The economy wide impact of HIV/AIDS and the funding dilemma in Africa: Evidence from a dynamic life cycle horizon of Uganda[1]

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Paper presented at the International Conference on Economic Modelling - EcoMod2015
Boston, USA
July 15-17, 2015

[1]This paper was produced as part of ***RethinkHIV***, a consortium of researchers on the economics of HIV. ***RethinkHIV*** is funded by the **Rush Foundation** and comprises of researchers from University of Oxford, Harvard University, Imperial College London and the London School of Hygiene and Tropical Medicine. Other members of the consortium have made valuable contributions and suggestions on the paper, and we specifically acknowledge Paul Collier, Olivier Sterck, Richard Manning, Rifat Atun, Angela Chang, Tim Hallett, Osondu Ogbuoji, Michelle Remme, Sachin Silva, Mariana Siapka, Mikaela Smit, Anna Vassall, Charlotte Watts and Marina Galanti for useful comments and discussions. We acknowledge Hans Lofgren, at the World Bank and Martin Cicowiez who provided the model code and technical assistance with the model.
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Abstract
Despite remaining a major killer in Africa, the HIV pandemic has been tamed medically into a chronic disease through advances in treatment drugs – antiretroviral therapies (ARTs). However, the full economic costs, over a lifecycle horizon, of keeping people on treatment and implementing prevention measures, are still not fully quantified and are still unfolding. Indeed, the economic effects of the HIV/AIDS disease, and also the economic effects of various interventions need to be better understood. Sub-Saharan Africa (SSA) disproportionately bears the burden of HIV/AIDS compared to the rest of the word. This paper analyses the long-term economic effects of HIV/AIDS using a computable general equilibrium (CGE) model. Taking Uganda as a case study for analysis, the paper aims to predict the economic impact of HIV/AIDS through: (i) the human resource channel and, (ii) the source of fiscal space for HIV/AIDS channel, and proposes policy options for funding HIV interventions in the long-term. The paper shows that if the government intervenes by scaling up treatment and prevention of HIV, the negative economic impacts of HIV/AIDS – including the soaring cost of production due to rising wages, declining GDP growth rates relative to the base, and the rising domestic debt as share of GDP – are reversed. The economy thrives from a growing labour force supply and resource flows to HIV interventions. Foreign-aid and direct taxation are both potential sources of fiscal space for HIV albeit with differential impacts on sectoral growth and government debt levels. The study demonstrates that low-income-countries (LICs) like Uganda have the capacity to mobilise domestic resources to fund HIV interventions by increasing revenues from direct taxes. It is recommended that policymakers – in Uganda and other LICs grappling with similar challenges – devise means to increase revenue from direct taxes particularly by tapping into the large informal sector. The paper also proposes that in the short to medium term, development-aid for health be increased in order for government to meet the future HIV/AIDS obligations. Overall, the research findings strengthen the case for policy makers to frontload investment in HIV treatment and prevention.

Keywords: Computable General Equilibrium, disease, treatment, prevention, policy, development, growth, HIV, Uganda
JEL classification: D580, I130, 011

1 Introduction

Despite remaining a major killer in Africa, the HIV pandemic has been tamed medically into a chronic disease through advances in treatment drugs – antiretroviral therapies (ARTs). However, the full economic costs, over a lifecycle horizon, of keeping people on treatment and implementing prevention measures, are still not fully quantified and are still unfolding. Indeed, the economic effects of the HIV/AIDS disease, and also the economic effects of various interventions need to be better understood. Sub-Saharan Africa (SSA) disproportionately bears the burden of HIV/AIDS compared to the rest of the word. Over 70% of the people living with HIV (PLHIV) are resident in SSA, of which 82% are adults (UNAIDS, 2010, 2014). The commitment by governments to provide HIV treatment (ART) to those who need it constitutes a long-term financial liability which can be conceptualised as a debt liability (Haacker, 2011). On the other hand, it is also evident that development assistance for health (DAH) has significantly shifted away from HIV/AIDS and its sustainability is not certain (Institute for Health Metrics and Evaluation (IHME), 2014a).

