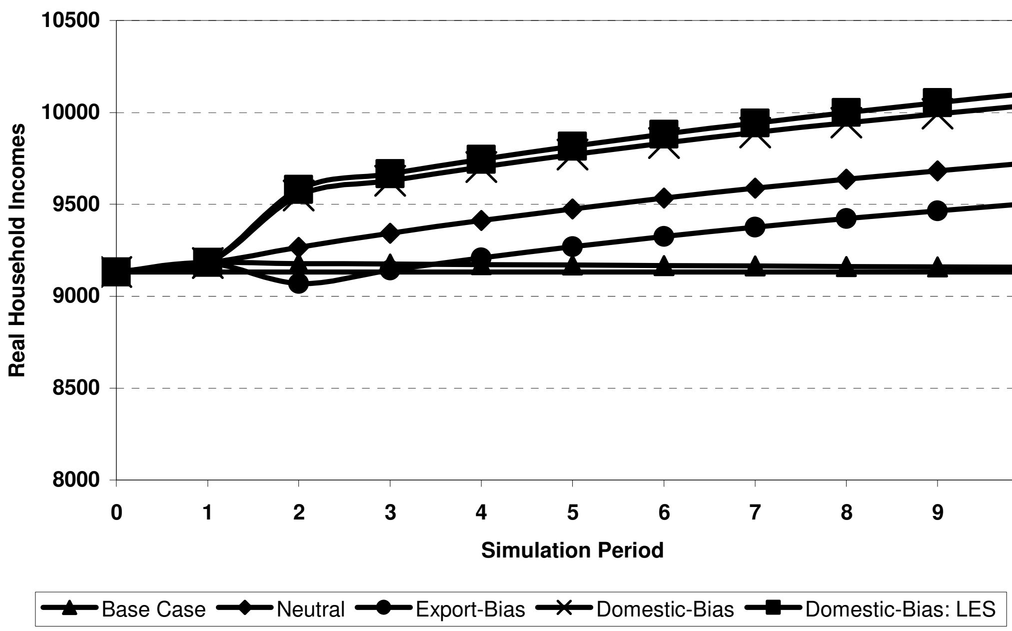

Figure 4
Rural Share in Total Income in Response to Aid-Financed Public Investment