Uganda

Aid, Public Expenditure, and Dutch Disease

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Executive Summary

Aid, Public Expenditure and Dutch Disease

Net aid flows to Uganda in 2000/01 were around 13 percent of GDP and are programmed to rise by up to a further 3 percent of GDP over the coming years. These elevated flows have raised a number of concerns, ranging from fears about the effect of aid inflows on the real exchange rate and export performance, about fiscal performance, and about the impact of aid on private investment, to concerns about overall debt sustainability. Underlying these is a more general concern about the impact of high aid flows on aggregate welfare and that of particular groups, especially the poor.

The current paper contributes to this debate by offering some simulation evidence on the possible impact of increased aid flows on the economy. Using a computable general equilibrium model of Uganda calibrated to data for the end of fiscal year 2001, the simulations allow us to examine how alternative supply-side responses to aid financed public expenditure modify the conclusions emerging from the short-run, demand-side focussed analysis of the impact of aid inflows which has a tendency to dominate the policy debate in Uganda.

The paper concentrates on the case of a permanent 12.5 percent increase in the net (grant) aid inflow to the economy, equivalent to just under 2 percent of GDP at initial domestic prices and considers consequences of varying a number of key assumptions about the functioning of the supply-side of the economy.

The basic conclusion to emerge from our simulation evidence is that beyond the short-run, in which demand-side effects do dominate economic outcomes, the relation between enhanced aid flows, real exchange rates, export volumes and welfare is a complex one. It is certainly not inevitable that increased aid will result in 'Dutch Disease' effects, particularly in the medium- to long-run. The key to the evolution of the aggregate economy is the supply-side response to the aid-funded public expenditure. In particular, productivity enhancements that are skewed towards the production of domestic goods deliver the largest aggregate return to aid.

However, such productivity biases however also exacerbate a key underlying distributional tension in the economy. Public expenditure is intensive in formal sector (urban) employment and draws disproportionately on the manufactured goods and services sectors for its

intermediate inputs. Rural households capture little of the direct benefit from these demand effects, and if supply side effects are powerful enough, so that domestic food prices fall relative to manufacturing and service prices, and if these are reinforced by a low income elasticity for demand for food, then rural household incomes suffer badly. These adverse distributional effects have the potential to undermine the aggregate gains from productivity-enhancing public expenditure.

This result, as with the others in this paper, emerges from a simulation model and is therefore only illustrative. Nonetheless it is of sufficient strength to suggest that close attention needs to be paid to the evolving distributional consequences of the public expenditure programme.

The experiments reported here are only illustrative of a range of possibilities that could be examined. Nonetheless, they do suggest that if it were feasible to choose infrastructure investment in a way that particularly enhanced production of one or other type of output, it would be preferable to do so in respect of domestic goods, not exports. However, identifying the real relationships between government expenditures and private production will be difficult; and even given the requisite knowledge, it may not be feasible to exercise choices of this sort.

1. Introduction

In view of its solid macroeconomic performance and coherent poverty reduction strategy, foreign aid inflows into Uganda have been increasing in recent years. Net aid flows in 2000/01 were around 13 percent of GDP but are programmed to rise by up to a further 3 percent of GDP over the next two fiscal years. These elevated flows have raised a number of concerns, of which we may note five in particular. As in so much else, the situation of Uganda provides a leading indicator of issues that will rapidly acquire a wider currency.

First, there are concerns about the real exchange rate (RER) implications of the aid inflows. The standard argument is that these must inevitably involve an appreciation of the RER, since the enhanced income must imply an increased demand for nontradable (domestic) goods, and this can only be satisfied by a switch in productive resources from tradables to nontradables which requires the bidding up of the price of latter relative the former. The concern here is that this inhibits the development of the tradable sector, particularly export production, and may also have adverse distributional implications.

Second, there are similar concerns about government revenue; this effect depends on the balance between government spending on tradables as opposed to nontradables, relative to the extent to which government revenues are levied on tradables as opposed to nontradables. If government expenditure is relatively more intensive in the nontradable goods, then a real exchange rate appreciation will lead to a deterioration in the government budget balance, and vice-versa.

Third, there are concerns about the impact on private investment. This is a complex issue, and involves a variety of factors. The impact of the enhanced aid inflow includes changes in public and private savings, changes in rates of return (which are particularly sensitive to whether the public use of aid involves productive public investment), and to changes in the price of private capital and in the interest rate.

Fourth, there are concerns about debt sustainability. Specifically, while the HIPC initiative lowered the ratio of the present value of external debt to around 150 percent of exports, the sluggish growth of exports (exacerbated by the low price of coffee), coupled with the scale of foreign assistance, not all of which is in the form of grants, means that this ratio is likely to rise again. A more rapid future rise in exports would neutralize this effect, and we return to this possibility below, but apart from this, there appear to be three other possibilities. One position might maintain the proposition that the 150 percent limit is a realistic measure of sustainability; the conclusion would then presumably be that the aid flow should be scaled back to be consistent with this limit. On the other hand is the view that the aid flows were productive and hence still warranted, but would imply further HIPC-type reductions. In effect, this would be tantamount to saying that a higher degree of concessionality in the aid flow would be appropriate, but that institutional or perceptual constraints means it will have to be implemented in the future rather than ‘up front’. The third possibility is to question the validity of the ratio itself and consider the concept of sustainability further. This is probably appropriate in any case. The 150 percent figure, and the other HIPC ratios, seem to be pretty arbitrary; they were doubtless useful in concentrating energies in mobilizing the HIPC initiative, but are not necessarily helpful for determining future strategy. A more careful examination of sustainable levels of debt service would certainly have to combine attention to the *external* transfer problem (exports and the foreign exchange burden) with attention to the *internal* transfer problem (domestic revenue and the shift of resources from the private to the public sector).

Fifth, and finally, at least in this catalogue, there are concerns about the absorptive capacity of the recipient economy, and particularly of the government itself. If this is sufficiently limited and potential aid flows are sufficiently high, then the sensible upper bound on the inflow might be determined by capacity limitations, not by the macroeconomic effects previously listed.

Underlying all these anxieties is the more general concern for how welfare in the recipient country will be affected, both on average, and for particular groups, especially the poor and vulnerable.

This paper uses a computable general equilibrium of the Ugandan economy to simulate the short- and medium-term consequences of increased donor aid flows. The immediate focus of interest is the real exchange rate itself but the simulation model allows us to track the implications for output and export volumes, for private investment and the budget and hence for the debt sustainability issue. The model also tracks the impact on household welfare across three distinct groups of household. The paper is structured as follows. Section 2 provides brief summary of the linkages between aid inflows and the real exchange rate paying particular attention to the role of supply-side responses to aid inflows. This is followed in Section 3 by a description of the model itself and the data used to calibrate it. Section 4 describes the simulation experiments and presents and discusses the results from eight individual runs spanning a range of policy-relevant alternatives. Section 5 draws some preliminary conclusions and suggestions for further development.

To complement the main text a brief sketch of the underlying analytic model is provided in Appendix I. Appendix II reports sensitivity analysis for the principal results of the paper and Appendix III reports ten-year model-based simulation for GDP, total revenue and exports which can be used to scale external debt projections. The full SAM and the GAMS programme used to simulate the model are provided in Appendix IV and V respectively.

2. Aid and the real exchange rate

One of the central problems in considering the impact of aid inflows on an economy concerns the expected duration and volatility of these flows. Both the appropriate (normative) government response, and the positive analysis of likely outcomes, will depend on whether the flow is (i) (relatively) permanent; (ii) steady but of finite duration; or (iii) temporary, and perceived to be so.[1] The focus of this paper is the first of these but before we turn to consider this case it is necessary to contrast policy choices in the case of the others. In reality, it may be unclear where in this categorization a particular event lies, and indeed views may change over time,[2] but this rather stark distinction helps to fix ideas.

A ‘permanent’ change in aid in practice is one which is considered to be of indefinite duration, but unlikely to be reversed over any reasonable horizon. If a permanent change is to be absorbed, a one-for-one domestic adjustment is required. However, the government still has to decide whether to take all the adjustment on the side of expenditure, by increasing current expenditure or infrastructure investment, for example, or to offset part of it by altering the rate of revenue mobilization. Some combination of both is likely to be optimal in many circumstances, especially if current tax structures are highly distortionary at the margin and/or there are limitations to the public sector’s absorptive capacity. However, in order to focus exclusively on variations in the public expenditure programme, the simulations considered later in the paper all take the rate of revenue mobilization as given.

[1] Evidently, there are additional possibilities governed by *mis*perceptions of what is happening.

[2] Similar interpretative problems arise in the case of trade shocks. It is notorious that in many oil producing countries, the oil price shocks of the mid-1970s and early 1980s were initially regarded as temporary, then re-interpreted as permanent, not long before they were reversed.

A temporary change is again, in practice, probably one of indefinite duration, but this time with the expectation of relatively early termination.[3] In this case, the usual sort of inter-temporal smoothing argument would suggest that only a (small) proportion of the change should be absorbed immediately, with the rest being spread over a longer horizon by the accumulation or decumulation of *foreign* financial assets. There are serious qualifications to this textbook argument however. The action may well be infeasible. If it implies a run-down of official net foreign assets, these have to be positive or else the government's access to credit must be good. If it implies a build-up (the case we concentrate on here), the donors would have to acquiesce in their aid being temporarily stored in an international portfolio, and it is extremely unlikely that they would do so. The 'saving' option will therefore be restricted in practice to a temporary change in the government's net *domestic* assets (i.e. adjustments in the domestic budget balance). But this transmits the adjustment into the private sector, which may not be desirable either.

Finally, note that this discussion is restricted to how temporary variations in the aid flow might best be handled if they occur. While it may be possible to reduce the adverse consequences in this way, the costs of variability will remain high. Hence much the best option is to organize a steadier and more predictable flow in the first place.

Increased government spending from an increased inflow.

We assume that government wishes to maintain the existing rate of expansion of the money supply, foreign exchange reserves and domestic credit to the private sector. In such circumstances the monetary injection arising from the additional spending would need to be sterilized by sales of the excess foreign exchange. These issues were discussed in detail Adam (September 2001)[4], but are worth recapping on briefly.

There are three cases to consider, depending on how the government splits its incremental spending between imports, domestically produced tradable goods, and non-tradable goods (and services).

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[3] It makes some difference whether this change is anticipated or signalled in advance on the one hand, or a surprise on the other: however this distinction is ignored here.

[4] Christopher Adam *Uganda: Exchange rate management, monetary policy, and aid.* (paper prepared for BoU/DFID, September 2001).

- To the extent that the government meets its additional expenditure requirements solely through the purchases of imported goods, the sterilization process happens automatically. There are no monetary implications and the foreign exchange inflow is self-liquidating.

- To the extent that the government increases its purchases of domestically produced tradable goods, the consequences depend on whether there is a supply response. If there is no supply response, the government purchases crowd-out existing private purchases one-for-one, and these are instead sourced from increased private imports. The latter require increased purchases of foreign exchange, which sterilize the monetary injection from the government's increased domestic expenditures.

  If, instead, there is a supply response - for example, because there is spare capacity in the economy - then this crowding-out process is only partial. The increase in domestic activity would indicate that some accompanying relaxation in monetary policy would be appropriate. However, if this does not take place, the increased private sector demand for foreign exchange, at the existing exchange rate, will be less than the amount the Central Bank is committed to selling. This will induce some appreciation of both the nominal and real exchange rates, with the effect being larger if the supply response is strong.

- To the extent that the government increases its purchases of nontradables, we have the same supply ambiguity, but with rather different implications. Of course, there is now no possibility of increasing imports, and the government's additional demand must be fully accommodated in some combination by inducing additional supply and reducing private demand. The more elastic the supply response, the smaller the required compression in private demand and hence the less the required appreciation of the exchange rate.

In the absence of spare capacity, the scale of the induced appreciation will depend partly on the composition of government spending and partly on the extent of substitutability in private demand. The existence of surplus capacity in the tradable sector will tend to increase the appreciation, while surplus capacity in the non-tradable sector will tend to reduce it.

This discussion has focused on surplus capacity as a complicating factor without analyzing the sources of this. There are two main contenders. One is the possibility of deficient effective demand and is more plausible in the nontradable than the tradable sector. The other is the possibility that supply may be impeded by bottlenecks of various sorts, and these are arguably more plausible in the tradable sector. For example poorly maintained roads are more likely to interfere with tradable than non-tradable activities. Much of government spending generates complementary social and infrastructural capital. Deficient spending may then be a source of bottlenecks, and increased spending may have direct supply effects as well (possibly) as effects via increased effective demand.

Augmenting private-sector supply capacity

More generally, the increased aid inflow may be used to *expand* the economy's supply capacity. Hence increased government spending does not crowd out private spending, but is added to it. This could happen, as noted earlier, either if the current resources in the economy would not otherwise be fully employed (so that the additional demand calls forth additional existing supply), or if the government spending created space for itself by expanding potential supply. In either case, the implied movement in the exchange rate is ambiguous. It depends on whether the supply increase is more concentrated in the tradable sector than the spending increase or vice versa, and this is a priori obscure.

The ways in which government spending can directly raise potential supply are clear enough in principle, but will tend to have different force in different categories of spending, so the overall effect will depend on composition. The extent to which it is feasible to expand existing spending in Uganda in a supply-enhancing way requires detailed knowledge and analysis of the expenditure programme. This is important to bear in mind when considering the simulations provided below. These necessarily abstract completely from issues of the government's implementation capacity and to a lesser extent from detailed issues of the composition of expenditure.

They do, however, allow us to consider the fundamental mechanics of the supply-side response. The argument is stated more formally in Appendix I, but the main thrust can be simply stated. The standard Dutch Disease proposition (that an aid inflow must appreciate the real exchange rate) depends on three explicit or implicit propositions. The first is that the aid flow increases national disposable income. The second is that the nontradable good is normal, so that demand for it will rise with income. The third is that the aid has no supply effect for the nontradable, so that the increase in demand is unmatched by any increase in supply *potential*. Hence the necessary increase in supply can only be induced by a shift in producer prices to make nontradable production more profitable. What happens if the aid is used to increase supply potential? Then there are three types of case to consider.

The first case is where the expansion of supply is neutral, in the sense that the economy's productive capacity is increased in a way which is symmetric between tradable and nontradable goods – it just becomes (equiproportionally) more productive in both. If this type of productive expansion is accompanied by homothetic preferences (so that an increase in consumer income at constant relative prices leads to equiproportionate increases in the various categories of spending), then the supply expansion has no effect on the aid-induced appreciation. Demand rises and so does supply, but a switch in the production shares is still required so that the extent of RER appreciation is unaffected. If demand is not homothetic, so that, for example, the income elasticity of demand for nontradables is low, the extent of the appreciation will be reduced but not reversed.

The second case is where the expansion of potential supply is biased toward the nontradable good. Provided this relative supply expansion is large enough, the RER appreciation may be neutralized or even reversed – the supply expansion may dominate the demand expansion. In these circumstances, as in those of the previous case, low income elasticities for the nontradable may have powerful consequences for the *extent* of the RER movement, even if they do not control its *sign.*

The third case is where the expansion of potential supply is biased toward the tradable good. Since this enhances productive capacity of the tradable but not the nontradable good, it leads to a larger RER appreciation than in the first, neutral, case. However, this RER appreciation reflects the fact that exporters have become *better* at exporting. So it is far from clear that this type of exchange rate movement represents a problem, either in terms of output growth or welfare.

3. The model and data calibration

Our simulation analysis is based on a small computable general equilibrium model calibrated to reflect the principal features of contemporary Uganda. In this section we provide a brief sketch of the general features of the model and discuss the properties of the data calibration employed in the simulations.[5]

The Model

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 country's terms of trade are independent of

[5] The model is written and solved using the GAMS programming language. A full listing of the model equations is attached as Appendix V to this paper.

domestic policy choices. Given the focus of this paper, the terms of trade are assumed to be constant across the range of experiments. The barter structure also implies that consumer and producer decisions are determined by *relative* prices only (for example between imports and domestic variants of a good); neither the aggregate price level nor inflation plays a role in this model. One implication of this structure is that the model is not suited to address a range of macroeconomic and monetary policy issues associated with an aid inflow. In particular, it cannot be used to evaluate alternative deficit financing options, for example between domestic debt and money financing, nor can it consider the properties of alternative nominal exchange rate strategies. The fiscal balance does, however, play an important role since budget deficits or surpluses feed back directly on the private sector by crowding-out or crowding-in private sector savings and hence investment.

As currently configured the model does not track the evolution of the external debt or the debt service implications of increased aid flows. This is an explicit choice adopted in the current version of the model, principally for convenience. There are two relevant dimensions to the treatment of external debt. The first is external debt service and here our model is based on two assumptions. The first is that the debt service costs in the initial baseline are stationary; assuming otherwise would mean that the baseline would not constitute a steady-state against which we can analyse the properties of our experiments. The second assumption is that any increase in the aid flow to Uganda is in terms of pure grants or highly concessional lending on IDA terms, or some combination of both. Even in the limiting case where the entire additional aid flow were on IDA terms, the *additional* debt-service implications for Uganda over the ten-year horizon we are considering would still be negligible. Hence from the point of view of tracking the debt service implications of the aid inflow the assumption of a constant dollar value of debt service seems reasonable; endogenizing debt service would add complexity with no insight.

The second issue is the evolution of the external debt stock itself. There are two reasons why we might be interested in modelling this specifically. The first is if there are important feedback mechanisms from the debt stock to domestic economic behaviour. Other than the debt-service link through the budget (and the balance of payments), which we have already suggested is likely to be negligible, the external debt stock does not have an independent effect on the domestic economy in this model. For example, there are no debt-overhang effects in the model. Building in appropriate feedback mechanisms that are plausible would require a substantial redesign of the model, which is beyond the scope of this project.

Even so, the international community is naturally interested in the evolution of the key HIPC ratios in their own right. Since the model does not embody any information on the structure and composition of the debt stock, it is ill suited to generating projections for the present-value of external debt, and certainly could not do so to the detail of those generated from specific debt sustainability exercises. However it does generate a relevant set of alternative counterfactual projections for the denominators of the key HIPC ratios (i.e. government revenue, total exports, and real GDP). It therefore makes sense to use this model to generate these denominators and combine them with values for the numerator from a debt sustainability analysis. These are reported in Appendix III.[6]

The model is dynamic, with each solution run tracking the economy over 10 periods from the initial policy change, where each period may be though of as a fiscal year. The dynamic structure is, however, rather rudimentary: at each point in time 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 expenditure decision being analysed). This solution defines a new vector of prices and quantities for the economy, including the level of public and private sector investment. Combined with the depreciation of the existing capital stock, these determine the new capital stock available to the economy at the beginning of the second period. 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 which, in the absence of any change in policy or external circumstances, exactly replicates itself *ad infinitum*[7].