The purpose of this paper is to assess the long-term economic impact of HIV/AIDS taking into account various modes of funding HIV/AIDS interventions, using a computable general equilibrium (CGE) model. Taking Uganda as a case study for analysis, this paper specifically aims to: (i) predict the economic impact of AIDS through the human resource impact channel and the source of fiscal space for HIV/AIDS impact channel, and (ii) propose policy options for funding HIV interventions in the long-term. Uganda is purposefully selected as a case study to reflect a country with high prevalence rates of HIV and currently resource-constrained but with prospects of future natural resource exploitation. The paper sets a contrast between an AIDS scenario without targeted treatment and prevention strategies versus a scenario of AIDS with targeted treatment and prevention strategies, funded from specific sources of fiscal space for health (HIV/AIDS). This study extends the previous CGE methodologies by incorporating updating equations that capture the cost impact channels of HIV/AIDS interventions and the source of fiscal space for HIV. Specifically, given the long term debt liability feature of HIV interventions, we explicitly model the increase in government health spending resulting from additional spending due to HIV/AIDS financed by foreign grants, direct taxes or foreign borrowing. We report the impact on economy-wide wages/rents, sectoral growth rates and GDP shares, the country's debt burden, in addition to the impact on growth rate in GDP, investment, consumption, exports and imports.

The main contribution of this research is that the findings strengthen the case for policy makers to frontload investment in HIV treatment and prevention. There are many benefits of doing so. The results show the negative impact of HIV prevalence in Uganda if government does not implement targeted treatment and prevention strategies. Relative to the base case, the economy experiences an increase in the cost of production from the rising cost of labour, all sectors of the economy shrink, and overall GDP growth rates decline while the domestic government debt as a share of GDP rises. On the other hand, if the government intervenes by scaling up treatment and prevention of HIV, the negative impacts are reversed and the economy thrives from a growing labour force supply and resource flows to HIV interventions. Foreign-aid and direct taxation are both potential sources of fiscal space for HIV albeit the differential impacts on sectoral growth and government debt levels. The results demonstrate that there is capacity for Uganda – and other LICs grappling with similar fiscal challenges - to mobilise domestic resources to fund HIV interventions by increasing revenues from direct taxes. This paper also proposes that in the short to medium term, aid-for-health be increased in order for government to meet the future HIV/AIDS obligations. The rest of this paper is structured as follows. Section 2 presents stylized facts for Uganda about the HIV status. The methodology in Section 3 describes the model and its application to Uganda, and the design of the simulation scenarios describing the HIV impact channels modelled. Section 4 presents the results while Section 5 discusses and concludes the paper.

2 HIV/AIDS in Africa: Some stylized facts for Uganda

Uganda has the highest adult prevalence rate of HIV in the East African region. By the end of 2013, the HIV prevalence for ages 15-49 years was 7.3% compared to 6% in Kenya, 5% in Tanzania, 2.9% in Rwanda and 1.3% in Burundi (World Health Organisation, 2014). The AIDS Indicator Surveys: 2004-05 and 2011, indicate that the epidemic has consistently affected women disproportionately compared to men (Uganda AIDS Commission, 2014). Table 1 shows the prevalence of HIV among adults between the two surveys for different regions in the country.

Table 1a HIV prevalence among 15-49 year olds in Uganda

	2004-05			2011		
Region	Female	Male	Total	Female	Male	Total
Central	10.2	6.6	8.5	11.1	8.2	9.8
Kampala	11.8	4.5	8.5	9.5	4.1	7.1
East Central	7.5	5.2	6.5	6.7	4.8	5.8
Eastern	6.2	4.4	5.3	4.4	3.8	4.1
North East	3.6	3.2	3.5	5.3	5.2	5.3
North Central	9.0	7.1	8.2	10.1	6.3	8.3
West Nile	2.7	1.9	2.3	4.7	5.0	4.9
Western	7.8	5.7	6.9	9.1	7.1	8.2
Southwest	7.1	4.4	5.9	9.0	6.6	8.0
Total	7.5	5.0	6.4	8.3	6.1	7.3

Source: Uganda AIDS Commission (2014)

The national response to HIV/AIDS in Uganda dramatically reduced prevalence rates from 18.8% in 1992 to 6.4% in 2004/05. However, the prevalence rate has since increased to 7.3% in 2013. The resurgence of new infections calls for concerted efforts to reverse the trend. At the policy level, the National AIDS Policy 2010, the revised National Strategic Plan (NSP) for HIV & AIDS 2011 – 2015, based on the two-year National Priority action Plans (NPAP) were developed to consolidate efforts to combat the epidemic. However, implementation of the envisaged strategies is hampered by lack of funding. For instance the NPAP 2012/13 resource estimates for HIV interventions indicated a 41% gap in resources in flows (Uganda AIDS Commission, 2011). Consequently, under the treatment and care target, only 69.4% of all ART-eligible PLHV were on treatment by September 2013, based on 2010 WHO ART guidelines. Moreover, the achievement rate drops to 40% when the 2013 WHO ART eligibility guidelines are used. Other planned activities in prevention, social support and health system strengthening have also experienced a decline in funding. Table 1b shows the financial gap from the NSP estimates under the full financing scenario for 2011/12 – 2014/15.

Table 1b Financial gap under the full funding scenario (US $ Millions)

NSP estimates (full funding)	2011/12	2012/13	2013/14	2014/15	Totals
Projected inflow	585.35	756.33	933.2	1,136.50	3,411.37
Government of Uganda	42	42	42	42	168
Others	376.08	412.9	397.54	409.53	1596.05
Total Projected inflows	418.08	454.9	439.54	451.53	1764.05
Funding gap	167.27	301.43	493.66	684.97	1647.32
Funding gap (% of total estimate)	28.6%	39.9%	52.9%	60.3%	48.3%

Source: National Strategic Plan for HIV 2011/12 – 2014/15

HIV spending as a share of GDP has been rising steadily, reaching about 3.7% in 2008/09 (Uganda AIDS Commission, 2012). Funding for HIV programmes in Uganda is largely from external sources. For instance, the government contribution to the total NPAP resource estimates in 2012/13 was only 5.6%, falling short of the NSP target of 15%. Moreover, it is argued that commitment to higher than current levels of treatment and care for PLHIV would raise Uganda's financial liabilities[4] to 59% of GDP (Atun et al., 2015). Additionally, a recent study on the moral duty of rescue for PLHIV has indicated that Uganda can only afford 46.7% of the total aggregated cost of ART, which is estimated at 21.1% of GDP for the period 2015 - 2050[5](Collier, Sterck, & Manning, 2015). Furthermore, a multi-country study that measured HIV spending against total health sector spending indicated that Uganda was spending about 50% of its health budget on HIV (Amico, Aran, & Avila, 2010). This finding resonates with another recent study on potential sources of domestic financing for HIV in Uganda which found that there was no room for reprioritizing HIV in the health sector budget (Remme et al., 2015). However, the same study on potential sources of fiscal space finds that economic growth and government revenue generation are some of the potential sources of additional funding for HIV in Uganda. Additionally, in establishing the National AIDS Trust Fund the government proposes a tax on direct incomes as one of the sources for the Fund. Given the established position on the fiscal dimensions of HIV responses, we are motivated to model the economy-wide impact of HIV mitigating strategies by creating fiscal space for HIV from accelerated growth in direct taxes' revenue (see description of simulation scenarios in Section 3.3).

3 Methodology

The main channels through which HIV/AIDS impacts the economy are labour quantity and quality, total factor productivity, and the quantity of savings (and investment). Specifically, the prevalence of HIV/AIDS generates both direct and indirect effects which can be captured at three levels of economic analysis. First, at the micro level, the household experiences increased costs of healthcare expenditure. Additionally, the household faces indirect costs of reduced earnings and income when the productive household members are infected. Second, at the meso level, sectors that are labour intensive are faced with lower labour productivity. Also the increased demand for healthcare implies that the health sector incurs higher budget allocations, which may necessitate a reduction of the budgets of other government functions. Third, at the macro level, there is loss in economy-wide productivity due to increased absenteeism of sufferers and carers of sick people. Increased mortality from AIDS leads to a reduction in total labour force supply. There is a change in the skill composition of the labour force if AIDS affects one category of skilled labour relatively more. And

[4] Financial liability is calculated as the sum of debt levels and the present-value of the stock of future HIV liabilities.

[5] Note that this estimate is scaled up for HIV incidence and uses the 2010 WHO eligibility for ART at the 350 CD4 cells/mm3 thresholds. This means the cost could be much higher when the 2013 WHO guidelines for ART threshold - 500 CD4 cells/mm3- is used.

finally, aggregate savings decline as a result of households resorting to assets and savings for immediate health expenditures, and the reduced capacity to earn income.