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[6] Having said this, it is worth re-iterating the key point we have made in the paper that a CGE model is not a forecasting model. Its role is to use simulations to highlight key mechanisms and linkages within the economy in a systematic manner rather than to generate forecasts of the short- or medium term path the economy is likely to take. For example, in order to focus on the question at hand we have assumed that the terms of trade are constant over the simulation horizon. This is eminently sensible for the question in hand but may be wholly inappropriate for researchers interested in forecasting HIPC ratios. Simulations we generate for exports, revenue and GDP must therefore be considered in this light.

[7] This may seem a wholly unrealistic restriction to impose on the model given the data. It is relatively straightforward to relax this assumption so that the baseline simulation describes an economy out of steady-state where the capital-labour and capital-output ratios are changing, but even in these circumstances our interest would still be primarily on the *deviation* of the economy from this baseline path in response to changes in aid inflows. Under reasonable assumptions about how quickly the

Production

The production side of the model is relatively standard. Firms in each of the five productive sectors, denoted *i*, are assumed to be perfectly competitive, producing a single good which can be sold to either the domestic or export markets. Intermediate inputs combine with value added in fixed proportions to produce gross output, with value added determined according to sector-specific Cobb-Douglas production functions of the form

$$X_i = AD_i S^{a\,si}{}_i \prod{}_{lc} L_{i,lc}^{a\,li,lc} KP_i^{a\,ki} KG^{a\,gi}. \qquad (1)$$

S, *L*, *KP*, and *KG* denote land, labour, sector-specific capital and infrastructure respectively. The index *lc* distinguishes between labour types, skilled and unskilled, *"s, "l , "k,* and *"g* are the factor shares, and *AD* a scaling factor. Only production in rural sectors requires land inputs; output in all other sectors requires only sector-specific private capital and the two types of labour. Land endowments are fixed in perpetuity and capital is fixed in each period so that labour is the only variable factor in the short run. Private sector output is also determined by the level of infrastructure, *KG*, which is provided by government. Infrastructure is a public good – hence it is not indexed by *i* in (1) – capable of augmenting the productivity of private factors in all sectors non-rivalrously. The model assumes constant returns to scale in the private factors of production (i.e *"s+S$_{lc}$"l+"k=1),* but allows for increasing returns in the presence of infrastructure (*"g=0).* In the simulations reported later in the paper, we consider alternative characterisations of infrastructure so that it may have differential effects across sectors (e.g. it a unit of additional infrastructure provision may be biased towards agriculture rather than the manufacturing sector, for example).

Labour markets

The supply of each type of labour is fixed in aggregate but is mobile across sectors. For the economy as a whole, labour of each skill level is paid the value of its marginal product but inter-sectoral wage differentials exist in equilibrium. These differentials around the skill-specific mean wage are fixed and may be thought of as reflecting constraints to full labour market clearing (i.e. equalization of the marginal product of labour across *all* sectors) arising from, say, union power in certain sectors or other structural features. Profit maximization by firms therefore determines the *average* wage for each labour type with the pattern of wage differentials determining the sector-specific pattern of wages.

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otherwise un-perturbed economy would converge to its long-run steady-state, it is unlikely that defining the model in these terms would alter our inference.

Goods markets

For each sector of the economy we distinguish between an internationally tradable and a domestic variant of the good. Each producer and each consumer is a price taker for all tradable goods, but domestic goods and factor prices are fully flexible. Output, which can be consumed as final or intermediate inputs or applied to the formation of the capital stock, is sold either to the domestic market or exported. On the production side, the model assumes firms cannot switch their output costlessly between domestic and foreign markets in response to relative price movements[8]. This imperfect substitutability is characterised as follows. Firms produce a total output (denoted *X*) which they allocate between the export market (*E*) and the domestic market (*D*) according to the a sector-specific homothetic constant elasticity of transformation (CET) functions of the form

$$X_i = AT_i[g_i E_i^{rt} + (1 - g_i D_i^{rt}]^{1/rt} \quad (2)$$

where $Dt = (S_i + 1)/S_i$ and S_i is the (constant) elasticity of transformation. (is a share parameter and *AT* is a scaling factor, both of which are defined by the baseline data set. The firm's optimal allocation of output between the two markets is determined by the maximization of (2) subject to the relative domestic producer price of the domestic and export variety (*pe/pd*) . The first order condition from this maximization defines the export supply functions for sector *i*

$$\left(\frac{E}{D}\right)_i = \left[\frac{(1-g_i)}{g_i}\left(\frac{pe}{pd}\right)_i\right]^{\Omega_i} \quad (3)$$

which relates the allocation of output between domestic and foreign markets to the relative (tax inclusive) producer price, $(pe/pd)_i$. This relative price can be thought of as the export real exchange rate for sector *i*.

Exactly the same structure operates on the consumption side of the goods market. Here consumers are assumed to distinguish between domestic and imported variants of each good (again this may be for reasons of quality). The composition of demand between domestic and imported goods by households (in final consumption) and firms (for intermediate purchases)

[8] This reflects, amongst other things, differences in quality of the good, packaging or other specification issues.

is therefore defined analogously to the firms' output allocation decision.[9] Consumers' utility is defined in terms of imports (*M*) and the domestic good (*D)* according to a constant elasticity of substitution function

$$Q_i = AC_i[d_i M_i^{-rc} + (1-d_i)D_i^{-rc}]^{-1/rc} \tag{4}$$

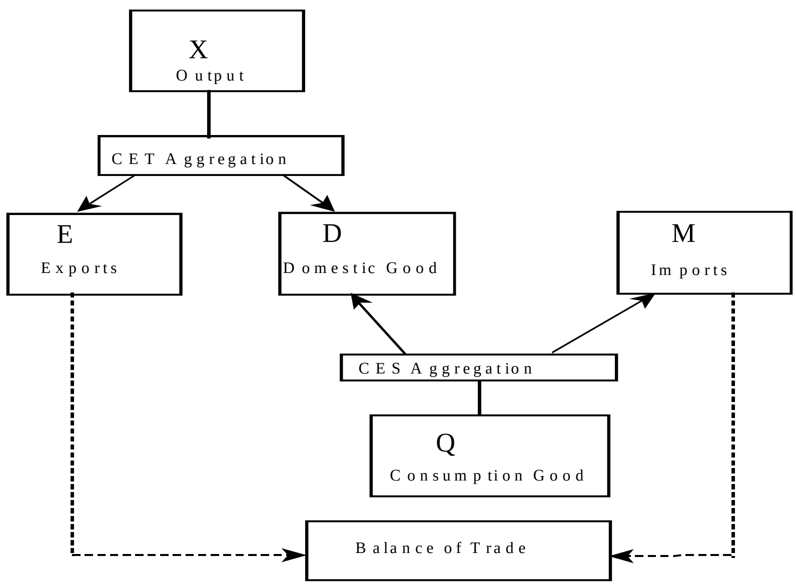
which has the same properties as (2) where $s_i = 1/(1+r_c)$ is the elasticity of substitution in consumption. Given the relative price of the domestic and imported variant of the good (*pm/pd)* this leads to the relative demand function for sector *i*

$$\left(\frac{M}{D}\right)_i = \left[\frac{(1-d_i)}{d_i}\left(\frac{pd}{pm}\right)_i\right]^{s_i}. \tag{5}$$

Again $(pm/pd)_i$ may be thought of as the import real exchange rate for sector *i*.

The following diagram clarifies this goods market structure and its link to the balance of trade.

Production and Consumption Structure (by sector)



[9] We assume, for convenience, that the elasticity of substitution between imports and domestic goods is the same for firms (over intermediate inputs) as it is for households (over final consumption).

Notice, therefore that each sector is characterised by its own import and export real exchange rate. In the experiments being considered here these will always move in step with each other, although this does not hold in general. Changes in the terms of trade or trade policy for example will have a differential effect on import and export real exchange rates.

Price determination

Three features of the model determine the behaviour of prices. The first, and most important, is the barter structure which, as noted earlier, means that the model solves for *relative prices* only and not for the aggregate price level. Second, the barter model requires a numeraire, or reference price (against which relative price movements can be calibrated). Because the properties of the model are entirely neutral to the choice of numeraire, any price can serve this function and typically the choice will be dictated by the question the model is designed to address. For example if one is interested in tax reforms it makes little sense to choose an after-tax price as the numeraire (since the numeraire will change as a result of policy changes). In this model, given that the terms of trade are fixed, a natural candidate is the world price of imports, *pwm.* Since the model is set up with a fixed nominal exchange rate and we do not consider changes in trade policy this means that the domestic price of imports, *pm*, is in effect always equal to the numeraire and takes the value of one throughout all experiments. [10] Finally, since world prices and the nominal exchange rate are fixed, it is movements in domestic prices that determine the market-clearing relative prices.

With this as a background we can derive the relationships between the various prices. We start with tradable goods prices. Letting *er* denote the nominal exchange rate, *tm* and *tx* the *ad valorem* tariff and export duty rates respectively, then domestic prices for imports and exports are defined by the price-taking assumptions as follows.

$$pm_i = p_i^{wm} er(1 + tm_i) \tag{6}$$

for imports and

$$pe_i = p_i^{we} er(1 + tx_i) \tag{7}$$

for exports. As noted above, domestic and traded goods are treated as imperfect substitutes so that consumers and producers make decisions over composite consumption (*Q*) and output

[10] The nominal exchange rate in this model therefore serves exclusively as a conversion factor between world and domestic prices. It plays no other role in the model.

(X). By virtue of the CES/CET aggregation functions the true price aggregates for these two composite are defined as:

$$pc_i = \frac{pd_i XD_i + pm_i M_i}{Q_i} \tag{8}$$

for consumption prices, and

$$px_i = \frac{pd_i XD_i + pe_i E_i}{X_i} \tag{9}$$

for aggregate output. This structure serves to endogenously determine the key domestic price *pd* which is the (implicit) price of domestic output. The remaining prices in the model are, essentially, accounting conventions. Since production involves both intermediate goods and value added we need to partition the total output price into the relevant prices for the two components. Intermediate goods consist of quantities of Q which are priced at the aggregate price *pc* and aggregated according to the input-output matrix. Thus the implicit price of value added is defined as the difference between the gross price of aggregate output and the price of intermediate inputs.

The composite commodity Q can be used for final or intermediate consumption or for capital formation. The decision to invest is made on a *destination* basis: given sectoral rates of return and the availability of savings, a firm in sector i will choose to increase its capital stock by DK_i .The price of a unit of this capital depends on its composition, for example between manufactured goods (machines and equipment) and services (construction services). These input requirements, which can vary across sectors, are priced at pc_i and when aggregated over the economy as a whole determines the volume of investment demand.

<u>Household income and expenditure</u>

We distinguish three different household types. The first is a rural household, the second an ‘urban-unskilled’ household, and the third an ‘urban-skilled’ household. The three household types are distinguished principally by their sources of income (reflecting their factor ownership) and to a lesser extent by their patterns of consumption and saving. The rural household is primarily involved in subsistence agriculture (it owns the land and capital in these sectors) but it also supplies some off-farm unskilled labour to food and cash crop production. This household is assumed to be outside the direct tax net, and to accumulate no savings beyond that required to maintain the capital in its sector.[11]

The 'urban unskilled' household's only factor of production is unskilled labour which it supplies to the manufacturing, services and government sectors. It owns no capital or land. In contrast to the rural household it does pay direct taxes but it too is assumed to have no aggregate savings. Finally the 'urban-skilled' household supplies skilled labour to the manufacturing, services and public services sectors and owns all of the non-agricultural capital in the economy. This sector 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.[12]

Net of direct income taxes and savings, household income is allocated to consumption across the composite goods produced in each sector. The consumption function for each household type is defined in terms of a constant-elasticity of substitution linear expenditure system (CES-LES) which defines the consumption of good *i* by household *h* as

$$cd_{(i,hh)} = g_{(i,hh)} + \left(\frac{(pc_i(1+it_i))^{1-s}\, b^{s}_{(i,hh)}}{\sum_j (pc_j(1+it_j))^{1-s}\, b^{s}_{(j,hh)}} \right) \left(\frac{yd_{hh} - \sum_j pc_j(1+it_j) g_{(j,hh)}}{pc_i(1+it_i)} \right) \quad (10)$$

where the net price of consumption is the price aggregate defined above inclusive of indirect taxes on consumption, *it*, *yd* denotes household disposable income, and *b(i,hh)* denotes household-specific consumption shares. The LES feature of this consumption expenditure system is that each household faces a minimum, or subsistence, level of consumption of good *i*, defined by $g(i,hh)$, which must be met prior to any discretionary allocation of income. The CES aspect means that consumers are not indifferent (in utility terms) between different goods in their consumption bundle but rather face a constant elasticity of substitution (denoted by F) between each good and the rest of the consumption aggregate.

[11] There may be extensive transfers between different rural households which provide a means of saving at the individual household level but in aggregate these households' net saving is zero.

[12] To reflect the reality of the Ugandan economy, all three household groups are assumed to be in receipt of remittances or other payments from overseas. Since the composition of these remittances is unknown they are treated as constant throughout the experiments.

This structure of consumption underpins households' utility which is defined as the product of private consumption and the level of public good provision in the economy, X_{pub} (which is assumed to be valued equally by all household types). Letting *cd(i,hh)* be private consumption as defined in (10), aggregate social welfare is simply the weighted sum of the welfare of the three households

$$U = \sum_{hh} hw_{hh} \left[\sum_{i} b\,(i,hh)(cd\,(i,hh) - g\,(i,hh))^{1-1/s} \right]^{\frac{1}{1-1/s}} X_{pub}^{\,bg} \tag{11}$$

where *hw* represents household weights based on the relative size of each household type.

<u>Government</u>

Government policy decisions impact on the private sector through a number of channels, only some of which we consider in this paper. We do not examine the consequences of changes to the structure of taxation, or to changes in direct transfers and interest costs. These are kept constant throughout all experiments. Instead we focus entirely on changes to public expenditure and in particular the balance between investment in infrastructure and the provision of government services. All public expenditure will have direct aggregate demand effects, but as we noted above infrastructure provision also directly affects the supply side of the economy by augmenting private sector production, possibly differentially across sectors. Government sector-specific investment (in government offices, schools, hospitals etc) obviously influences only the cost of producing public services (by altering the marginal product of labour), while direct current expenditure on public services has only pure demand side effects. Although public services are not purchased through the market and hence do not enter private expenditure decisions (equation (10)), they do have direct consumption value to households. To reflect this we have allowed the level of real government current consumption, for example on health and education, to enter the household utility function directly (see equation (11)).

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 current 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.[13]

Current government savings, the excess of revenue over government expenditure including transfers and external debt service, are applied to government capital formation which is allocated between sector-specific investment (i.e. in government building etc) and public infrastructure. The shortfall/excess of government savings relative to the cost of government capital formation is financed from foreign savings or by directly crowding out private investment.

Savings and investment

In the language of CGE models we adopt a neoclassical closure which constrains total investment to equal the level of domestic savings. This closure rule is consistent with conditions in Uganda where there is no access to world capital markets and domestic savings (in aggregate) are relatively interest inelastic. Hence total household and government savings are augmented by an exogenously determined level of aid (foreign savings), and together these three determine the total resources available for gross investment. Once exogenous public sector investment requirements have been met, the sectoral allocation of the residual investment is defined by a return sensitive function where firms' demand for (their own sector-specific) capital is a function of the differential between the sectoral real rate of return and the economy wide average

$$DK_i = \frac{k_i(1+q_i)(r_i - \bar{r})[S - pk_{pub}(DK_{pub} + DKG)]}{pk_i} \tag{12}$$

where 6 is the investment share parameter and 2 measures the sectoral responsiveness of investment to rate of return differentials, and *S* denotes total economy-wide saving. Investment by sector of demand is translated into a demand for investment goods (typically machinery and construction services) governed by the capital composition matrix.

Macroeconomic balances and dynamics

[13] It would be possible in principle to add a labour augmenting productivity effect to the model to reflect longer-term returns to health and education but we would again be faced with a problem of calibrating the size and duration of these potential effects. It is worth noting that the Integrated Macroeconomic Model for Poverty Analysis (IMMPA), currently being developed at the World Bank Institute by Pierre-Richard Agenor and colleagues, allows, at least in its design, for both migration effects and productivity gains from public expenditure on human capital. The former is assumed to be a medium term phenomenon and the latter productivity effects are assumed to emerge only after 5 to 10 years. The IMMPA has yet to be simulated on country data so it is impossible to assess the empirical importance of these mechanisms for policy analysis.

Macroeconomic balance is determined by three conditions. The first is that the goods market clears

$$Q_i = \sum_{hh} CD_{i,hh} + ND_i + GD_i + ID_i \tag{13}$$

where Q denotes total supply, CD , ND, GD and ID denote real final consumption, intermediate consumption, government expenditure, and investment demand respectively. The second condition is that the external balance constraint is satisfied

$$\Delta NFA = \sum_i p_i^{we} E_i + aid + \sum_{hh} rmit_{hh} - \sum_i p_i^{wm} M_i - i_f \tag{14}$$

where NFA denotes net foreign assets, $rmit$ remittances to households and i_f interest on foreign debt. The third constraint is that the labour market clears

$$\sum_i L_{i,lc} = \bar{L}_{lc}. \tag{15}$$

The dynamic behaviour of the economy is governed by the evolution of the public and private capital stocks. At the beginning of each period each sector's stock of physical capital, K, including publicly-provided infrastructure is updated according to the dynamic equation

$$K_{i,t} = K_{i,t-1}(1 - f_i) + \Delta K_{i,t-1} \tag{16}$$

where $K_{i,t-1}$ denotes the initial capital in the previous period, N_i denotes the rate of depreciation, and $\Delta K_{i,t-1}$ the sector-specific investment in the previous period.

Data and parameter calibration

The data used to calibrate the CGE model are taken from the social accounting matrix reported in Appendix IV. The main features of the SAM are also summarised in Table 1. As is well known, 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.[14] Despite its synthetic character we feel this SAM is a reasonable representation of the principal structural features of the Ugandan economy.