Three types of macro models have been employed to evaluate the economic impact of HIV/AIDS. First, macro-econometric models have been employed to estimate the association of HIV/AIDS and growth in real GDP per capita and the impact of HIV on economic growth (Bloom & Mahal, 1997; Bonnel, 2000; McDonald & Roberts, 2006). For example, in a regression model of per capita growth rates on HIV prevalence for a cross-section of countries, Bloom and Mahal (1997) found little support that the AIDS epidemic hinders economic growth. The macro-econometric models employed in these studies are essentially of a partial equilibrium nature incapable of capturing the back and forth a linkage of the mechanisms through which HIV impacts the economy. For instance, they cannot reflect the economy-wide wage differentials arising from the skill-biased effect of HIV/AIDS or the shift in resources between the tradable and non-tradable sectors, through the exchange rate movements, which might occur as more external resources for HIV interventions enter the economy.

Second, macro-simulation models, designed around the one-sector neoclassical growth model, have been employed to study the macro-economic impact of HIV, mainly in Africa. This approach has been applied in Tanzania to estimate the potential path of GDP and GDP per capita in the presence of HIV/AIDS (Cuddington, 1993), Botswana by (MacFarlan & Sgherri, 2001), Kenya by (Robalino, Voetberg, & Picazo, 2002); and Swaziland, Botswana, Lesotho by (Anyanwu, Siliadin, & Okonkwo, 2013). Additionally, a simple growth model with one sector and one type of labour was used to estimate the fiscal dimension of HIV/AIDS in South Africa, Botswana, Swaziland and Uganda (Lule & Haacker, 2012). The macro-simulation models can only capture the HIV effects at an aggregate level and not at intermediate level such as the sectoral effects. They are single-sector-design models which are incapable of showing the differential impact of HIV on the various sectors, cannot capture the compensating effect of other sectors and could potentially overestimate the loss in aggregate output by not accounting for the shift in resources and output between sectors.

Third, computable general equilibrium (CGE) models have been used to overcome the shortcomings of the partial equilibrium techniques in estimating the economic impact of HIV/AIDS. Given the forward and backward linkages between different actors and sectors in the economy, CGE models specify equations that are capable of capturing the direct and indirect effects of HIV both at the sectoral and macro level. CGE models are capable of capturing the price-triggered substitution mechanisms during production, consumption and distribution of output, both within and between sectors. Additionally, CGE modelling is capable of analysing several policy shocks simultaneously to capture their combined effect as well as investigate effects of policy changes from internal or external shocks on macroeconomic variables. Overall, CGE models are a form of approximate numerical investigation that explores the size of policy effects and the direction (sign) of the net outcome. Hence CGE results are conventionally reported as deviations from the baseline equilibrium.

CGE modelling to assess the economic impact of HIV/AIDS has been empirically applied to some African countries and the Indian sub-continent. For example, the application to Cameroon specified 11 sectors; two factors: labour, disaggregated into rural, urban-unskilled and urban-skilled, and capital, and a single household sector (Kambou, Devarajan, & Over, 1992). The authors concluded that AIDS could potentially cut GDP growth by up to 50%. The South African application specified an economy comprising 14 sectors, five factors of production (professional, skilled, unskilled, informal labour, and physical capital); five household categories, and seven government functional spending categories (Arndt & Lewis, 2000, 2001). Both studies depict a decline in economic growth in the AIDS scenario although unemployment rates are reportedly the same between the AIDS and no-AIDS scenarios. In Botswana, the study designed proposals for HIV/AIDS interventions that aim to strengthen the health system service delivery to mitigate the spread of the pandemic (Dixon, McDonald, & Roberts, 2004). The authors found that the epidemic posed a serious reduction in potential consumption whereby up to 70% private consumption is lost. In a dynamic CGE micro-simulation model of Botswana employed to study the poverty and income distribution dimension, in addition to the impact on growth, AIDS treatment programs increase annual GDP growth by 0.4% relative to the no-treatment AIDS scenario (Thurlow, 2007). Another application to KwaZulu-Natal and South Africa used an integrated survey and a demographic model to estimate the impact of HIV/AIDS on growth and poverty (Thurlow, Gow, & George, 2009). The results showed that HIV/AIDS lowers economic growth by 1.4% and 1.6% per year in Kwa-Zulu Natal and the rest of South Africa respectively. The application to the Indian economy was mainly to understand the sectoral impacts of HIV/AIDS (Ojha & Pradhan, 2006). The "with-AIDS" scenario shows that sectors which use unskilled labour intensively were hit hardest to an extent of an 18% loss in value-added for the tourism sector for example. The Indian economy "with-AIDS" scenario predicts lower growth rates real in GDP and GDP per capita when compared with the "no-AIDS" scenario. The application to Uganda combines results from an aggregate macro model and a CGE model that analyses the economy at an aggregate level (Jefferis & Matovu, 2008). The CGE component of the results does not include intermediate impact on wages and sector outputs nor does it model the impact of an increase in direct tax revenue as a source of additional funding for HIV interventions.

The early studies using CGE modelling technique to evaluate the economy-wide impact of HIV/AIDS have concentrated on articulating the adverse effects of a decline in both quantity and quality of human capital. The majority of the studies assess the impact of HIV/AIDS through the main channels of population, labour supply and labour productivity growth. No study has articulated the impact of creating fiscal space for HIV interventions in Africa despite the fact that HIV interventions generate a long-term expenditure liability. The HIV/AIDS impact on the government budget and the sources of funding the HIV interventions have implications for the government debt. The impact of fiscal space for HIV on government debt is an important policy issue for low-income countries (LICs) like Uganda but has not been studied in the early CGE papers. To the best of our knowledge, there is no CGE application assessing the impact of HIV/AIDS and the funding dilemma of HIV/AIDS both at the aggregate and intermediate level in Uganda.

3.1 Model description and HIV/AIDS impact channels

The CGE model is a set of simultaneous equations specifying the behaviour of different actors in the economy. We use a recursive dynamic model in order to capture the lagged effects of HIV/AIDS related health effects and the HIV intervention investments over time. This model is an adaption of the "core" version of the Maquette for MDG Simulations (MAMS) model developed by the Word Bank group and documented in (Lofgren, Cicowiez, & Diaz-Bonilla, 2013). Technically the model is comprised of a static (within-period) equilibrium solution where producers maximise profit and consumers maximise utility in a given set of institutional constraints, and a dynamic (between-period) equilibrium solution. For the dynamic component, exogenous variables are updated to reflect changes in HIV/AIDS induced population and labour supply growth rates, capital accumulation and total factor productivity growth changes. Additionally, the HIV related government expenditure patterns and sources of funding are updated over the model period. The dynamic module captures the tracking of assets and liabilities of the households and the government, a feature that makes it suitable to predict the impact of HIV intervention cost on debt sustainability. In principle, the within-period model solution for period n forms the basis for the next model run for period $n+1$, the solution to which forms the basis for model run $n+2$, etc., to form a recursive dynamic.

3.1.1 Production and trade

Production by the various sectors in the economy is represented by activities, where each activity produces a “commodity” (good or service). Producers are assumed to maximise profit in perfectly competitive markets and the production is assumed to exhibit constant returns to scale. Production in each sector is defined by a nested two-level structure. At the top level, an aggregate value-added bundle is combined with an aggregate intermediate bundle using either constant elasticity of substitution (CES) or Leontief technology to produce the sector output. At the bottom level are CES production functions for factor input combinations to generate value-added and Leontief functions for intermediate input combinations. Equations (1)-(2) define the CES technology, (3)-(4) define the Leontief technology and (5) is the value-added equation.

$$QA_a = \alpha_{a_a}.\left[\delta_{a_a}.QVA_a^{-\rho_{a_a}} + (1-\delta_{a_a}).QINTA_a^{-\rho_{a_a}}\right]^{-\frac{1}{\rho_{a_a}}} \quad (1)$$

$$\frac{QVA_a}{QINTA_a} = \left[\frac{PINTA_a}{PVA_a}.\frac{\delta_{a_a}}{1-\delta_{a_a}}\right]^{\frac{1}{1+\rho_{a_a}}} \quad (2)$$

$$QVA_a = iva_a.QA_a \quad (3)$$

$$QINTA_a = inta_a.QA_a \quad (4)$$

$$QVA_a = \alpha va_a.\left[\sum \delta va_{f,a}.(fprd_{f,a}.QF_{f,a})^{-\rho va_a}\right]^{-\frac{1}{\rho va_a}} \quad (5)$$

where QA_a is quantity (level) of activity, QVA_a is quantity of (aggregate) value-added, $QINTA_a$ is quantity of aggregate intermediate input used in activity, $PINTA_a$ and PVA_a are intermediate input price and value-added price respectively, α_{a_a} is shift parameter for top level CES function, δ_{a_a} is a share parameter for top level CES function and ρ_{a_a} is a top level function exponent, iva_a is quantity of value-added per unit of activity a, $inta_a$ is quantity of aggregate intermediate input per unit of activity a , $\delta va_{f,a}$ is CES value-added function share parameter for factor f in activity a, ρva_a is CES value-added function exponent.