[14] The data sources we have used to construct the SAM are: (i) the latest expenditure-based GDP estimates from Uganda Bureau of Statistics; (i) the 1997 Labour Force Survey; and (iii) the Bank of Uganda Quarterly Report (September 2001). These data are used to define the 'control totals' for the SAM, namely the external balance, the fiscal balance, and total value added by sector. The disposition of income across household types and household-specific consumption and saving was based on research by S.Appleton in P.Collier and R.Reinikka (eds) *Uganda's Recovery: the Role of Farms, Firms and Government* (World Bank, 2001). The remainder of the data in the SAM were determined residually subject to the calibration choices described in the text.

The productive side of the economy is represented by five sectors, subsistence agriculture (denoted FOOD), cash crops (CCROP), manufacturing (MAN), private sector services (SERV) and public services (PUB). Each sector is defined to reflect key economic characteristics rather than to faithfully reproduce reality. Thus, for example, it makes sense to treat a sector that has trivially small amounts of international trade as if there were no international trade at all. In this spirit, our cash-crop sector is taken as a pure export sector.[15] Similarly, the private services sector, the largest in the economy, is characterized as being completely non-tradable.[16] Seventy percent of the output of this sector is consumed as intermediate inputs or inputs into capital formation and only 30 percent represents final consumption. 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 1.0 and 5.0 settling eventually on a value of 2.0.

Aggregate investment demand is more or less equally intensive in services and manufactured goods, although government infrastructure investment is rather more service-intensive than is private sector investment.

As discussed above, the model assumes that 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 "g. There are no reliable empirical estimates,

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[15] The reconciliation of divergent data sources for this sector revealed a number of inconsistencies in official data, the biggest being in the cash crop sector. Recorded GDP for coffee and tea sectors for 2000/01 was substantially in excess of the total value of exports. Since cash crops are typically not used either as intermediate inputs or capital inputs into the production of cash crops, or of other goods and services, this suggests mis-recorded activity. Either GDP is over-stated, exports understated (or mis-measured given the large movements in world prices); there are un-recorded domestic inventories of coffee awaiting export, or some combination of all three. Lacking information to provide an authoritative reconciliation of this data inconsistency we choose to *increase* recorded coffee exports accordingly. In order to leave the external balance unchanged we have also increased the volume of recorded agricultural imports by the same amount. As a consequence, the SAM characterizes a more open economy than official data sources indicate (see Table 1). While it is indeed desirable to arrive at a full reconciliation of this problem, the structure of the simulation model means that correction will not alter the results in any appreciable way.

[16] This is perhaps a more serious simplification. Balance of payments data indicate that there is substantial trade in services. We have taken the view that since much of this trade is in effect bundled with manufactured goods (transport and insurance costs for example) it makes sense for modelling purposes to re-allocate this international trade from services to manufacturing in the SAM.

either for Uganda or elsewhere, with which to calibrate this parameter. We therefore choose a value of "g=0.5 which has the property that public capital was more or less as equally productive as private capital in producing agricultural output but less productive than private capital in producing manufactured goods and services (see the following table). In view of the uncertainty around this parameter the sensitivity analysis in Appendix II reports simulations for "g=0.2.[17]

Marginal Product of Public and Private Capital

Sector	Food	Cash Crops	Manufacturing	Services	Public
Marginal Product					
Private Capital	11.6%	11.8%	10.1%	14.3%	
Public Capital ("g=0.5)	12.9%	12.0%	4.0%	11.9%	1.8%

Note:

Marginal product of private capital defined as MX_i /MKP_i = "$_{ki}(X_i/KP_i)$ and MX_i /MKG = "$_g(X_i/KG)$.

Private final consumption is dominated by food (58 percent) with the balance equally spread across manufactured goods (including petroleum) and services. This balance is maintained 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.

[17] It is important to note also that since we do not have independent data on public or private capital stocks, we are unable to determine how far the economy is from its optimal capital stock levels. We have calibrated the model on a 'capital shortage' assumption, which means that the baseline public capital stock is too small in the sense that at the margin social welfare will increase in response to a dollar increase in domestic tax-financed public formation. From this starting point (which seems a sensible one) moderate changes in the scale of the aid-financed infrastructure capital will be productive *and* welfare enhancing. By contrast, if the baseline configuration assumed that the public capital stock was at or close to its optimal, so that its marginal physical product is close to zero, increases in aid-financed infrastructure investment would take the economy to the point where the real-exchange rate distortions on the domestic economy outweigh the output gains from additional units of infrastructure capital.

A central objective in calibrating the SAM is to ensure that the fiscal and overall external balance constraints are consistent with current conditions in Uganda. This obliged us to make a number of strategic choices, each of which may be debated and refined. First, the general pattern of taxation was taken directly from the fiscal accounts but a number of assumptions were made in terms of its incidence: the rural household was assumed to pay no direct taxes on income; manufactured goods were assumed to attract a higher average tariff (14 percent of the world price) than food imports (2 percent); and the effective average net VAT rate on manufactured goods was higher than on services.

Most importantly, however, we have allocated the government development programme across three broad categories of expenditure. Approximately 40 percent was assumed to be recurrent expenditure; a further 50 percent was categorized as infrastructure investment and the balance as sector-specific public-sector capital formation. This allocation has the consequence that while the overall fiscal position is broadly consistent with the MTEF for 2000/01, the disposition between recurrent and capital expenditure is not.

It is worth entering an important caveat at this point. The reconciliation requirements imposed on the SAM requires the modeller to make a range of assumptions which may appear to do injustice to official data sources: this is inevitable and can only be resolved with the construction of an official social accounting matrix. We feel that the strategy adopted in constructing the SAM for this model has resulted in a reasonable approximation of the current configuration of the Ugandan economy. As such we take the view that the qualitative (and quantitative) character of our simulation are likely to be broadly invariant to refinements of the SAM. Nonetheless this is a testable assumption and it will be worthwhile reviewing the SAM, and hence the model's properties, as and when more up-to-date data become available.

4. Experiment design and simulation results

As noted above, we focus our attention mainly on one basic experiment and consider the consequences of varying a number of key assumptions about the functioning of the economy. In all cases we are interested in 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 at baseline domestic prices.[18]This increased aid can be used in two alternative ways:

[18] Appendix II reports results of a sensitivity analysis in which we examine the consequences of an increase of 6.25% (1 percent of GDP) and an increase of 15% (2.4 percent of GDP). We note there that

In the basic experiment the incremental aid flow is used to finance an increase in infrastructure investment. In this experiment we make a range of assumptions about how the investment affects the private productive sectors of the economy, and in particular what the consequences are for productive capacity in these sectors. Simulation 1 provides a benchmark, with the infrastructure investment being of no value whatever: the economy's total capital stock is increased but does not sustain higher output. Simulation 2 examines the case where the investment has substantial productivity effects which are uniform across sectors and unbiased with respect to productivity of the domestic and export varieties of each good. The remaining variants of the basic experiment (simulations 3 – 8) examine a number of cases where the productivity impact is sector-specific, or biased between the production varieties, or both. With one exception, these simulations assume that the subsistence component in consumption is negligible. The exception is simulation 5 where a very high subsistence component is assumed for food (equal to 90 percent of the initial consumption level). This has the effect of lowering the income elasticity of demand for food sharply below one.

In simulation 9 we examine the effect of the same aid flow being used exclusively to finance an increase in the volume of public services. This is achieved by increasing sector specific capital and recurrent expenditure (ultimately) in equal proportions. Initially the enhanced aid flow is used to raise capital to its new (stationary) level, and then the flow is used to hire the associated additional labour and intermediate inputs to produce additional government current consumption.

It is assumed that the government does not alter its tax structure and takes into account price changes in determining the volume of expenditure which can be financed with the additional aid. Hence the government is portrayed as setting out to behave in a way which is (domestic) budget neutral. Changes in the level of household income, demand, and relative price effects arising from these experiments and acting on existing government activities will, however, have an impact on the fiscal balance.

For each experiment we track the evolution of the economy over a period of ten years from the implementation of the experiment. In each case we report the impact effect (year 1) and the cumulative evolution of the economy after 5 and 10 years. By construction, CGE models generate an enormous volume of results (since each simulation generates a period-by-period

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since the model's key behavioural relationships are homothetic the response of the model economy to representation of the entire economy over the 10 years of the simulation). In order to simplify our presentation we focus only on changes in: (i) the export-weighted real exchange rate[19]; (ii) the volume of exports and imports and the domestic good supply; (iii) real GDP; (iv) private investment; (iv) the fiscal accounts; and (v) 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. As we discuss below, when the level of government current expenditure is altered this measure understates true welfare. These summary results are presented in Table 2, and the experiments are ranked according to various criteria in Tables 3 and 4.[20]

Experiment 1 provides a benchmark for what follows. Here the infrastructure investment confers no benefits on private productivity. As would be expected, the aid flow has little impact on GDP, but it does lead to a depreciation 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 balance, so that total imports rise despite the decline in private export earnings.

The evolution over the medium-term points to a progressive deterioration in overall economic performance as a result of a decline in real private sector investment. In part this reflects a decline in total savings as a result of the deterioration of the fiscal balance, 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 decline in private capital formation means that although the real exchange rate depreciation moderates over time the deterioration of the capital stock means that the decline in export performance does not reverse and hence the initial welfare gains weaken (and indeed worsen in the case of the rural household).

moderate changes in the aid inflow, relative to our base case, is broadly linear.

[19] The CGE model solves for relative prices (real exchange rates) for imports and exports for each sector. In the current model there are three export real exchange rates (for food, cash-crops and manufactured goods) and two import real exchange rates (food and manufactured goods). In the presence of a constant external terms-of-trade and no changes to domestic trade policy the import and export real exchange rates for each sector will move in line with each other. Hence we need to track only one or the other, and for simplicity we report a weighted index of the sector-specific export real exchange rates.

[20] The complete results for each simulation run are obtainable on request from the corresponding author.

[21] The real exchange rate appreciation reduces the domestic value of net aid support to the budget which therefore increases the domestic financing requirement.

Finally it is worth noting that in this simulation while total real income increases, rural households actually suffer a decline in real income. This is an important and, as shall be seen, a persistent result across the simulations which needs some explanation. The principal reason for this outcome is that the demand effects from increased government expenditure (either capital or current) 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 shall be seen, below, these demand effects are exacerbated in circumstances when relative price effects turn sharply against the rural sector.

By contrast, in Experiment 2 government infrastructure investment raises private-sector productivity uniformly across sectors although the productivity gain remains neutral with respect to the domestic/exportable bias of the supply response.[22] 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.[23] 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. Over the medium-term most of the real exchange rate appreciation has been reversed, but more importantly, even though the real exchange rate remains appreciated relative to its baseline value, the initial 6 percent fall in exports is reversed, moving to a 4 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, 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 household has been reversed. Rural households enjoy an increase in real income over time in this experiment, even though this gain is appreciably lower than that enjoyed by urban households.

Experiments 3 and 4 consider the likely outcome if the productivity gains witnessed in Experiment 2 are biased towards the production of tradable (exportable) or non-tradable

[22] The infrastructure productivity parameter in equation (1) is set to "g=0.5 for all sectors in the economy.

[23] Revenues grow as real incomes and expenditures grow, while, after the initial step change, real government spending does not. Savings available for private investment grow partly as GDP grows 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 portrayed as duly being invested. In practice, whether that occurs will depend on investor confidence, etc.

(domestic goods).[24] 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. For purposes of illustration, the capacity to produce the domestic version in these sectors is assumed unchanged, so that the entire payoff to infrastructure investment is concentrated on the export good. (See Appendix I for a detailed discussion.) As should be expected, since the overall productivity gain delivers no gain in the productivity of non-tradable production, this powerfully exacerbates the RER appreciation. The adverse export supply response is equally marked for the cash-crop sector with the long-run export growth in this sector only 1.6 percent above baseline compared with 4.1 percent in the previous experiment. By contrast, although manufacturing exports suffer in the short- to medium-term from the more appreciated real exchange rate, the export-biased productivity gains are powerful enough to offset this effect so that in the long-run export supply performance is better than in Experiment 2.

When the productivity is biased entirely towards the production of the domestic good, as shown in Experiment 4, outcomes are markedly different. The domestic good bias in production (which increases the supply of non-tradable goods) is sufficiently strong to almost entirely offset the demand effects of the increase aid flows so that the real exchange rate movement is more or less neutral and much less pronounced that in Experiment 2. 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 result is a greater initial decline and more sluggish recovery in manufacturing exports.

The domestic-biased supply response leads to a larger improvement in the long-run domestic fiscal balance (0.6 percentage points of GDP) reflecting favourable relative price movements and higher growth, higher long-run private investment and higher real GDP growth than 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 2.1 percent over its baseline compared to 4.5 percent when the supply response is neutral between exports and

[24] Since the cash-crop sector is exclusively an export sector and the public and private services sectors wholly non-tradable this switch in the bias of productivity gains is only meaningful in the context of the food crop and manufacturing sectors.

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 7 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 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 Experiment 2 and 4 these adverse distributional effects are weak enough not to 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. The effect of this minor adjustment to assumed consumer behaviour is dramatic. The real exchange rate now initially depreciates sharply and remains more depreciated than the baseline throughout the simulation run. 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 8.6 percent over the baseline in the long-run.

However, the distributional impact in this experiment is adverse, with very large income gains to urban households and large falls to rural ones. The reason for this is simple; in this experiment the adverse shift in the internal terms of trade against rural households noted under Experiment 4 is magnified by the low income elasticity of demand in consumption from all households. Rural households suffer twice over in this case, first from the fall in prices of food as noted above and second from the weakness of the demand for food as a result of the low income elasticity, which drives food prices even lower.

The final three experiments concerned with increased infrastructure expenditure are reported as Experiments 6 to 8. These revert to no subsistence requirements and to unbiased productivity gains but instead assume that the effects of government infrastructure expenditure are sector-specific. Experiment 6 assumes that the only sectors benefiting from the investment are the agricultural ones, experiment 7 that it is only manufacturing, and experiment 8 that it is only services.[25] As expected, the real GDP and total income gains are now much smaller than in experiment 2 (the direct comparator) since in each experiment the effect of infrastructure is, in some sense, 'wasted' on the non-favoured sectors. Nonetheless, taken together these experiments illustrate how the observed patterns of income distribution noted in earlier experiments emerge. For the economy as a whole the real GDP gains are largest when productivity growth is concentrated in non-tradable intensive sectors (services and agriculture) but investment gains (which will underpin growth beyond the horizon considered here) are greater when the productivity gains are focussed on manufacturing and the services sectors. Finally, for the reasons described above, the greater the expansion of supply in the services and manufacturing sectors as opposed to the agricultural sector, the more the distribution of real income favours the rural household.

In the final Experiment 9, we move away from considering the effects of increased infrastructure investment to examine the case where the aid inflow is used exclusively to increase production of the public service. Since by construction there are no spillovers onto private sector productivity in this experiment the simulation is remarkably similar to experiment 1 (wasteful investment), at least initially. Over the longer-run, this experiment leads to a marginally larger domestic fiscal deficit, lower private investment and lower long-run real GDP growth.[26]

The movement of real incomes also closely matches the outcome for Experiment 1. As with infrastructure, the production of public services is relatively intensive in urban skilled labour and so benefits urban workers relative to rural ones. There is one important caveat in this case, though. As we noted in our discussion of household welfare above, households directly derive utility from the consumption of government services. By reporting only the real

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[25] We assume that any agricultural infrastructure benefits food and cash crop production equally. The parameter "g is set to zero in equation (1) for all sectors except food and cash crops in Experiment 6, except manufacturing in Experiment 7, and except services in Experiment 8.

[26] We assume that the government designs its expansion of expenditure to be budget-neutral *ex ante* and hence factors in the impact of its additional expenditure on its price. However we assume that the existing volume of expenditure represents 'real' commitments. The effect of relative price movements on this inframarginal component of government expenditure is therefore not anticipated in the experiment. It is these relative price movements which alter fiscal outcomes.

consumption income component of household welfare Table 2 understates any implicit valuation of the increased volume of public services produced under this experiment. Given the parameterization of the model, the valuation of this increase is unlikely to exceed 1-1.5 percent of income for each household type. Factoring in this valuation would reinforce the welfare gains of urban households; it would be insufficient to fully compensate for the decline in rural incomes.[27]

Summary

The mass of detail in Table 2, even though it represents an extremely concise summary of the full output from the model, is difficult to digest. Table 3 attempts to 'summarise the summary', by ranking the experiments, at 1 year and at 10 years, in terms of their impact on various magnitudes of concern. These are the real exchange rate (from maximum appreciation down to maximum depreciation), export volume, real income of rural households, real income overall, real GDP, private investment and the fiscal balance.

There are five broad qualitative conclusions from this exercise. First, there is a broad similarity between the rankings for both impact and long run effects, with the notable exception of the export-biased experiment (experiment 3). The impact effect of an increase in aid in the presence of an export-biased supply response has an adverse impact effect on the economy, but improves markedly over time. The second main conclusion is that 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. Third, 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. Fourth, the combination of a domestic bias in production and a high subsistence requirement in food (experiment 5) delivers a large supply response which dominates the other cases, were it not for its highly adverse distributional effects. Fifth, there are potentially substantial payoffs via an improved fiscal balance and increased private investment in all the experiments involving uniform effects across sectors, regardless of the presence or absence of bias (experiments 2-5).

Before concluding, it is useful to briefly consider the size of these qualitative effects. Table 4 reports the short- and long-run general equilibrium elasticities of the real exchange rate, total

[27] It is assumed that each household type values government expenditure equally. Only if this valuation differed greatly between household types, in particular it was much more highly valued by rural households, would these results change.

exports and real GDP with respect to net aid, ordered according to the format of Table 3. The top panel of the table illustrates clearly how conventional ‘demand-side’ effects dominate the short-run response of the economy to ain aid inflow. With the exception of experiment 5 an increase in net aid, regardless of its use, will lead to an appreciation of the export real exchange rate with an elasticity of between 0.1 and 0.5, and a decline in total exports with an elasticity of around 0.5. In the short-run, of course, this decline in exports reflects a pure reallocation effect; there is no substantial growth in total real GDP.