In the product market, a single sector produces one or more outputs and any commodity may be produced by and marketed by more than one sector. On the supply side, the allocation of domestic output between exports and domestic sales is determined using the assumption that domestic producers maximize profits, subject to imperfect transformability between these two alternatives. The production possibility frontier of the economy is defined by a constant elasticity of transformation (CET) function between domestic supply and export[6]. On the demand side, a composite commodity is made up of domestic demand and final imports and it is consumed by households, enterprises and the government. The Armington assumption[7] is adopted to distinguish

[6] The CET parameter is restricted to a positive but determinate value to reflect the case that a sector’s domestic sales and export sales may not necessarily be identical products. As a result, output is not perfectly substitutable across domestic and foreign markets. One sector may produce different products for the domestic market and the export market. In Uganda, for example, the agricultural sector produces bananas for domestic consumption while it produces coffee for the export market. Given the concave production possibility frontier, a determinate elasticity of transformation between bananas and coffee serves to highlight the fact that it becomes increasingly difficult, with given a fixed land acreage (and/or capital), to produce more bananas and less coffee or vice versa.

[7] The (Armington, 1969) assumption postulates that imports are differentiated from each other by country of origin and these form a group that is distinguishable from the domestically produced product. Thus, a consumer’s utility function is separable in types of goods according to preferences, and then the Armington

between domestically produced goods and imports. For each good, the model assumes imperfect substitutability in a CES function between imports and the corresponding composite domestic goods.

3.1.2 Households

Households receive factor income redistributed according to the value shares, given the factor endowment shares for each household. In addition, households earn income from net interest (the difference between net interest earnings from loans to government and net interest payments to the rest of the world), and receive transfers from other households, the government and the rest of the world.

$$YH_h = \sum YIF_{h,f} + YIINT_h + TR_{ng} + TR_g + \bar{e}.TR_{row} \quad (6)$$

$$YIINT_h = gintrat_h.GDEBT_h - fintrat_h.FDEBT_h.\bar{e} \quad (7)$$

where YH_h is income of household h, $YIINT_h$ is net interest income of household h, TR_{ng} is transfer from domestic non-government institutions to household h such as transfers from other households, $\mathrm{TR_g}$ is government transfer to household h, TR_{row} is transfers from the rest of the world to household h converted into local currency by the exchange rate $\bar{\mathrm{e}}$, $\mathrm{gintrat_h}$ is interest rate on government bonds ($GDEBT_h$) for household h and $fintrat_h$ is interest rate on foreign debt ($FDEBT_h$) for household h. Both domestic and international remittances are a significant source of household income in Uganda. Domestic remittances are common between migrant household members in urban areas who send money to their rural household members. Personal remittances[8] received in Uganda rose from 4.1% of GDP in 2010 to 4.4% in 2011 before declining to 3.8% in 2013 (World Bank, 2014).

Households use their income to pay direct taxes to government, for commodity consumption (disposable income after tax), transfers to other households and the remainder is saved according to each household's marginal propensity to save. A household's disposable income is allocated across different commodities consumption by maximizing a Stone-Geary utility function under a linear expenditure system (LES)[9].

3.1.3 Government

The government current revenue is earned from direct taxation of factors of production, indirect taxation from domestic production and commodity outputs and import tariffs, and transfers from domestic institutions and the rest of the world.

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assumption in a CES form is adopted for the sub-functions of each type of good distinguished into demand for the domestic product originating from the home country and the demand for the products originating from foreign countries. Thus, goods produced in different countries are imperfect but close substitutes with their domestic counterparts. The Armington CES form can be adopted at a third level of household budget allocation, where demand for foreign products is a function of the demand for each type of good supplied by each of the foreign countries. This is particularly important when there are several sources of imports and the aim is to evaluate the gains from trade such as the regional disaggregation in international trade in a South African model (Thurlow, 2008).