Over the long-run, however, the real exchange rate and export supply elasticities moderate sharply (with the latter turning positive for experiments 2, 3, 4 and 5) while the output elasticity rises to almost 0.3 for the same experiments. Only in the case where the aid is devoted exclusively to higher current government expenditure, or if infrastructure investment fails to deliver any productivity gains at all, does real GDP remain stagnant.

5. Conclusion and extensions

The basic conclusion of this discussion is that beyond the short-run, in which demand-side effects dominate, the relation between enhanced aid flows, real exchange rates, export volumes and welfare is a complex one. It is certainly not inevitable that increased aid will result in ‘Dutch Disease’ effects, particularly in the medium- to long-run. The key to the evolution of the aggregate economy is the supply-side response to the aid-funded public expenditure; we have indicated that productivity enhancements that are skewed towards the production of domestic goods deliver the largest aggregate return to aid.

Such productivity biases however also exacerbate a key underlying distributional tension. Public expenditure is intensive in formal sector (urban) employment and draws disproportionately on the manufactured goods and services sectors for its intermediate inputs. Rural households capture little of the direct benefit from these demand factors. On the other hand, if supply side effects are powerful enough that domestic food prices fall relative to manufacturing and service prices, and if these are reinforced by a low income elasticity for demand for food, rural household incomes suffer, possibly absolutely as well as relative to urban households. These adverse distributional effects have the potential to undermine the aggregate gains from productivity-enhancing public expenditure. This result, as with the others in this paper, emerges from a simulation model and is therefore only illustrative. Nonetheless it is of sufficient strength to suggest that close attention needs to be paid to the evolving distributional consequences of the public expenditure programme.

The experiments reported here are only illustrative of a range of possibilities that could be examined. Nonetheless, they do suggest that if it were feasible to choose infrastructure investment in a way that particularly enhanced production of one or other type of output, it would be preferable to do so in respect of domestic goods, not exports. However, identifying the real relationships between government expenditures and private production will be difficult; and even given the requisite knowledge, it may not be feasible to exercise choices of this sort.

Table 1: Representative Uganda SAM Fiscal Year 2000/01

Macro-Aggregates

	Ush bn	%GDP	%GNY
GDP	8036	100.0%	85%
GNY	9409	117%	100.0%
Exports		17.4%	14.9%
Imports		47.0%	40.1%
Trade		64.4%	55.0%
Private Consumption		108.0%	92.2%
Private Investment		8.1%	6.9%
Depreciation		8.1%	6.9%
Private Saving		5.7%	4.9%
Current Account (before aid)		-14.1%	-12.1%
Aid		15.8%	13.5%
Reserve Accumulation		1.6%	1.4%
Government Revenue		13.6%	11.6%
Government Current Expenditure		18.4%	15.7%
Current Budget Balance		-4.8%	-4.1%
Government Investment		7.0%	6.0%
Overall Deficit (before Aid)		-11.7%	-10.0%

Sectoral Data

Sectors	**X**	**XD**	**E**	**M**	**Net Exports**	**ND**	**ID**	**CD**
Food Crops	5107	4984	123	644	-521	780	30	4818
Cash Crops	640	30	610	0	610	20	10	0
Manufacturing	3647	2982	665	3593	-2928	4184	549	1842
Services	5612	5612	0	0	0	3331	621	1660
Public Services	1345	1345	0	0	0	0	0	0
Total	16351	14953	1398	4237	-2839	8315	1210	8320
As share of Total								
Food Crops	31.2%	33.3%	8.8%	15.2%	18.4%	9.4%	2.5%	57.9%
Cash Crops	3.9%	0.2%	43.6%	0.0%	-21.5%	0.2%	0.8%	0.0%
Manufacturing	22.3%	19.9%	47.6%	84.8%	103.1%	50.3%	45.4%	22.1%
Services	34.3%	37.5%	0.0%	0.0%	0.0%	40.1%	51.3%	20.0%
Public Services	8.2%	9.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
As share of X by sector								
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
XD	Domestic Sales to Domestic Economy (X-E)
E	Exports
M	Imports
CD	Private consumption demand
ND	Intermediate demand
ID	Investment demand

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

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

Experiment		1	2	3	4	5	6	7	8	9
Infrastructure productivty effect [3]		None	All	All	All	All	Agric	Man	Serv	None
Supply response [4]		Neutral	Neutral	E-bias	D-bias	D-bias	Neutral	Neutral	Neutral	Neutral
Subsistence Consumption [5]						Food (90%)				
PRICES AND QUANTITIES	**Time Period**									
Export Weighted RER [6]	**to t=1**	-2.6%	-2.6%	-5.8%	-0.9%	5.0%	-2.6%	-2.6%	-2.6%	-2.0%
	to t=5	-2.0%	-1.6%	-2.6%	-0.5%	0.2%	-1.9%	-1.8%	-1.9%	-1.8%
	to t = 10	-2.1%	-0.7%	-1.8%	0.4%	1.4%	-1.6%	-1.4%	-1.6%	-1.5%
Total Exports	**to t=1**	-6.2%	-6.2%	-6.7%	-5.7%	-2.8%	-6.2%	-6.2%	-6.2%	-6.7%
	to t=5	-6.4%	-2.6%	-3.3%	-1.9%	2.2%	-4.9%	-5.7%	-5.2%	-7.4%
	to t = 10	-6.7%	4.2%	3.2%	5.3%	11.7%	-2.9%	-4.8%	-2.9%	-7.9%
Manufacturing Exports	**to t=1**	-6.0%	-6.0%	-5.1%	-6.8%	-7.4%	-6.0%	-6.0%	-6.0%	-6.8%
	to t=5	-6.2%	-0.3%	-2.0%	-3.3%	-4.2%	-7.5%	-3.9%	-4.4%	-8.1%
	to t = 10	-6.9%	4.2%	4.7%	3.9%	2.3%	-10.1%	-0.5%	-1.1%	-9.0%
Cash crop Exports	**to t=1**	-6.9%	-6.9%	-8.5%	-5.2%	-1.0%	-6.9%	-6.9%	-6.9%	-6.9%
	to t=5	-7.0%	-3.1%	-4.9%	-1.1%	4.9%	-3.4%	-7.9%	-6.1%	-7.2%
	to t = 10	-7.2%	4.1%	1.6%	6.4%	16.1%	2.1%	-9.3%	-4.4%	-7.7%
Total Imports	**t=1**	1.9%	1.9%	1.7%	2.1%	3.3%	1.9%	1.9%	1.9%	1.7%
	t=5	1.8%	3.2%	3.0%	3.5%	5.2%	2.4%	2.1%	2.3%	1.5%
	to t = ss	1.7%	5.8%	5.4%	6.2%	8.8%	3.1%	2.4%	3.1%	1.3%
Total Domestic Goods Supply	**to t=1**	0.6%	0.6%	-0.6%	1.9%	2.0%	0.6%	0.6%	0.6%	0.7%
	to t=5	0.5%	2.2%	0.9%	3.6%	3.7%	1.1%	0.8%	1.1%	0.7%
	to t = 10	0.4%	5.1%	3.7%	6.7%	7.0%	1.9%	1.3%	2.2%	0.5%
Real GDP	**to t=1**	0.1%	0.1%	0.0%	0.1%	0.3%	0.1%	0.1%	0.1%	0.0%
	to t=5	0.0%	0.6%	0.6%	0.6%	0.6%	0.2%	0.1%	0.2%	0.0%
	to t = 10	-0.1%	3.3%	3.1%	3.4%	3.6%	1.2%	0.3%	1.1%	-0.3%
Private Investment	**to t=1**	-3.2%	-3.2%	-5.2%	-1.1%	0.8%	-3.2%	-3.2%	-3.2%	-4.2%
	to t=5	-2.6%	2.3%	0.2%	4.6%	7.4%	-3.1%	-1.7%	0.2%	-4.9%
	to t = 10	-2.9%	11.2%	8.8%	13.8%	18.3%	-4.2%	-0.5%	4.9%	-5.5%
FISCAL ACCOUNTS [7]										
Total Revenue	**to t=1**	0.0%	0.0%	-0.1%	0.1%	0.8%	0.0%	0.0%	0.0%	0.0%
	to t=5	0.0%	0.0%	-0.1%	0.1%	1.1%	0.1%	0.0%	0.0%	0.0%
	to t = 10	0.0%	0.0%	-0.1%	0.2%	1.6%	0.2%	-0.1%	-0.1%	0.0%
Total Current Expenditure	**to t=1**	0.0%	-0.1%	-0.1%	0.0%	0.7%	-0.1%	-0.1%	-0.1%	0.9%
	to t=5	0.0%	-0.3%	-0.4%	-0.2%	0.7%	0.1%	-0.1%	-0.2%	2.0%
	to t = 10	0.0%	-0.8%	-0.8%	-0.7%	0.6%	0.2%	-0.3%	-0.4%	2.1%
Domestic Budget Balance	**to t=1**	-0.4%	-0.4%	-0.5%	-0.3%	-0.1%	-0.4%	-0.4%	-0.4%	-0.5%
	to t=5	-0.4%	-0.1%	-0.2%	0.1%	0.3%	-0.4%	-0.3%	-0.2%	-0.6%
	to t = 10	-0.4%	0.4%	0.3%	0.6%	1.0%	-0.5%	-0.3%	0.1%	-0.6%
REAL DISPOSABLE INCOME										
Rural	**to t=1**	-1.4%	-1.4%	-2.3%	-0.6%	-6.5%	-1.4%	-1.4%	-1.4%	-1.6%
	to t=5	-1.5%	0.2%	-0.9%	1.2%	-7.3%	-1.8%	-1.1%	-0.1%	-1.9%
	to t = 10	-1.8%	3.6%	2.2%	4.9%	-7.7%	-2.6%	-0.5%	2.3%	-2.4%
Urban - Unskilled	**to t=1**	2.1%	2.1%	-1.1%	5.5%	10.7%	2.1%	2.1%	2.1%	2.1%
	to t=5	2.1%	3.3%	0.1%	6.7%	14.4%	3.9%	2.3%	1.3%	2.0%
	to t = 10	2.0%	5.1%	1.9%	8.6%	20.6%	6.8%	2.5%	-0.1%	1.9%
Urban -Skilled	**to t=1**	1.8%	1.8%	-1.3%	5.1%	10.9%	1.8%	1.8%	1.8%	2.1%
	to t=5	1.8%	3.1%	0.0%	6.4%	14.8%	3.7%	1.7%	1.5%	2.3%
	to t = 10	1.9%	5.2%	2.0%	8.5%	21.5%	6.6%	1.5%	1.0%	2.4%
Total	**to t=1**	0.5%	0.5%	-1.7%	2.7%	3.3%	0.5%	0.5%	0.5%	0.5%
	to t=5	0.4%	1.9%	-0.4%	4.2%	5.1%	1.3%	0.6%	0.8%	0.4%
	to t = 10	0.3%	4.5%	2.1%	7.0%	8.6%	2.6%	0.8%	1.4%	0.2%

NOTES

[1] All experiments consider a permanent increase in net aid inflows of 12.5%, equivalent to 1.97% of initial GDP. In Experiments 1 through 8 this increase is applied to infrastructure investment, raising infrastructure capital by 1.3% in the first year. By year 10 the infrastructure stock is 9.5% higher than in the baseline. In experiment 9 the aid is use to increase government current expenditure and sector-specific capital. This entails an initial increase in the sector specific capital stock by 5.6% (effective in t=2). Thereafter total expenditure is allocated between current and capital expenditure so as to maintain the capital-output ratio constant. This is consistent with a long-run increase in government expenditure of 11.4%

[2] The values reported indicate changes relative to the baseline for all variables except the fiscal measures which are measured as percentage points of GDP

[3] Denotes the sectors benefitting from government infrastructure expenditure (see Equation (1) in the text).

[4] Denotes whether the supply response in tradable sectors (food and manufacturing) is biased towards domestic or export production.

[5] Indicates the presence of a sector-specific subsistence level of consumption (as %age of baseline consumption) .

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

[7] See note [2].

TABLE 3. SUMMARY RANKING OF SIMULATION OUTCOMES BY KEY INDICATORS

(a) Impact Effect (t=1)

Ref	ERER	Ref	Exp	Ref	RGDP	Ref	PINV	Ref	YD-Rural	Ref	YD-Tot	Ref	BDEF
3 E	-5.8%	3 E	-6.7%	3 E	-0.02%	3 E	-5.2%	5 DS	-6.5%	3 E	-1.7%	3 E	-0.54%
1	-2.6%	9	-6.7%	9	0.00%	9	-4.2%	3 E	-2.3%	1	0.5%	9	-0.49%
2	-2.6%	1	-6.2%	1	0.06%	1	-3.2%	9	-1.6%	2	0.5%	1	-0.41%
6	-2.6%	2	-6.2%	2	0.06%	2	-3.2%	1	-1.4%	6	0.5%	2	-0.41%
7	-2.6%	6	-6.2%	6	0.06%	6	-3.2%	2	-1.4%	7	0.5%	6	-0.41%
8	-2.6%	7	-6.2%	7	0.06%	7	-3.2%	6	-1.4%	8	0.5%	7	-0.41%
9	-2.0%	8	-6.2%	8	0.06%	8	-3.2%	7	-1.4%	9	0.5%	8	-0.41%
4 D	-0.9%	4 D	-5.7%	4 D	0.14%	4 D	-1.1%	8	-1.4%	4 D	2.7%	4 D	-0.28%
5 DS	5.0%	5 DS	-2.8%	5 DS	0.30%	5 DS	0.8%	4 D	-0.6%	5 DS	3.3%	5 DS	-0.11%

[b] Long Run Effect (t=10)

Ref	ERER	Ref	Exp	Ref	RGDP	Ref	PINV	Ref	YD-Rural	Ref	YD-Tot	Ref	BDEF
1	-2.1%	9	-7.9%	9	-0.25%	9	-5.5%	5 DS	-7.7%	9	0.2%	9	-0.58%
3 E	-1.8%	1	-6.7%	1	-0.13%	6	-4.2%	6	-2.6%	1	0.3%	6	-0.54%
6	-1.6%	7	-4.8%	7	0.34%	1	-2.9%	9	-2.4%	7	0.8%	1	-0.37%
8	-1.6%	6	-2.9%	8	1.10%	7	-0.5%	1	-1.8%	8	1.4%	7	-0.25%
9	-1.5%	8	-2.9%	6	1.18%	8	4.9%	7	-0.5%	3 E	2.1%	8	0.10%
7	-1.4%	3 E	3.2%	3 E	3.12%	3 E	8.8%	3 E	2.2%	6	2.6%	3 E	0.28%
2	-0.7%	2	4.2%	2	3.25%	2	11.2%	8	2.3%	2	4.5%	2	0.42%
4 D	0.4%	4 D	5.3%	4 D	3.38%	4 D	13.8%	2	3.6%	4 D	7.0%	4 D	0.56%
5 DS	1.4%	5 DS	11.7%	5 DS	3.61%	5 DS	18.3%	4 D	4.9%	5 DS	8.6%	5 DS	0.98%

Notes
[1] Ref denotes the experiments defined in Table 2. Each block ranks the set of experiments in ascending order of impact on the indicator.
[2] ERER denotes the export real exchange rate; **Exp** total exports ; **RGDP** real GDP ; **PINV** private investment; **YD-Rural** rural real disposable income ;
YD-Total total real disposable income ; **BDEF** domestic budget deficit (after grants).
[3] E denotes export-bias in supply response ; **D** denotes a domestic-good bias in supply response ; **S** denotes the presence of subsistence consumption (see Notes to Table 2).

TABLE 4. RER, EXPORT AND OUTPUT ELASTICITIES

(a) Short-run (t=1)

Ref	ERER	Ref	Exp	Ref	RGDP
3 E	-0.46	3 E	-0.54	3 E	0.00
1	-0.21	9	-0.53	9	0.00
2	-0.21	1	-0.50	1	0.00
6	-0.21	2	-0.50	2	0.00
7	-0.21	6	-0.50	6	0.00
8	-0.21	7	-0.50	7	0.00
9	-0.16	8	-0.50	8	0.00
4 D	-0.07	4 D	-0.45	4 D	0.01
5 DS	0.40	5 DS	-0.22	5 DS	0.02

[b] Long Run (t=10)

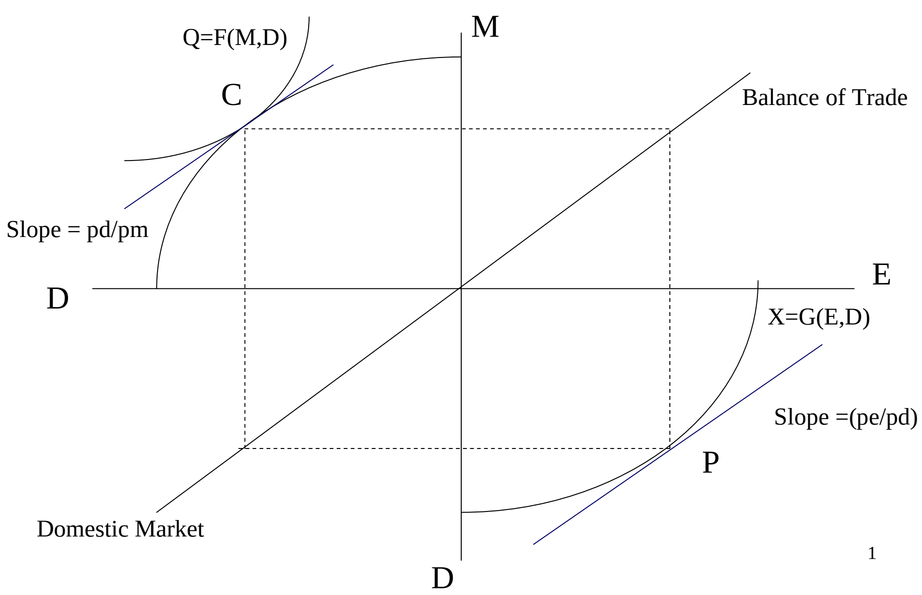
Ref	ERER	Ref	Exp	Ref	RGDP
1	-0.17	9	-0.64	9	-0.02
3 E	-0.14	1	-0.54	1	-0.01
6	-0.13	7	-0.38	7	0.03
8	-0.13	6	-0.23	8	0.09
9	-0.12	8	-0.23	6	0.09
7	-0.11	3 E	0.26	3 E	0.25
2	-0.06	2	0.34	2	0.26
4 D	0.03	4 D	0.42	4 D	0.27
5 DS	0.11	5 DS	0.93	5 DS	0.29

Notes See Table 3.

Appendix I: Analytics of Aid in the Dependent Economy Model (Tradables versus Nontradables).

While the numerical analysis developed in this paper utilizes a multi-sector version of the so-called 1-2-3 model, it is possible to gain some insight by examining the simpler structure of the more familiar tradable - nontradable model. Indeed, provided we exclude shifts in the terms of trade (which have been important in the case of Uganda), the two models reduce to the same thing. To see this look at the four-quadrant diagram below, maintaining the terms of trade, and consider an aid shock which may or may not shift the transformation frontier in the SE quadrant.

The 1-2-3 Model



Given the fixed ToT we can aggregate *E* and *M* into a single tradable good. Re-label *D* as *N*; re-label *M* as *C* (for consumption of the tradable) and E as T (for production of the tradable). Then:

$$P_t C = P_t T + G \quad \text{(A1)}$$

where *G* is the dollar value of the aid inflow. Hence the two models are equivalent under the fixed ToT.

Now consider the N-T model and the impact of the aid shock. It may be easier, and seems less arbitrary, to think about a possible asymmetric shift in the transformation frontier by going behind this to the constituent good-specific value added production functions. To obtain the CET frontier, these need to be Cobb Douglas in sector specific capital and mobile labour, with *common* exponents. So maintaining the assumption of CRS in privately owned factors, we have, in the obvious notation:

$$N = B_n K_n^a L_n^{1-a} K_g^{a_{gn}}$$
$$T = B_t K_t^a L_t^{1-a} K_g^{a_{gt}} \qquad \text{(A2)}$$

Since we are going to leave the private capital stocks unchanged, we simplify the notation by writing:

$$A_n = B_n K_n^a$$
$$A_t = B_t K_t^a$$

Then if competitive firms in each industry face a common wage[28], the first order conditions from profit maximization yield a labour allocation:

$$P_n A_n L_n^{-a} K_g^{a_{gn}} = P_t A_t L_t^{-a} K_g^{a_{gt}} \qquad \text{(A3)}$$

From (A1) and the full employment condition $L_n + L_t = L$, we obtain the transformation frontier between N and T:

$$\left(\frac{N}{A_n K_g^{a_{gn}}}\right)^{\frac{1}{1-a}} + \left(\frac{T}{A_t K_g^{a_{gt}}}\right)^{\frac{1}{1-a}} = L \qquad \text{(A4)}$$

Using (A4), (A2) and (A3), we obtain the relation:

$$\frac{P_n}{P_t} = (A_t / A_n)^{\frac{1}{1-a}} (N/T)^{\frac{a}{1-a}} K_g^{\frac{a_{gt}-a_{gn}}{1-a}} \qquad \text{(A5)}$$

[28] Exactly the same result would follow if the two production processes were internal to competitive firms, so that they allocated their own labour force between the two activities to equate their respective marginal products to the going wage.

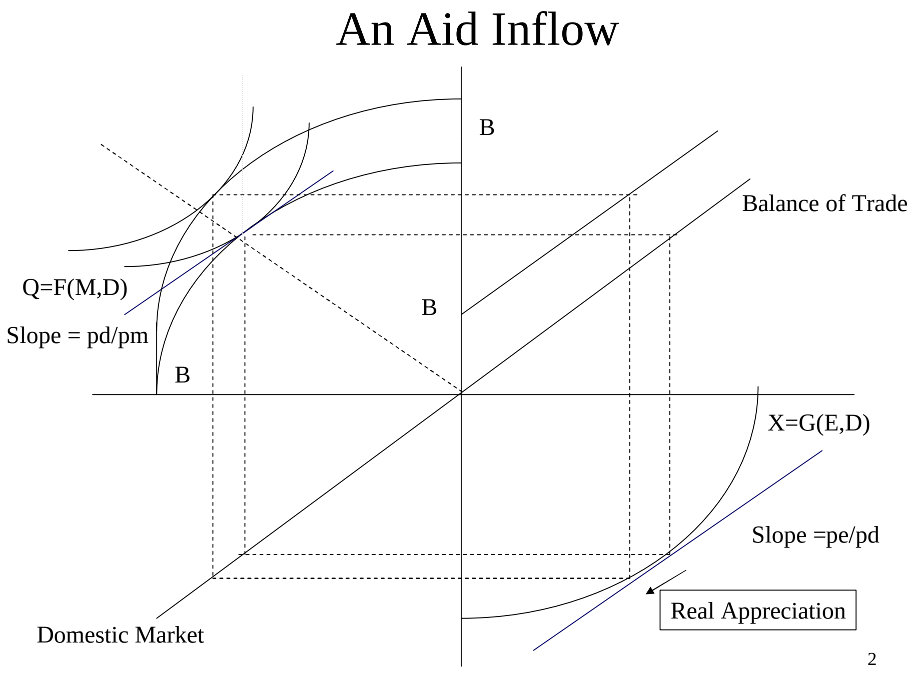
Then, adopting the usual set-up for the composite good:

$$Q = \left(d^{1/e} N^{1-1/e} + (1-d)^{1/e} C^{1-1/e}\right)^{\frac{1}{1-1/e}} \quad \text{(A6)}$$

we obtain the first order condition:

$$\frac{P_n}{P_t} = \left(\frac{dC}{(1-d)N}\right)^{1/e} \quad \text{(A7)}$$

Consider an increase in aid from zero. Clearly, if there are no productive effects via infrastructure, then *C* rises relative to initial *N*, and there must be a real appreciation.



Now consider the case where there is some infrastructure investment out of the aid flow, and this exactly offsets the appreciation, i.e. P_n / P_t is stationary. From (A1), and setting $P_t = 1$, C rises from T_0 to $T_1 + G$. Hence a stationary price ratio requires $C_1 / N_1 = (T_1 + G)/N_1 = T_0 / N_0$, or $N_1 / N_0 = (T_1 + G)/T_0$; i.e. nontradable production must rise in the same ratio as tradable consumption, or by the percentage increase of aid relative to previous imports. We may rewrite this as:

$$(N_1/N_0)(T_0/T_1) = (T_1+G)/T_1$$

$$\left(\frac{(N_1/T_1)}{(N_0/T_0)}\right)^{\frac{a}{1-a}} = \left((T_1+G)/T_1\right)^{\frac{a}{1-a}} \tag{A8}$$

From (A5) and (A8), for P_n/P_t stationary, we need:

$$\left((T_1+G)/T_1\right)^{\frac{a}{1-a}} = (K_{g1}/K_{g0})^{\frac{a_{gn}-a_{gt}}{1-a}} \tag{A9}$$

Hence, assuming that there is indeed a *rise* in infrastructure, this stationarity is only possible if

$$a_{gn} > a_{gt} \tag{A10}$$

This is necessary but not sufficient; the latter depends on their being a sufficient gap between the two infrastructure exponents, coupled with a sufficiently large proportional expansion in infrastructure. For example, suppose that $a_{gn} - a_{gt} > a$; then an aid-financed increase in infrastructure, equiproportionate relative to the aid-financed increase in import capacity, is sufficient to induce a real exchange rate *depreciation*.

Now suppose that we abandon the homothetic form for preferences, by introducing subsistence requirements. I.e. in place of (A6) we now have:

$$Q = \left(d^{1/e}(N-g_n)^{1-1/e} + (1-d)^{1/e}(C-g_t)^{1-1/e}\right)^{\frac{1}{1-1/e}} \tag{A11}$$

and hence in place of (A7),

$$\frac{P_n}{P_t} = \left(\frac{d(C-g_t)}{(1-d)(N-g_n)}\right)^{1/e}$$

A stationary exchange rate now requires that the ratio of the discretionary quantities is constant. It seems most likely that at calibration

$$g_n/N > g_t/C \tag{A12}$$

i.e. non-tradables have a higher ‘necessary’ component than tradables. In that case, when P_n / P_t is stationary *C* will be rising faster than *N*. However, both will be rising, so (A10) remains necessary for the real appreciation to be neutralized.

The implication of (A11), given (A12), is that the relations

(i) between the excess nontradable infrastructure exponent and the private capital exponent and
(ii) that between the relative increases in infrastructure and in imports

can be weakened, with the extent of the weakening depending on the gap between the relative subsistence requirements.

Returning to the four-quadrant diagram, the outcome depends on three things.

(i) The size of the aid increment (NE quadrant)
(ii) The extent, if any, and the direction, of any rotation in the outward shift of the transformation frontier (SE quadrant)
(iii) The extent, if any, and the direction, of any rotation in the outward shift in the consumption (absorption) contours (NW quadrant)

Note that the above analysis assumes that the construction of infrastructure utilizes the same composite commodity as everything else (including any other government activities). Hence infrastructure investment has no independent demand-side effect on relative prices. This also means that the composite commodity should not be interpreted as a measure of utility, because it includes infrastructure spending as well as consumption. The analysis also assumes that transfers of resources between private and public sector (if any) are nondistortionary, or lump-sum.

All this carries through to the 1-2-3 model, and must hold *on average* in the multi-sector version too. Of course, taxes and other complications will modify these results at the margins, but not alter their general thrust.

Appendix II: Sensitivity Analysis

Our principal experiments were based on the assumption that the productivity of public capital was 0.5 and we considered a 12.5% increase in the volume of aid, equivalent to just under 2 percent of initial GDP. Table A1 relaxes these assumptions. Here we examine the effect of a lower and a higher volume of the aid inflow; the former consisting of an increase of 6.25% (1% of GDP), which is reported in the (a) columns, and the latter an increase of 15% (2.4% of GDP), reported in the (b) columns. Experiments (c) report the results from lowering the productivity parameter from its original value of 0.5 to 0.2. We report sensitivity results for only three key experiments, runs 2, 4 and 5 and for convenience we include the original simulation results from Table 2.

Since the key behavioural relationships in model are homothetic, the economy's response to moderate changes in the scale of aid is broadly linear. Three main conclusions therefore follow. First, altering the scale of the net aid inflow preserves the *direction* of response of all the key prices, quantities and income flows reported in Table 2 of the original paper. Second, as a result of the linearity of the simulation model, the elasticities reported in Table 4 of the original paper, though calculated for a single set of experiment values, are relevant summary measures of the response to moderately higher or lower aid flows. Thus for a smaller aid inflow both the initial deterioration in the export supply response and the long-run increase are greater than in the base case, and vice versa for in the face of a higher aid inflow. Finally, this linearity in response implies the relative ranking of outcomes reported in Table 3 is invariant to changes in the volume aid flows.[29]

Similarly, the lower value of "g does not alter the initial impact of aid on the economy but weakens the supply-side response over time and hence moderates the changes in income and its distribution. However the qualitative nature of the results, including the 'shape' of the economy's response remains unchanged. In the limit, of course, the economy moves towards the configuration initially described in Experiment 1 as "g tends to zero. Moreover, this tendency is more or less proportional to the change in the value of the productivity parameter.

[29] These results hold even for the case where we have assumed a high initial subsistence threshold in food consumption (Experiment 5). This threshold has the consequence that the marginal income elasticity of demand for food falls to below unity, but that the effect remains locally linear.

TABLE A1: SENSITIVITY ANALYSIS [1].

Experiment		2a	2	2b	2c	4a	4	4b	4c	5a	5	5b	5c
Infrastructure productivty effect		All	All	All	All	All	All	All	All	All	All	All	All
Supply response		Neutral	Neutral	Neutral	Neutral	D-bias	D-bias	D-bias	D-bias	D-bias	D-bias	D-bias	D-bias
Aid Increase		6.25%	12.5%	15.0%	12.5%	6.25%	12.5%	15.0%	12.5%	6.25%	12.5%	15.0%	12.5%
Spillover		0.5	0.5	0.5	0.2	0.5	0.5	0.5	0.2	0.5	0.5	0.5	0.2
Subsistence Consumption										Food (90%)	Food (90%)	Food (90%)	Food (90%)
PRICES AND QUANTITIES	**Time Period**												
Export Weighted RER	**to t=1**	-1.3%	-2.6%	-3.2%	-2.6%	2.2%	0.9%	0.3%	0.9%	6.1%	5.0%	4.5%	5.0%
	to t=5	-0.8%	-1.6%	-1.9%	-1.8%	0.3%	-0.5%	-0.8%	-0.7%	0.8%	0.2%	0.0%	-0.2%
	to t = 10	-0.4%	-0.7%	-0.9%	-1.5%	0.8%	0.4%	0.2%	-0.4%	1.4%	1.4%	1.4%	0.2%
Total Exports	**to t=1**	-3.1%	-6.2%	-7.4%	-6.2%	-2.6%	-5.7%	-6.9%	-5.7%	0.1%	-2.8%	-4.0%	-2.8%
	to t=5	-1.3%	-2.6%	-3.1%	-4.9%	-0.6%	-1.9%	-2.4%	-4.2%	2.8%	2.2%	1.9%	-0.8%
	to t = 10	2.2%	4.2%	5.0%	-3.7%	3.2%	5.3%	6.1%	-1.4%	7.9%	11.7%	13.1%	3.1%
Manufacturing Exports	**to t=1**	-3.0%	-6.0%	-7.2%	-6.0%	-3.9%	-6.8%	-8.0%	-6.8%	-4.5%	-7.4%	-8.4%	-7.4%
	to t=5	-1.4%	-3.0%	-3.2%	-4.8%	-2.0%	-3.3%	-3.8%	-5.6%	-2.9%	-4.2%	-4.7%	-6.0%
	to t = 10	2.1%	4.2%	5.1%	-2.6%	1.7%	3.9%	4.7%	-2.9%	0.6%	2.3%	2.9%	-3.6%
Cash crop Exports	**to t=1**	-3.4%	-6.9%	-8.2%	-6.9%	-1.8%	-5.2%	-6.6%	-5.2%	2.3%	-1.0%	-2.3%	-1.0%
	to t=5	-1.5%	-3.1%	-3.8%	-5.4%	0.5%	-1.1%	-1.8%	-3.6%	5.6%	4.9%	4.6%	1.6%
	to t = 10	2.1%	4.1%	4.8%	-2.8%	4.6%	6.4%	7.0%	-0.5%	11.8%	16.1%	17.5%	6.4%
Total Imports	**t=1**	0.9%	1.9%	2.3%	1.9%	1.2%	2.1%	2.5%	2.1%	2.2%	3.3%	3.7%	3.1%
	t=5	1.6%	3.2%	3.9%	2.4%	1.9%	3.5%	4.2%	2.6%	3.1%	5.2%	5.9%	4.1%
	to t = ss	2.9%	5.8%	6.9%	3.3%	3.3%	6.2%	7.3%	3.7%	5.2%	8.8%	10.2%	5.5%
Total Domestic Goods Supply	**to t=1**	0.3%	0.6%	0.7%	0.6%	1.6%	1.9%	2.0%	1.9%	1.7%	2.0%	2.1%	2.0%
	to t=5	1.1%	2.2%	2.6%	1.2%	2.5%	3.6%	4.0%	2.6%	2.6%	3.7%	4.2%	2.7%
	to t = 10	2.6%	5.1%	6.1%	2.3%	4.1%	6.7%	7.7%	3.8%	4.4%	7.0%	8.0%	4.0%
Real GDP	**to t=1**	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%	0.1%	0.3%	0.3%	0.3%	0.3%
	to t=5	0.3%	0.6%	0.7%	0.2%	0.3%	0.6%	0.7%	0.2%	0.3%	0.6%	0.7%	0.3%
	to t = 10	1.7%	3.3%	3.9%	1.2%	1.8%	3.4%	4.0%	1.3%	2.0%	3.6%	4.2%	1.5%
Private Investment	**to t=1**	-1.4%	-3.2%	-4.0%	-3.2%	0.6%	-1.1%	-1.8%	-1.1%	2.5%	0.8%	0.0%	0.8%
	to t=5	1.2%	2.3%	2.8%	-0.6%	3.4%	4.6%	5.1%	1.5%	5.7%	7.4%	8.2%	4.0%
	to t = 10	5.8%	11.2%	13.4%	2.8%	8.3%	13.8%	16.2%	5.2%	11.5%	18.3%	21.1%	8.5%
FISCAL ACCOUNTS													
Total Revenue	**to t=1**	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.8%	0.8%	0.8%	0.8%
	to t=5	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.1%	0.9%	1.1%	1.3%	1.0%
	to t = 10	0.0%	0.0%	0.1%	0.0%	0.1%	0.2%	0.2%	0.1%	1.2%	1.6%	1.7%	1.2%
Total Current Expenditure	**to t=1**	0.0%	-0.1%	-0.1%	-0.1%	0.0%	0.0%	0.0%	0.0%	0.7%	0.7%	0.7%	0.7%
	to t=5	-0.2%	-0.3%	-0.4%	-0.1%	-0.1%	-0.2%	-0.3%	-0.1%	0.7%	0.7%	0.7%	0.7%
	to t = 10	-0.4%	-0.8%	-0.9%	-0.3%	-0.4%	-0.7%	-0.9%	-0.3%	0.6%	0.6%	0.5%	0.7%
Domestic Budget Balance	**to t=1**	-0.2%	-0.4%	-0.5%	-0.4%	-0.1%	-0.3%	-0.4%	-0.3%	0.1%	-0.1%	-0.2%	-0.1%
	to t=5	0.0%	-0.1%	-0.1%	-0.2%	0.1%	0.1%	-0.1%	-0.1%	0.3%	0.3%	0.3%	0.1%
	to t = 10	0.2%	0.4%	0.5%	-0.1%	0.4%	0.6%	0.6%	0.1%	0.7%	1.0%	1.1%	0.4%
REAL DISPOSABLE INCOME													
Rural	**to t=1**	-0.7%	-1.4%	-1.7%	-1.4%	0.2%	-0.6%	-0.8%	-0.6%	-5.4%	-6.5%	-6.9%	-6.5%
	to t=5	0.1%	0.2%	0.2%	-0.9%	1.1%	1.2%	1.2%	0.2%	-5.8%	-7.3%	-7.9%	-6.8%
	to t = 10	1.8%	3.6%	4.2%	0.3%	3.2%	4.9%	5.5%	1.6%	-6.0%	-7.7%	-8.4%	-7.0%
Urban - Unskill	**to t=1**	1.1%	2.1%	5.3%	2.1%	4.4%	5.5%	6.0%	5.5%	9.4%	10.7%	11.3%	10.7%
	to t=5	1.7%	3.3%	5.5%	2.5%	5.0%	6.7%	7.4%	6.0%	11.3%	14.4%	16.2%	12.2%
	to t = 10	2.5%	5.1%	6.2%	3.2%	5.9%	8.6%	9.7%	6.7%	14.5%	20.6%	22.9%	14.7%
Urban -Skilled	**to t=1**	0.9%	1.8%	4.9%	1.8%	4.2%	5.1%	5.5%	5.1%	9.6%	10.9%	11.4%	10.9%
	to t=5	1.6%	3.1%	5.3%	2.4%	4.8%	6.4%	7.1%	5.6%	11.6%	14.8%	16.1%	12.5%
	to t = 10	2.6%	5.2%	6.3%	3.2%	5.9%	8.5%	9.6%	6.5%	15.2%	21.5%	23.9%	15.2%
Total	**to t=1**	0.2%	0.5%	2.1%	0.5%	2.5%	2.7%	2.8%	2.7%	3.0%	3.3%	3.4%	3.3%
	to t=5	1.0%	1.9%	3.1%	1.0%	3.2%	4.2%	4.6%	3.3%	4.0%	5.1%	5.7%	4.0%
	to t = 10	2.3%	4.5%	5.4%	1.9%	4.7%	7.0%	7.8%	4.4%	5.9%	8.6%	9.7%	5.4%

NOTES
See Table 2

Appendix III: HIPC Ratios

Table A2 reports 10-year simulations for the three HIPC ratios for the 9 core experiments presented in Table 2 plus the variants for experiments 2, 4, and 5 reported in Table A1. As noted in the main text, CGE models of the type used here do not determine the aggregate price level but rather solve for relative prices given the choice of numeraire. Since we assume the terms of trade to be constant, we take the world price of importable goods (expressed in 2001 Uganda Shillings) as the numeraire. The projections for GDP and exports in Table A2 are thus in constant 2001 Ugandan Shillings (based on a nominal exchange rate of USh 1750 / US$) and real government revenue is nominal revenue scaled by the GDP deflator.