[8] According to the World Development Indicators published by the World Bank, personal remittances comprise of personal transfers and compensation of employees. Personal transfers consist of all current transfers in cash or in kind made or received by resident households to or from nonresident households. Personal transfers thus include all current transfers between resident and nonresident individuals. Compensation of employees refers to the income of border, seasonal, and other short-term workers who are employed in an economy where they are not resident and of residents employed by nonresident entities.

[9] In this regard therefore, a household's demand for a product is given by $Pc_iC_{i,h} = Pc_iC_{i,h}^{min} + \omega_{i,h}\left(CTH_h - \sum_h Pc_iC_{i,h}^{min}\right)$, where $\omega_{i,h}$ is marginal share of good i in total household consumption, $C_{i,h}^{min}$ is minimum consumption of good i, $C_{i,h}$ is household h consumption of good i (volume), and CTH_h is household h total consumption (value).

$$Y_G = \sum_i TI_i + \sum_i DTH_h + DTF + \sum_i TRG_{row} \quad (8)$$

$$TI_i = [(\sum tva_a . PVA_a . QVA_a) + (\sum te_c . Pwe_c E_c . \bar{e}) + (\sum tm_c . \overline{Pwm_c} M_c . \bar{e}) + (tq_c . PX_c . X_c)] \quad (9)$$

$$DTH_h = TYR_h . tyh_h . YH_h \quad (10)$$

$$TYR_h = 1 + \overline{TINSADJ}_h . tyh_h \quad (11)$$

$$DTF = tyf . YF \quad (12)$$

where Y_G is government income, $DTH_h$and DTF are receipts from direct taxation on households' and firm income respectively, TI_i is revenue from indirect taxes including value-added tax (VAT_i), export taxes (TE_i), import tariffs (TM_i), and sales tax (ST_i), and TRG_{row} is transfer to the government from the rest of the world. The parameter t_i defines a tax rate such that, tyh_h is direct tax rate on income of household h , tyf is direct tax rate on firm income, TYR is uniform compensatory tax rate on household income and $\overline{TINSADJ}_h$ is direct tax scaling factor for households, an exogenous variable.

For indirect taxes, tva_a tm_c, te_c and tq_c represent value-added tax rate, import tariff rate, export tax rate and sales tax rate, respectively. For prices, PVA_a, PX_c, Pe_c, $\overline{Pwm_c}$ represent value-added price, producer price, domestic export price, and international import price (in foreign currency), of good i; and E_c, M_c, QVA_a, X_c are the volumes of exports, imports, value-added and production output, respectively.

The government current revenue is used to finance (re)current expenditure which includes commodity consumption (government services such as provision of healthcare), transfers to households and the rest of the world, and interest payments on domestic and foreign debt. Total government commodity consumption is exogenously determined and fixed in real terms (relative to the numeraire). The specific sector spending in the current period is determined by the total spend for the previous period times a growth factor scaled by the consumption adjustment factor for government spending in the sector. Therefore, from the government income equation:

$$Y_G = E_G + S_G \quad (13)$$

$$E_G = Pindex . QG_c + \sum TR_{ins,gov} + \sum gintrat_i . GBOND_i + fintrat_{gov} . \bar{e} \quad (14)$$

$$QG_c = QG_{c,t-1}\left[(1 + \overline{RQGT}_c) + (\sum_{\acute{c} \in \acute{C}} rqgadj_{c,c'} . \overline{RQGCT}_{c'}\right] \quad (15)$$

where E_G is total government expenditures (value), QG_c is government commodity consumption i.e. public services provision, $QG_{c,t-1}$ is the previous period government commodity consumption, $RQGT_c$ is real government consumption growth for all c in current period relative to previous period, $RQGCT_c$ is real government consumption growth of c in current period relative to previous period, $rqgadj_{c,c'}$ is a parameter linking government consumption growth across commodities, , $GADJ_i$ is the government consumption adjustment factor for government function i (as an exogenous variable), $TR_{ins,gov}$ is government transfers to other institutions, $GBOND_i$ is endowment of government bonds for domestic institution i, $gintrat_i$ is interest rate on government bonds for domestic institution i and $fintrat_{gov}$ is interest rate on foreign debt paid by government (adjusted by the exchange rate, $\bar{e}$).