TABLE A2: GDP, Exports and Real Government Revenue

SIMULATION	1	2	2a	2b	2c	3	4	4a	4b	4c	5	5a	5b	5c	6	7	8	9
Year																		
Real GDP																		
2001	8036	8036	8036	8036	8036	8036	8036	8036	8036	8036	8036	8036	8036	8036	8036	8036	8036	8036
2002	8041	8041	8039	8042	8041	8034	8047	8045	8048	8047	8060	8058	8061	8060	8041	8041	8041	8036
2003	8038	8090	8063	8100	8059	8082	8098	8071	8108	8067	8114	8087	8125	8082	8063	8045	8055	8033
2004	8036	8137	8087	8156	8076	8127	8147	8097	8166	8086	8166	8115	8186	8104	8084	8050	8069	8025
2005	8035	8184	8111	8212	8094	8172	8195	8123	8224	8105	8218	8143	8247	8125	8103	8055	8083	8021
2006	8033	8229	8134	8266	8111	8216	8243	8148	8280	8124	8268	8170	8306	8146	8122	8059	8097	8018
2007	8031	8275	8158	8320	8127	8259	8290	8172	8336	8142	8318	8198	8365	8167	8139	8064	8111	8014
2008	8029	8319	8180	8373	8144	8302	8336	8197	8391	8160	8368	8225	8424	8187	8156	8068	8126	8011
2009	8027	8363	8203	8426	8160	8344	8382	8221	8445	8178	8417	8251	8481	8207	8171	8073	8140	8008
2010	8026	8407	8225	8477	8176	8386	8428	8245	8499	8195	8466	8278	8539	8227	8186	8077	8154	8004
2011	8024	8449	8247	8528	8191	8427	8472	8268	8552	8212	8514	8304	8595	8246	8199	8082	8168	8001
Total Exports																		
2001	1398	1398	1398	1398	1398	1398	1398	1398	1398	1398	1398	1398	1398	1398	1398	1398	1398	1398
2002	1311	1311	1354	1294	1311	1304	1319	1362	1301	1319	1359	1399	1342	1359	1311	1311	1311	1305
2003	1310	1328	1363	1314	1317	1320	1337	1371	1323	1326	1383	1412	1371	1368	1317	1313	1316	1304
2004	1309	1345	1371	1334	1323	1336	1354	1381	1343	1333	1406	1424	1398	1378	1323	1316	1321	1297
2005	1308	1361	1380	1354	1329	1352	1371	1390	1364	1339	1429	1437	1425	1387	1329	1318	1326	1295
2006	1307	1378	1388	1373	1335	1367	1388	1399	1384	1346	1451	1449	1452	1397	1334	1320	1331	1294
2007	1307	1394	1396	1392	1341	1383	1405	1408	1404	1352	1474	1461	1478	1406	1339	1322	1336	1292
2008	1306	1410	1405	1411	1347	1398	1422	1417	1424	1359	1496	1473	1504	1415	1344	1325	1341	1291
2009	1305	1426	1413	1430	1353	1413	1439	1425	1444	1365	1518	1485	1530	1424	1349	1327	1347	1289
2010	1304	1442	1421	1449	1358	1428	1455	1434	1463	1371	1540	1497	1555	1433	1353	1329	1352	1288
2011	1304	1457	1429	1468	1364	1443	1472	1443	1483	1378	1561	1509	1581	1442	1357	1331	1357	1287
Real Government Revenue																		
2001	1092	1092	1092	1092	1092	1092	1092	1092	1092	1092	1092	1092	1092	1092	1092	1092	1092	1092
2002	1092	1092	1092	1092	1092	1081	1103	1103	1103	1103	1160	1158	1161	1160	1092	1092	1092	1091
2003	1092	1100	1096	1101	1095	1089	1111	1107	1112	1106	1177	1166	1181	1167	1097	1092	1093	1091
2004	1092	1107	1100	1110	1098	1096	1118	1111	1121	1109	1193	1175	1200	1173	1102	1092	1094	1089
2005	1092	1114	1103	1118	1101	1103	1126	1115	1130	1112	1208	1183	1218	1179	1107	1092	1096	1089
2006	1092	1121	1107	1126	1103	1110	1133	1118	1138	1115	1223	1191	1235	1185	1112	1092	1097	1089
2007	1091	1127	1110	1134	1106	1116	1139	1122	1146	1117	1237	1198	1252	1191	1116	1092	1098	1089
2008	1091	1134	1113	1142	1108	1123	1146	1125	1154	1120	1251	1206	1268	1197	1120	1093	1099	1089
2009	1091	1140	1117	1149	1111	1129	1152	1128	1161	1122	1264	1213	1284	1203	1124	1093	1101	1089
2010	1091	1146	1120	1156	1113	1134	1158	1132	1169	1125	1277	1220	1299	1208	1128	1093	1102	1088
2011	1091	1152	1123	1163	1115	1140	1164	1135	1176	1127	1290	1227	1314	1213	1131	1093	1103	1088

Note:
All data are in real terms valued at constant 2001 Ugandan Shillings (at average exchange rate of Ush 1750 / US$)

Appendix IV. Uganda Social Accounting Matrix

Note: This version assumes zero net total investment
with adjustments to total investment (and no intl trade in services)

Nominal Market Prices
January 14, 2002

	Ush billions	Factors of Production					Current Account						Production			
		1	2	3	4	5	6	7	8		9	10	11	12	13	14
								Households		Total HH						
1	Labour - Unskilled												400	250	100	1000
2	Labour - Skilled												0	0	390	884
3	Rent												2532	0	0	0
4	Operating Surplus												200	100	302	790
5	Consumption of Capital												100	50	200	300
6	Household - Agric	650		2532	300	150						350				
7	Household - Urban Unskilled	1200										350				
8	Household - Urban Skilled		1612		1092	500					57	616				
	Total Households	1850	1612	2532	1392	650					57	1316				
9	Government						0	50	227	277			80	0	100	175
10	Rest of World										73					
11	Food															
12	Cash Crops															
13	Manufacturing															
14	Services															
15	Public services															
16	Food						2680	870	1348	4898			485	70	125	100
17	Cash Crops						0	0	0	0			0	20	0	0
18	Manufacturing						502	430	1010	1942			808	50	1290	1420
19	Services						800	200	835	1835			582	100	1240	1118
20	Public services						0	0	0	0	1345		0	0	0	0
21	Food											123				
22	Cash Crops											610				
23	Manufacturing											665				
24	Services											0				
25	Public services											0				
26	Household - Agric						0									
27	Household - Urban Unskilled							0								
28	Household - Urban Skilled								457							
	Total Households									457						
29	Government										-383					
30	Government															
31	Reserves															
32	Rest of World											1267				
	TOTAL	1850	1612	2532	1392	650	3982	1550	3877	9409	1092	3981	5187	640	3747	5787

	Aggrgate Supply					Exports					Capital Account								
15	16	17	18	19	20	21	22	23	24	25	26	27	28		29	30	31	32	TOTAL
														Total HH					
100																			1850
338																			1612
0																			2532
0																			1392
0																			650
																			3982
																			1550
																			3877
																			9409
0	13	0	447	0	0	0	0	0	0	0									1092
	631	0	3146	0	0												131		3981
	5187																		5187
		640																	640
			3747																3747
				5787															5787
					1345														1345
0						123					0	0	30	30	0	0			5831
0							610				0	0	10	10	0	0			640
616								665			0	0	325	325	24	200			7340
291									0		0	0	285	285	36	300			5787
0										0	0	0	0	0	0	0			1345
																			123
																			610
																			665
																			0
																			0
																			0
																			0
																			457
																			457
																			-383
																			0
																			0
																			1267
1345	5831	640	7340	5787	1345	123	610	665	0	0	0	0	650	650	60	500	131	0	

Appendix V: Equation Listing

```
$TITLE  MODEL NAME: Uganda04.GMS
$ OFFSYMXREF OFFSYMLIST
*
*----------------------------------------------------------------------*
* This model is calibrated to a full steady-state (with zero-pop growth)*
* to examine consequences of alternative aid-funcded public expenditure *
* programmes.                                                           *
* Model designed January 2002 by C.S.Adam and D.L.Bevan, Department of  *
* Economics, Oxford University.                                         *
*                                                                       *
* The nominal currency unit is the Ugandan Shilling with an exchange    *
* rate of USh 1750 / US$. All values are in billions of Shillings unless*
* stated.                                                               *
*                                                                       *
* Data are read in using the relevant $include files in Block B.        *
*                                                                       *
*                                                                       *
* ----------------------------------------------------------------------*


*################## BLOCK A: DECLARATION OF SETS AND PARAMETERS ###########

*  This block defines all the sets used in the model.

 SET I       SECTORS   / FOOD        Food production
                         CCROP       Cash crop production
                         MAN         Manufacturing
                         SERV        Services
                         PUB         Non-Marketed Public Services  /

* We define subsets for the sectors

  IM(I)   IMPORTABLE SECTORS
  IX(I)   EXPORTABLE SECTORS
  IN(I)   NONTRADED SECTORS
  INM(I)  NON-IMPORTABLE SECTORS
  INX(I)  NON-EXPORTABLE SECTORS
  IC(I)   CONSUMPTION SECTORS
  IP(I)   PRIVATE SECTORS /FOOD, CCROP, MAN, SERV /
  IR(I)   RURAL SECTORS / FOOD, CCROP /
  IU(I)   URBAN SECTORS / MAN, SERV, PUB /

* In the current version of the model we have two labour categories
* and three household types.

  LC      LABOR CATEGORIES  / UNSK       Unskilled labour
                              SK         Skilled labour   /

  HH      HOUSEHOLD TYPES  /  RURAL      Rural households
                              URBU       Urban unskilled
                              URBS       Urban skilled    /


* The simulation period is define as T. The index
* only enters the solution and updating loop. The
* year index denotes the end of a fiscal year.

  T       SIMULATION PERIOD /2001*2011 / ;

* To allow interaction between sectors of the form "from sector i to
* sector j" we need an alternative index, j. This is given by the
* alias command.

     ALIAS (I,J)  ;
     ALIAS (IC,JC);
     ALIAS (IP,JP);
     ALIAS (LC,LF);
     ALIAS (HH,hf);

PARAMETERS
       M0(I)       IMPORTS
       E0(I)       COMPETITIVE EXPORTS
       X0(I)       DOMESTIC OUTPUT BY SECTOR
       VA0(I)      VALUE ADDED BY SECTOR
       LAND0(I)    LAND BY SECTOR
       KP0(I)      CAPITAL STOCKS BY SECTOR
       ID0(I)      INVESTMENT BY SECTOR OF ORIGIN
       DEPRC0(I)   DEPRECIATION EXPENDITURE
       ND0(I)      INTERMEDIATE INPUT DEMANDS
       XD0(I)      DOMESTIC SALES BY SECTOR
       Q0(I)       COMPOSITE SUPPLY GOODS
       PWE0(I)     WORLD MARKET PRICE OF EXPORTS
       PWM0(I)     WORLD MARKET PRICE OF IMPORTS
       PD0(I)      DOMESTIC GOOD PRICE
       PE0(I)      DOMESTIC PRICE OF EXPORTS
       PX0(I)      AVERAGE OUTPUT PRICE BY SECTOR
       PC0(I)      PRICE OF COMPOSITE CONSUMER GOOD
       PP0(I)      PRICE OF COMPOSITE PRODUCER GOOD
       PM0(I)      DOMESTIC PRICE OF IMPORTS
       PVA0(I)     VALUE ADDED PRICE BY SECTOR
       PK0(I)      CAPITAL PRICE
       QD(I)       DUMMY VARIABLE FOR COMPUTING AD(I)
       XLE0(I,LC)  EMPLOYMENT BY SECTOR AND SKILL (Millions of Persons)
       XLLB(I,LC)  DUMMY VARIABLE (L MATRIX WITH NO ZEROS)
       WDIST(I,LC) WAGE PROPORTIONALITY MATRIX
       WA0(LC)     AVERAGE WAGE RATE BY LABOR CATEGORY (Kwacha per employee)
       LG0(LC)     ANNUAL GROWTH IN LABOUR SUPPLY
       LD(LC)      EMPLOYMENT
       LS0(LC)     LABOR SUPPLIES BY CATEGORY
       LY0(LC)     LABOUR INCOME BY CATEGORY
       IT0(I)      INDIRECT TAX BY SECTOR
       TTM0(I)     IMPORT DUTIES
       TTE0(I)     EXPORT DUTIES
       CDM(I,HH)   PRIVATE CONSUMPTION AT MARKET PRICES
       CD0(I,HH)   PRIVATE CONSUMPTION AT PRODUCER PRICES
       CBASE0(I,HH) LES BASE CONSUMPTION SHARES
       GD0(I)      GOVERNMENT FINAL CONSUMPTION
       DK0(I)       INVESTMENT BY DESTINATION
       IO(I,J)     INPUT-OUTPUT COEFFICIENTS
       IMAT0(I,J)  CAPITAL COMPOSITION COEFFICIENTS
```

```
       DELTA(I)    ARMINGTON SHARE PARAMETER
       AC(I)       ARMINGTON SHIFT PARAMETER
       AT(I)       CET FUNCTION SHIFT PARAMETER
       GAMMA0(I)   CET FUNCTION SHARE PARAMETER
       EPSC(I)     ARMINGTON ELASTICITY OF SUBSTITUTION
       EPST(I)     CET ELASTICITY OF TRANSFORMATION
       AD0(I)      PRODUCTION FUNCTION SHIFT PARAMETER
       CLESX(I,HH) DUMMY FOR CONSTRUCTION OF CLES
       CLES(I,HH)  CONSUMPTION SHARE PARAMETER
       GLES        SHARE OF CONS OF GOVERNMENT OUTPUT IN UTILITY
       DEPR(I)     DEPRECIATION RATES
       KI0(I)      SHARES OF CAPITAL STOCK
       TM0(I)      TARIFF RATES
       TE0(I)      EXPORT DUTY RATES
       ITAX0(I)    INDIRECT TAX RATES PERCENT  CONSUMPTION
       ALPHL(LC,I) LABOR SHARE PARAMETER IN PRODUCTION
       ALPHG(I)    PUBLIC CAPITAL SHARE PARAMETER
       ALPHK(I)    CAPITAL SHARE PARAMETER IN PRODUCTION
       ALPHS(I)    LAND SHARE IN PRODUCTION
       WP(I)       WEIGHTS FOR PRODUCER PRICE INDEX
       WC(I)       WEIGHTS FOR CONSUMER PRICE INDEX
       RK0(I)      QUASI RENT (GROSS PROFIT)
       RS0(I)      LAND RENT BY SECTOR
       R0(I)       GROSS PROFIT RATE
       RBAR0       AVERAGE GROSS PROFIT RATE
       RMIT0(HH)   REMITTANCES (Local currency)
       HHSAV0(HH)  HOUSEHOLD SAVING
       DIRTAX0(HH) DIRECT TAXES
       TRNS0(HH)   TRANSFERS TO HOUSEHOLDS
       DINT0(HH)   INTEREST ON DOMESTIC DEBT
       MPS0(HH)    MARGINAL PROPENSITY TO SAVE
       AID0        FOREIGN SAVINGS (US DOLLARS MILLIONS)
       DTAX0(HH)   DIRECT TAX RATE
       GDPVA0      GDP AT FACTOR COST MEASURED BY VALUE ADDED
       RGDP0       REAL GDP AT FACTOR COST
       PPI0        PRODUCER PRICE INDEX
       PGDP0       GDP DEFLATOR
       CPI0        CONSUMER PRICE INDEX
       YD0(HH)     PRIVATE DISPOSABLE INCOME
       Y0(HH)      PRIVATE GROSS FACTOR INCOME
       INVEST0     TOTAL INVESTMENT
       HW0(HH)     HOUSEHOLD WEIGHTS
              ;

*#################### BLOCK B BASE DATA TABLES AND SCALAR LISTS ###########
* The data are read in from the following base-data file UGANDADAT03.GMS  *
* These data are analysed in UG_SAM_04.xls. This is a "representative"    *
* SAM which provides for zero net investment in both public and private   *
* sectors in the baseline, and reallocates international trade in services*
* to manufacturing.                                                        *

$INCLUDE D:\DFID\UGRER\UGANDADAT04.GMS

$INCLUDE D:\DFID\UGRER\GAMMA.GMS
*                                                                          *
*++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++*
```

```
*Key Assumptions

TABLE ELASTICITY(*,I) CES CET AND EXPORT DEMAND ELASTICITIES

* Note that the values in this table are the elasticities of
* substitution in consumption, other absorption and transformation

            FOOD    CCROP   MAN    SERV    PUB

 EPSC       0.50    0.50    0.50   0.50    0.50
 EPST       2.00    2.00    2.00   2.00    2.00
 ALPHG      0.20    0.20    0.20   0.20    0.20

 TABLE SHARES(I,HH) SUBSISTENCE CONSUMPTION SHARES

               RURAL  URBU  URBS

 FOOD            0.90  0.90  0.90
 CCROP           0.00  0.00  0.00
 MAN             0.00  0.00  0.00
 SERV            0.00  0.00  0.00

 ;

SCALARS

    SIGC    CES   ELASTICTY OF SUBSTITUTION                   / 0.50 /

;
*#################### BLOCK C: COMPUTATION OF PARAMETERS FOR CALIBRATION ####
*In this section we compute the parameters and variables for the model using
*the base data entered from the data files.

OPTION DECIMALS=6;

 EPSC(I)      = ELASTICITY("EPSC",I) ;
 EPST(I)      = ELASTICITY("EPST",I);

 RMIT0(HH)    = HHOLD("RMIT0",HH);
 HHSAV0(HH)   = HHOLD("HHSAV0",HH);
 DIRTAX0(HH)  = HHOLD("DIRTAX0",HH);
 TRNS0(HH)    = HHOLD("TRNS0",HH);
 DINT0(HH)    = HHOLD("DINT0",HH);
 HW0(HH)      = HHOLD("HW0",HH);

 RMIT0(HH)    = RMIT0(HH)/ER0;
 FINT0        = FINT0/ER0;
 DRES0        = DRES0/ER0;


 DEPRC0(I)    = MACRO("DEPRC0",I);
 LAND0(I)     = MACRO("LAND0",I);
 RS0(I)       = MACRO("RS0",I);
 KP0(I)       = MACRO("KP0",I);
 M0(I)        = MACRO("M0",I);
 E0(I)        = MACRO("E0",I);
```

```
TTM0(I)       = MACRO("TTM0",I);
TTE0(I)       = MACRO("TTE0",I);
X0(I)         = MACRO("X0",I);
VA0(I)        = MACRO("VA0",I);
IT0(I)        = MACRO("IT0",I);
DK0(I)        = MACRO("DK0",I);
PD0(I)        = MACRO("PD0",I);
GD0(I)        = MACRO("GD0",I);
ID0(I)        = MACRO("ID0",I);

CDM(I,HH)     = CONS(I,HH);
XLE0(I,LC)    = XL(I,LC)/1000000;
XLLB(I,LC)      = XLE0(I,LC) + (1 - SIGN(XLE0(I,LC)));
LS0(LC)       = SUM(I, XLE0(I,LC) );
WA0(LC)       = LY0(LC)/LS0(LC);
WDIST(I,LC)$XLE0(I,LC)=(WAGE(I,LC)/XLE0(I,LC))/WA0(LC);

IM(I)         = YES$(M0(I));
IX(I)         = YES$(E0(I));
IN(I)         = YES$(M0(I)+E0(I) EQ 0.0);
INM(I)        = YES$(M0(I) EQ 0.0);
INX(I)        = YES$(E0(I) EQ 0.0);
IC(I)         = YES$(SUM(HH,CDM(I,HH)));

XD0(I)        = X0(I)-E0(I) ;
Q0(I)         = XD0(I)+M0(I);
IO(I,J)       = INT(I,J)/X0(J);
IMAT0(I,JP)   = CAPCOMP(I,JP)/DK0(JP);
IMAT0(I,"PUB")=CAPCOMP(I,"PUB")/(DK0("PUB")+DKG0);
ND0(I)        = SUM(J,IO(I,J)*X0(J));
DEPR(I)       = DEPRC0(I)/KP0(I);
KI0(IP)       = KP0(IP)/SUM(JP,KP0(JP));

PK0(I)        = PD0(I) ;
PM0(I)        = PD0(I) ;
PE0(I)        = PD0(I) ;
PX0(I)        = (PD0(I)*XD0(I) + (PE0(I)*E0(I))$IX(I))/X0(I) ;
PC0(I)        = (PD0(I)*XD0(I) + (PM0(I)*M0(I))$IM(I))/Q0(I) ;
TM0(IM)       = TTM0(IM)/(M0(IM)-TTM0(IM));
TE0(IX)       = TTE0(IX)/(E0(IX)+TTE0(IX));
PWM0(I)       = PM0(I)/((1+TM0(I))*ER0) ;
PWE0(I)       = PE0(I)/((1-TE0(I))*ER0) ;
PVA0(I)       = VA0(I)/X0(I) ;
ND0(I)        = SUM(J, IO(I,J)*X0(J) ) ;

ITAX0(IC)    =IT0(IC)/(SUM(HH, CDM(IC,HH))-IT0(IC));
CD0(I,HH)$CDM(I,HH)=CDM(I,HH)/(1+ITAX0(I));
CBASE0(IC,HH)= SHARES(IC,HH)*CD0(IC,HH);
CLESX(IC,HH) = (PC0(IC)*(1+ITAX0(IC))*(CD0(IC,HH)-CBASE0(IC,HH)))
               /(CDMTOT-SUM(JC,PC0(JC)*(1+ITAX0(JC))*CBASE0(JC,HH)));
CLES(IC,HH)= (CLESX(IC,HH)/((PC0(IC)*(1+ITAX0(IC)))**(1-SIGC)))**(1/SIGC);

GLES          = GD0("PUB")/(GD0("PUB")+CDTOT0);
WP(IP)        = Q0(IP)/SUM(JP,Q0(JP)) ;
WC(I)         = SUM(HH, CDM(I,HH))/CDMTOT ;
```

```
*++++++++++Calibration of Demand and Supply Function Parameters++++++++

* DELTA shares are calculated from the COSTMIN equation
* AC is calculated from the ARMINGTON equation
* GAMMA shares are calculated from the ESUPPLY equation
* ALPHL coefficients are calculated from the PROFITMAX equation
* AD is calculated from OUTPUT equation
* LD is calculated from first order conditions PROFITMAX
* AT is calculated from the CET equation


DELTA(IM)$M0(IM) = PM0(IM)/PD0(IM)*(M0(IM)/XD0(IM))**(1/EPSC(IM)) ;

DELTA(IM) = DELTA(IM)/(1+DELTA(IM)) ;

AC(IM) = Q0(IM)/(DELTA(IM)*M0(IM)**(1-1/EPSC(IM))
         +(1-DELTA(IM))*XD0(IM)**(1-1/EPSC(IM)))**(1/(1-1/EPSC(IM))) ;


GAMMA0(IX) = 1/(1 + PD0(IX)/PE0(IX)*(E0(IX)/XD0(IX))**(1/EPST(IX)) ) ;

GAMMA0(IN) = 0;

ALPHS("FOOD") = RS0("FOOD")/(PVA0("FOOD")*X0("FOOD"));

ALPHS("CCROP")= 0.0 ;

ALPHS(IU) = 0.0;

ALPHL(LC,I) = (WDIST(I,LC) * WA0(LC) * XLE0(I,LC))/(PVA0(I)*X0(I));

ALPHK(I) = (1-ALPHS(I)-SUM(LC, ALPHL(LC,I)));

ALPHG(I) = ELASTICITY("ALPHG", I) ;

QD(IP)  = (XLLB(IP,"SK")**ALPHL("SK",IP))*(XLLB(IP,"UNSK")**ALPHL("UNSK",IP))
          *(LAND0(IP)**ALPHS(IP))*(KP0(IP)**ALPHK(IP))*(KG0**ALPHG(IP)) ;

QD("PUB")  =
(XLLB("PUB","SK")**ALPHL("SK","PUB"))*(XLLB("PUB","UNSK")**ALPHL("UNSK","PUB"))
             *(KG0**ALPHG("PUB"));

AD0(I)  = X0(I)/QD(I);


LD(LC) = SUM(I,(X0(I)*PVA0(I)*ALPHL(LC,I)/
         (WDIST(I,LC)*WA0(LC)))$WDIST(I,LC)) ;

AT(IX) = X0(IX)/(GAMMA0(IX)*E0(IX)**(1+1/EPST(IX))
          +(1-GAMMA0(IX))*XD0(IX)**(1+1/EPST(IX)))**(1/(1+(1/EPST(IX)))) ;

* The following block computes the baseline parameters for the investment
function

 RS0(I)  = ALPHS(I)*X0(I)*PVA0(I);
 RK0(I)  = VA0(I)-RS0(I)-SUM(LC, WA0(LC)*WDIST(I,LC)*XLE0(I,LC));
```

```
 R0(IP)  = RK0(IP)/KP0(IP);
 RBAR0   = SUM(IP, RK0(IP))/SUM(IP, KP0(IP));



* The final section in this block computes labour income, factor cost value
* added, real GDP, the direct tax rate, gross disposable income and
* gross savings rate

 AID0      = (SAVING0 - GOVSAV0 - SUM(HH,HHSAV0(HH)))/ER0;
 GDPVA0    = SUM(I, PVA0(I)*X0(I))  ;
 RGDP0     = SUM(I, X0(I) - ND0(I));
 PGDP0     = GDPVA0/RGDP0 ;

 Y0("RURAL") = SUM(IR, VA0(IR));
 Y0("URBU")  = SUM(IU, WAGE(IU,"UNSK"));
 Y0("URBS")  = SUM(IU, VA0(IU))-SUM(IU, WAGE(IU,"UNSK"));
 DTAX0(HH)   = DIRTAX0(HH)/Y0(HH) ;
 YD0(HH)     = Y0(HH)*(1-DTAX0(HH))+ER0*RMIT0(HH)+TRNS0(HH)+DINT0(HH);
 MPS0(HH)    = HHSAV0(HH)/YD0(HH) ;
 INVEST0     = SUM(I, ID0(I)) ;
 PPI0        = SUM(I, WP(I)*PX0(I));
 CPI0        = SUM(I, WC(I)*PC0(I));



* Finally we display the model sets, calibration parameters, and variables

DISPLAY

  I, IM, IX, IN, INM, INX, IC, IR , IU

  EPSC, EPST, DEPR, KI0, TM0, TE0, ITAX0, CLES, GLES,
  WP, WC, DELTA, GAMMA0, ALPHL, ALPHK, ALPHS, QD, AD0, AC, AT, IO, IMAT0,

  X0, XD0, Q0, VA0, M0, E0, ND0, DEPRC0,
  CD0, GD0, ID0, DK0, RK0,IT0, TTM0, TTE0,

  GOVSAV0, RMIT0, GDTOT0, TRNS0, GR0, DKG0, DK0,

  XLE0, KP0, LS0, RK0, WA0, R0, RBAR0, ADJ0, LAND0, RS0

  PD0, PM0, PE0, PK0, PX0, PC0, PWM0, PWE0, PVA0, GDPVA0, RGDP0,
  PGDP0, DTAX0, Y0, YD0, MPS0, INVEST0, PPI0, AID0, CPI0,
  RMIT0, TRNS0, DINT0, FINT0, HHSAV0, DRES0, SAVING0, INVEST0

   ;

*#################### BLOCK D: DEFINITION OF MODEL VARIABLES #############
*This block defines the variables (both exogenous and endogenous) that will
*be included in the model. The block ends with the specification of tolerance
*level for the model. The tolerance levels ensure that the solution derived
*is consistent with theory. For example prices are restricted to be positive.

VARIABLES

*PRICES BLOCK
   ER        EXCHANGE RATE
   PD(I)     DOMESTIC PRICES
   PM(I)     DOMESTIC PRICE OF IMPORTS
   PE(I)     DOMESTIC PRICE OF EXPORTS
   PK(I)     RATE OF CAPITAL RENT BY SECTOR
   PX(I)     AVERAGE OUTPUT PRICE BY SECTOR
   PC(I)     PRICE OF CONSUMER COMPOSITE
   PVA(I)    VALUE ADDED PRICE BY SECTOR
   PWM(I)    WORLD MARKET PRICE OF IMPORTS
   PWE(I)    WORLD MARKET PRICE OF EXPORTS
   TM(I)     TARIFF RATES
   TE(I)     EXPORT DUTIES
   PGDP      GDP DEFLATOR
   PPI       PRODUCER PRICE INDEX
   CPI       CONSUMER PRICE INDEX

*PRODUCTION BLOCK

   Q(I)      COMPOSITE SUPPLY
   X(I)      TOTAL DOMESTIC OUTPUT BY SECTOR
   XD(I)     DOMESTIC SALES
   E(I)      EXPORTS BY SECTOR
   M(I)      IMPORTS
   GAMMA(I)  CET SHARE PARAMETER

* FACTORS BLOCK
   AD(I)     PRODUCTION FUNCTION SHIFT PARAMETER
   LAND(I)   LAND
   KG        PUBLIC CAPITAL STOCK
   KP(I)     CAPITAL STOCK BY SECTOR
   KI(I)     CAPITAL SHARES
   WA(LC)    AVERAGE WAGE RATE BY SKILL
   LS(LC)    LABOR SUPPLY BY SKILL
   L(I,LC)   EMPLOYMENT BY SECTOR AND SKILL
   RS(I)     LAND RENTAL
   RK(I)     SECTORAL PROFIT
   R(I)      PROFIT RATE BY SECTOR
   RBAR      WEIGHTED AVERAGE PROFIT RATE
   ADJ       INVESTMENT ADJUSTMENT PARAMETER

*DEMAND BLOCK

   ND(I)     INTERMEDIATE USES
   CBASE(I,HH) SUBSISTENCE CONSUMPTION
   CD(I,HH)  FINAL DEMAND FOR PRIVATE CONSUMPTION
   GD(I)     FINAL DEMAND FOR GOVERNMENT CONSUMPTION
   ID(I)     FINAL DEMAND FOR PRODUCTIVE INVESTMENT
   DEPRC(I)  DEPRECIATION EXPENDITURE
   GDPVA     TOTAL VALUE ADDED AT FACTOR COST
   RGDP      REAL GDP AT FACTOR COST
   RMIT(HH)  REMITTANCES (US DOLLARS)
   Y(HH)     GROSS FACTOR INCOME
   YD(HH)    PRIVATE DISPOSABLE INCOME
   MPS(HH)   MARGINAL PROPENSITY TO SAVE OUT OF YD
   DTAX(HH)  DIRECT TAX RATE
```

```
   ITAX(I)   INDIRECT TAX RATE
   GR        GOVERNMENT REVENUE
   TARIFF    TARIFF REVENUE
   INDTAX    INDIRECT TAX REVENUE
   DUTY      EXPORT DUTY REVENUE
   TRNS(HH)  TRANSFERS
   DIRTAX(HH) DIRECT TAX REVENUE
   DINT(HH)  DOMESTIC INTEREST PAYMENTS
   FINT      FORIGN INTEREST PAYMENTS (Usd)
   GDTOT     TOTAL GOVERNMENT CONSUMPTION
   HHSAV(HH) TOTAL HOUSEHOLD SAVINGS
   GOVSAV    GOVERNMENT SAVINGS
   DEPRECIA  TOTAL DEPRECIATION EXPENDITURE
   IMAT(I,J) INPUT-OUTPUT COEFFICIENTS
   SAVING    TOTAL SAVINGS
   AID       FOREIGN SAVINGS
   DRES      CHANGE IN RESERVES
   INVEST    TOTAL INVESTMENT
   DKG       PUBLIC INVESTMENT
   DK(I)      INVESTMENT BY DESTINATION
   HW(HH)    HOUSEHOLD SIZE WEIGHT
   OMEGA     OBJECTIVE FUNCTION

* UPDATING VARIABLES
   KGUP      PUBLIC CAPITAL STOCK ACCUMULATION
   KPUP(I)   CAPITAL STOCK ACCUMULATION
   ADUP(I)   TFP UPDATING VARIABLE
   LG(LC)    LABOUR SUPPLY GROWTH RATE
   LSUP(LC)  LABOUR SUPPLY GROWTH
   COUNT     COUNTER


   ;

*#################### BLOCK E: MODEL EQUATIONS ##########################
* This block lists the equation names for the model. The equations are
* then specified in the following blocks.

 EQUATIONS

*PRICE BLOCK

   PMDEF(I)         DEFINITION OF DOMESTIC IMPORT PRICES
   PEDEF(I)         DEFINITION OF DOMESTIC EXPORT PRICES
   CONSUMP(I)       DEFINITION OF COMPOSITE GOODS PRICES
   SALES(I)         DEFINITION OF COMPOSITE OUTPUT PRICES
   ACTP(I)          DEFINITION OF VALUE ADDED ACTIVITY PRICES
   PVAPUB(I)        DEF OF PUB. SEC. VALUE ADDED PRICE
   PKDEF(I)         DEFINITION OF CAPITAL GOODS PRICE
   PGDPDEF          DEFINITION OF GDP DEFLATOR
   PPIDEF           DEFINITION OF PRODUCER PRICE INDEX
   CPIDEF           DEFINITION OF CONSUMER PRICE INDEX

*OUTPUT BLOCK

   ACTEQ(I)          PRODUCTION FUNCTION
   PROFITMAX(I,LC)   FIRST ORDER CONDITION FOR PROFIT MAXIMUM
   LMEQUIL(LC)       LABOR MARKET EQUILIBRIUM
   CET(I)            CET FUNCTION
   ESUPPLY(I)        EXPORT SUPPLY
   ARMINGTON(I)      COMPOSITE GOOD AGGREGATION FUNCTION
   COSTMIN(I)        FIRST ORDER CONDITION FOR COMPOSITE GOOD
   XDSN(I)           DOMESTIC SALES FOR NONTRADED SECTORS
   QSN(I)            COMPOSITE GOODS FOR NONTRADED  SECTORS
   XGD(I)            GOVERNMENT SECTOR BALANCE
   LANDRENT(I)       SECTORAL RENTAL INCOME
   CAPRENT(I)        SECTORAL GROSS PROFIT

*DEMAND BLOCK

   NDEQ(I)           TOTAL INTERMEDIATE USES
   CDEQ(I,HH)        PRIVATE CONSUMPTION BEHAVIOUR
   DEPREQ(I)         SECTORAL DEPRECIATION
   GDPEQ             VALUE ADDED GDP AT FACTOR COST
   RGDPEQ            REAL GDP AT FACTOR COST
   YEQR(HH)          RURAL HOUSEHOLD GROSS FACTOR INCOME
   YEQU(HH)          URBAN UNSKILLED HOUSEHOLD GROSS FACTOR INCOME
   YEQS(HH)          URBAN SKILLED HOUSEHOLD GROSS FACTOR INCOME
   YDEQ(HH)          DISPOSABLE PRIVATE INCOME
   GDEQ              GOVERNMENT CONSUMPTION BEHAVIOUR
   GREQ              GOVERNMENT REVENUE
   TARIFFDEF         TARIFF REVENUE
   INDTAXDEF         INDIRECT TAXES ON DOMESTIC PRODUCTION
   DUTYDEF           EXPORT DUTIES
   DIRTAXDEF(HH)     DIRECT INCOME TAXES

*SAVINGS-INVESTMENT BLOCK

   KPROF(I)          SECTORAL PROFIT RATES
   KPROFAV           WEIGHTED AVERAGE PROFIT RATE
   HHSAVEQ           HOUSEHOLD SAVINGS
   GRUSE             GOVERNMENT SAVINGS
   DEPRECIAQ         DEPRECIATION EXPENDITURE
   TOTSAV            TOTAL SAVINGS
   TOTINV            TOTAL INVESTMENT
   KSHARE(I)         CAPITAL STOCK SHARES
   PRODINV(I)        INVESTMENT BY SECTOR OF DESTINATION
   IEQ(I)            INVESTMENT BY SECTOR OF ORIGIN


*BALANCE OF PAYMENTS

   CAEQ              CURRENT ACCOUNT BALANCE (US dollars)

*MARKET CLEARING

   EQUIL(I)         CONSUMER GOODS MARKET EQUILIBRIUM
   OBJ               OBJECTIVE FUNCTION
   ;
*+++++++++++++++++++++++ Tolerance Limits +++++++++++++++++++++++++++++++
```

```
PC.LO(IC)=0.00;
PD.LO(I)=0.00;
PM.LO(IM)=0.00;
PE.LO(IX)=0.00;
PK.LO(I)=0.00;
PX.LO(I)=0.00;
PWE.LO(IX)=0.00;
PWM.LO(IM)=0.00;

Q.LO(IC)=0.00;
X.LO(I)=0.00;
M.LO(IM)=0.00;
E.LO(IX)=0.00;
XD.LO(I)=0.00;
ND.LO(I)=0.00;
L.LO(I,LC)=0.00;
CD.LO(IC,HH)=0.00;
*################### BLOCK F: EQUATION DEFINITION #######################
* Having defined the equation names, this block finally specifies the
* equations of the CGE model.


*PRICES BLOCK

 PMDEF(IM)..       PM(IM) =E= PWM(IM)*ER*(1 + TM(IM)) ;

 PEDEF(IX)..       PE(IX) =E= PWE(IX)*ER*(1-TE(IX)) ;

 CONSUMP(IC)..     PC(IC)*Q(IC) =E= PD(IC)*XD(IC) + (PM(IC)*M(IC))$IM(IC);

 SALES(I)..        PX(I)*X(I) =E= PD(I)*XD(I) +(PE(I)*E(I))$IX(I) ;

 ACTP(I)..         PX(I) =E= PVA(I) + SUM(J,IO(J,I)*PC(J) ) ;

 PVAPUB("PUB")..   PVA("PUB") =E= (SUM(LC, WA(LC)*WDIST("PUB",LC)*L("PUB",
LC)))/ X("PUB") ;

 PKDEF(I)..         PK(I) =E= SUM(JP, PC(JP)*IMAT(JP,I) );

 PPIDEF..          PPI   =E= SUM(I, WP(I)*PX(I) );

 CPIDEF..          CPI   =E= SUM(I, WC(I)*PC(I));

 PGDPDEF..         PGDP  =E= GDPVA / RGDP ;


*OUTPUT AND FACTORS OF PRODUCTION BLOCK


 ACTEQ(I)..    X(I) =E=
AD(I)*LAND(I)**ALPHS(I)*PROD(LC$WDIST(I,LC),L(I,LC)**ALPHL(LC,I))*
                            KP(I)**ALPHK(I)*KG**ALPHG(I);

 PROFITMAX(I,LC)$WDIST(I,LC).. WA(LC)*WDIST(I,LC)*L(I,LC) =E=
X(I)*PVA(I)*ALPHL(LC,I) ;
```

```
 LMEQUIL(LC)..     SUM(I, L(I,LC)) =E= LS(LC) ;

 CET(IX)..     X(IX) =E=
AT(IX)*(GAMMA(IX)*E(IX)**(1+1/EPST(IX))+(1-GAMMA(IX))*XD(IX)**(1+1/EPST(IX)))**
(1/(1+1/EPST(IX))) ;

 ESUPPLY(IX)..     E(IX)/XD(IX) =E= (
PE(IX)/PD(IX)*(1-GAMMA(IX))/GAMMA(IX))**(EPST(IX)) ;

 ARMINGTON(IM).. Q(IM) =E= AC(IM)*(DELTA(IM)*M(IM)**(1-1/EPSC(IM))
                 +(1-DELTA(IM))*XD(IM)**(1-1/EPSC(IM)))**(1/(1-1/EPSC(IM)));

 COSTMIN(IM)..   M(IM)/XD(IM) =E=
(PD(IM)/PM(IM)*DELTA(IM)/(1-DELTA(IM)))**(EPSC(IM)) ;

 XDSN(INX)..       XD(INX) =E= X(INX) ;

 QSN(INM)..        Q(INM)  =E= XD(INM) ;

 XGD("PUB")..      X("PUB") =E= GD("PUB");

 LANDRENT(I)..     RS(I) =E= ALPHS(I)*X(I)*PVA(I);

 CAPRENT(I)..      RK(I) =E= PVA(I)*X(I) - RS(I) - SUM(LC,
WA(LC)*WDIST(I,LC)*L(I,LC));

*DEMAND BLOCK

 NDEQ(I)..         ND(I) =E= SUM(J, IO(I,J)*X(J) )  ;

 CDEQ(IC,HH)..    PC(IC)*(1+ITAX(IC))*CD(IC,HH) =E=
((PC(IC)*(1+ITAX(IC)))**(1-SIGC)*CLES(IC,HH)**SIGC /
                  SUM(JC,(PC(JC)*(1+ITAX(JC)))**(1-SIGC)*CLES(JC,HH)**SIGC))*
                  ((1-MPS(HH))*YD(HH)-SUM(JC,
PC(JC)*(1+ITAX(JC))*CBASE(JC,HH)))+ PC(IC)*(1+ITAX(IC))*CBASE(IC,HH) ;

 DEPREQ(IP)..      DEPRC(IP) =E= DEPR(IP)*KP(IP)*PK(IP) ;

 GDPEQ..           GDPVA =E= SUM(I, (PVA(I)*X(I)))  ;

 RGDPEQ..          RGDP =E= SUM(I, X(I) - ND(I)) ;

 YEQR("RURAL")..    Y("RURAL") =E= SUM(IR, (PVA(IR)*X(IR)));

 YEQU("URBU")..     Y("URBU") =E= SUM(IU, WA("UNSK")*WDIST(IU,"UNSK")
                                 *L(IU,"UNSK"));

 YEQS("URBS")..     Y("URBS") =E= SUM(IU, (PVA(IU)*X(IU)))-Y("URBU");

 YDEQ(HH)..        YD(HH) =E= Y(HH)*(1-DTAX(HH))+ ER*RMIT(HH) +
TRNS(HH)+DINT(HH);

 KPROF(IP)..       R(IP) =E= RK(IP) / (PK(IP)*KP(IP)) ;

 KPROFAV..         RBAR =E= SUM(IP, RK(IP)) / SUM(IP, PK(IP)*KP(IP));
```

```
 HHSAVEQ(HH)..     HHSAV(HH) =E= MPS(HH)*YD(HH);

 GREQ..            GR =E= TARIFF + DUTY + INDTAX  + SUM(HH, DIRTAX(HH));

 GDEQ..            GDTOT =E= (PVA("PUB") + SUM(JP,
IO(JP,"PUB")*PC(JP)))*GD("PUB") ;

 GRUSE..           GOVSAV =E= GR - GDTOT -
SUM(HH,TRNS(HH))-SUM(HH,DINT(HH))-ER*FINT;

 TARIFFDEF..       TARIFF =E= SUM(IM, TM(IM)*M(IM)*PWM(IM) )*ER ;

 INDTAXDEF..       INDTAX =E= SUM(IC, ITAX(IC)*PC(IC)*SUM(HH, CD(IC,HH)));

 DIRTAXDEF(HH)..   DIRTAX(HH) =E= Y(HH)*DTAX(HH) ;

 DUTYDEF..         DUTY =E= SUM(IX, TE(IX)*E(IX)*ER*PWE(IX));

 DEPRECIAQ..       DEPRECIA =E= SUM(IP, DEPRC(IP)) ;

 TOTSAV..          SAVING  =E= SUM(HH, HHSAV(HH)) + GOVSAV + AID*ER ;

 KSHARE(IP)..       KI(IP) =E= KP(IP) / SUM(JP, KP(JP)) ;

 PRODINV(IP)..      PK(IP)*DK(IP) =E= KI(IP)*(1+ ADJ*(R(IP) -
RBAR))*(SAVING-ER*DRES-PK("PUB")*(DK("PUB")+DKG));

 IEQ(IP)..          ID(IP) =E= SUM(JP,
IMAT(IP,JP)*DK(JP))+IMAT(IP,"PUB")*(DK("PUB")+DKG);

 TOTINV..          INVEST =E= SUM(I, ID(I)) ;

 CAEQ..            SUM(IM, PWM(IM)*M(IM)) +FINT +DRES =E= SUM(IX,PWE(IX)*E(IX))
+ AID + SUM(HH, RMIT(HH));

*MARKET CLEARING

 EQUIL(I)..        Q(I) =E= SUM(HH, CD(I,HH))+ ND(I) + ID(I) + GD(I);

 OBJ..              OMEGA =E= SUM(HH, HW(HH)*(SUM(IC, CLES(IC,HH)*

(CD(IC,HH)-CBASE(IC,HH))**(1-1/SIGC))**(1/(1-1/SIGC)))
                          *X("PUB")**GLES);


*#####BLOCK G: INITIALIZATION OF ENDOGENOUS VARIABLES AND CLOSURE RULES ####
* The following block set intial values for all the variables of the
* model and then establishes the closure rule of the model by specifying the
* value of the exogenous variables in the model.
* We set the initialization out in three steps: endogenous variables,
* exogenous variables, and a block of variables whose status will depend on
* the definition of the steady state.

*+++++++++++++ I. Endogenous Variable Initialization ++++++++++++++++++++++
*PRICES

 PD.L(I)  = PD0(I);
 PM.L(I)  = PM0(I);
 PE.L(I)  = PE0(I);
 PK.L(I)  = PK0(I);
 PX.L(I)  = PD0(I);
 PC.L(I)  = PC0(I);
 PVA.L(I) = PVA0(I);
 PGDP.L   = PGDP0;
 PPI.L    = PPI0;
 CPI.L    = CPI0 ;

*PRODUCTION

 Q.L(I)   = Q0(I) ;
 X.L(I)   = X0(I);
 XD.L(I)  = XD0(I);
 E.L(I)   = E0(I);
 M.L(I)   = M0(I);

*FACTORS

 WA.L(LC) = WA0(LC);
 L.L(I,LC)= XLE0(I,LC);
 RS.L(I)  = RS0(I) ;
 RK.L(I)  = RK0(I);
 KI.L(I)  = KI0(I) ;
 R.L(I)   = R0(I);
 RBAR.L   = RBAR0;

*DEMAND

 ND.L(I)      = ND0(I);
 CD.L(I,HH)   = CD0(I,HH);
 ID.L(I)      = ID0(I);
 GDPVA.L      = GDPVA0 ;
 RGDP.L       = RGDP0 ;
 Y.L(HH)      = Y0(HH);
 YD.L(HH)     = YD0(HH);
 GR.L         = GR0;
 TARIFF.L     = TARIFF0;
 INDTAX.L     = INDTAX0 ;
 DUTY.L       = DUTY0;
 DIRTAX.L(HH) = DIRTAX0(HH);
 GDTOT.L      = GDTOT0 ;
 HHSAV.L(HH)  = HHSAV0(HH);
 DEPRECIA.L   = DEPRECA0 ;
 GOVSAV.L     = GOVSAV0;
 SAVING.L     = SAVING0 ;
 INVEST.L     = INVEST0 ;
 DK.L(IP)     = DK0(IP);
 DEPRC.L(I)   = DEPRC0(I);


*++++++++++++++++++ II. Exogenous Variable Specification++++++++++

 COUNT.FX       = 2001 ;
```

```
 GAMMA.FX(I)    = GAMMA0(I);
 LS.FX(LC)      = LS0(LC);
 PWM.FX(I)      = PWM0(I);
 PWE.FX(I)      = PWE0(I);
 TM.FX(I)       = TM0(I);
 TE.FX(I)       = TE0(I);
 ITAX.FX(I)     = ITAX0(I);
 AID.FX         = AID0;
 RMIT.FX(HH)    = RMIT0(HH);
 TRNS.FX(HH)    = TRNS0(HH);
 ER.FX          = ER0;
 CBASE.FX(IC,HH)= CBASE0(IC,HH);
 MPS.FX(HH)     = MPS0(HH);
 DTAX.FX(HH)    = DTAX0(HH);
 ADJ.FX         = ADJ0;
 AD.FX(I)       = AD0(I) ;
 LAND.FX(I)     = LAND0(I);
 IMAT.FX(I,J)   = IMAT0(I,J);
 HW.FX(HH)      = HW0(HH);
 DK.FX("PUB")   = DK0("PUB");
 DKG.FX         = DKG0 ;
 KG.FX          = KG0;
 KP.FX(I)       = KP0(I);
 GD.FX("PUB")   = GD0("PUB");
 DINT.FX(HH)    = DINT0(HH);
 FINT.FX        = FINT0;
 DRES.FX        = DRES0;

*++++++++++++++++++++++++++++++++++++++

* Finally, to avoid problems for the solver, we specify certain zero-value
* constraints from the SAM.

 M.FX(INM)  = 0;
 E.FX(INX)  = 0;
 E.FX(IN)  = 0;
 CD.FX("PUB",HH) = 0;
 CD.FX("CCROP",HH)=0;
 GD.FX(IP)=GD0(IP);
 RS.FX("CCROP")=0;
 RS.FX(IU)=0;
 DTAX.FX("RURAL")=0;

*#################### BLOCK H: SOLVE AND DISPLAY #########################
* This section sepcifies the model and requests GAMS to solve the model by
* maximizing the objective function which is a Cobb Douglas utility
* function in private consumption. The recursive dynamics of the model are
* provided by nesting the solve statement within a loop defined over the
* simulation period T.

MODEL UGANDA /ALL / ;

DISPLAY  "DYNAMIC REAL CGE MODEL FOR UGANDA  ";

OPTION ITERLIM = 1000
LIMROW=6 , LIMCOL=0 , SOLPRINT=ON ;

*FILE UGA01;
*FILE UGA02;
FILE UGA03;

LOOP(T, SOLVE UGANDA MAXIMIZING OMEGA USING DNLP;

* The following "include" statement reads EXTREAL.GMS which generates
* an ASCII file for reading into a spreadsheet
*-----------------------------------------------------
*This block runs the extract file for HIPC ratios

UGA03.AP=1 ;
PUT UGA03  ;
UGA03.PC=5 ;
$INCLUDE D:\DFID\UGRER\EXUGA03.GMS


*-----------------------------------------------------
*This block runs the extract file for KG and OMEGA

*UGA02.AP=1 ;
*PUT UGA02  ;
*UGA02.PC=5 ;
*$INCLUDE D:\DFID\UGRER\EXUGA02.GMS


*-----------------------------------------------------
*This block runs the extract file for the full output

*UGA01.AP=1 ;
*PUT UGA01  ;
*UGA01.PC=5 ;
*$INCLUDE D:\DFID\UGRER\EXUGA01.GMS

*-----------------------------------------------------

* The solution loop now continues to update the capital stock and
* labour supply and to implement the experiments.


   KPUP.FX(IP)=(KP.L(IP)*(1-DEPR(IP)))+DK.L(IP) ;
   KPUP.FX("PUB")=(KP.L("PUB")*(1-DEPR("PUB")))+DK.L("PUB") ;
   KGUP.FX = KG.L*(1-DEPR("PUB")) + DKG.L ;
   KG.FX = KGUP.L ;
   KP.FX(I)=KPUP.L(I) ;
   LG.L(LC) = LG0(LC);
   LSUP.FX(LC)=LS.L(LC)*(1+LG.L(LC));
   LS.FX(LC)=LSUP.L(LC);


 DISPLAY KP.L, LS.L ;

    COUNT.FX = COUNT.L +1 ;
    IF(COUNT.L GE 2002,
```

```
* Set investment sensitivity

    ADJ.FX = 0.75 ;
    GAMMA.FX("MAN")=GAMMA0("MAN")*GAMSHIFT("GAMMAZ","MAN");
    GAMMA.FX("FOOD")=GAMMA0("FOOD")*GAMSHIFT("GAMMAZ","FOOD");

* Aid-financed increase in KG ;

     AID.FX=AID0*1.125;
*    dres.fx=dres0+0.03;
     dkg.fx=dkg0+((aid.l-aid0-(dres.l-dres0))*er.l)/pk.l("pub");


* Aid-financed increase in GD(pub) ;

*   AID.FX=AID0*1.125 ;
*
gd.fx("pub")=gd0("pub")+(((aid.l-aid0)*er.l)/px.l("pub"))/(1+KP.l("pub")/X.l("p
ub"));
*
DK.fx("pub")=dk0("pub")+((aid.l-aid0)*er.l)/px.l("pub")-gd.l("pub")+gd0("pub");
    );

    IF(COUNT.L GE 2003,

    );

    IF(COUNT.L GE 2004,

*    dk.fx("pub")=dk0("pub")*(1+depr("pub"));
*    gd.fx("pub")=gd0("pub")+((aid.l-aid0)*er.l)/px.l("pub");

    );

    IF(COUNT.L GE 2005,

    );

    IF(COUNT.L GE 2006,

    );
    );

* End of Loop
*################## END OF MODEL ###########################
```