The fiscal balance is given by the difference between current revenue and current expenditures. In the Ugandan application, foreign borrowing is the variable that clears the government budget for the baseline scenario. Other government closure rules are experimented in the financing policy simulations. In addition, the following rules are specified for government spending and receipts. Government commodity consumption is modelled as a fixed growth rate. The GDP growth rate determines the evolution path of government consumption over time. The exogenous specification of government consumption spending allows for the modelling of increased government healthcare expenditure to cater for additional spending on HIV/AIDS treatment and prevention interventions. On the receipt side, taxes are modelled as a fixed variable thus permitting the possibility of modelling an imposed earmarked health tax for raising additional revenue to spend on HIV/AIDS interventions. Similarly, transfers to government from rest of world (grant aid) and domestic borrowing are modelled as a fixed growth rate and is assumed to follow the GDP growth path. This specification permits the model to evaluate the impact of imposing additional growth in foreign-aid inflows and domestic taxes to generate additional funding for HIV/AIDS interventions.

A related model closure rule for non-government payments is specified to incorporate foreign direct investments to facilitate the modelling of foreign direct investments, transfers to non-government institutions from rest of world, foreign borrowing by non-government institutions and transfers to factors from rest of world. Each of these variables is modelled as a fixed rate of growth whereby the growth in GDP determines the evolution of the respective variables over the model period.

3.1.4 Factor markets

The profit maximising condition of the producer implies that factors are employed up to the point where the marginal cost of each factor in the production activity equals the marginal revenue product of that factor input in the production activity. Given the Ugandan setting, the factor market constraint is defined as follows. Labour is assumed to be fully employed and mobile across sectors. The mobility of labour implies that workers who are laid-off by contracting sectors are able to find employment in expanding sectors so that the full employment condition is maintained. In reality the existence of a large informal sector occupies the unemployed. Equilibrium is obtained through flexible wages which adjust to assure that the sum of labour demands from all sectors equates the quantity supplied. Land and capital are fully employed[10] and immobile across sectors, earning a sector-specific wage that is variable.

3.1.5 Investment

The government and private investment, and the sources of financing the investments, are determined. On the supply side, domestic savings by households and government are transformed into different types of investments while foreign savings are transmitted to the domestic economy through transfers from the rest of the world and foreign direct investments (FDI). The government fixed investment value is derived from the government spending on capital goods. The government capital expenditure is financed by the sum of government savings net of spending on stock changes, new government bonds, government central bank borrowing, foreign borrowing and foreign grants[11]. For investment by domestic non-government institutions, the household's fixed investment value is given by its savings net of spending on stock changes and lending to government, plus borrowing and grants from the rest of the world.

$$I_{gov} = S_G - \sum PQ_c . qdst_{c,gov} + DGBOND + CRBOR + \left(\overline{FBOR}_{gov} + \overline{FGRANT}_{gov}\right) . \bar{e} \qquad (16)$$

[10] Full employment of capital applies to private capital only.

[11] Note that foreign grant in this equation is a distinct and separate category from government transfers from the rest of the world in the recurrent revenue equation. Here, the grants are captured in the government capital account.

$$I_h = S_H - \sum PQ_c . qdst_{c,h} - DGBOND_h - CRBOR_h + (\overline{FBOR}_h + \overline{FGRANT}_h). \bar{e} \quad (17)$$

$$I_{row} = fdi_{row}. \bar{e} \quad (18)$$

where I_{gov} is government investment value, PQ_c is composite commodity price, $qdst_{c,gov}$ is quantity of government stock change, $DGBOND$ is total change in holding of government bonds, $CRBOR$ is total government Central Bank borrowing (deficit monetisation), and $\overline{FBOR}_{gov} + \overline{FGRANT}_{gov}$ are foreign borrowing by government and foreign grants to government, transformed to local currency by the exchange rate, $\bar{e}$. I_h is fixed investment value for household h and I_{row} is investment value by the rest of the world, row.

On the demand side, investment in different capital stocks is determined differently for non-government institutions and for the government. For households, investment in different capital stocks is determined by total fixed investment values, the prices of capital goods, and the exogenous shares of different capital stocks. The government investment demand for capital stock is determined by the difference between the expected capital demand in the next period and the capital stock that would remain if no investments were made. The expected future demand for capital is based on production growth in the previous period.

$$PK_f . DK_{h,f} = gfcfshr_{f,h} . I_h \quad (19)$$

$$DKGOV_f \geq \sum (ifa_{f,a} . QA_{a,t} \cdot \frac{QA_{a,t}}{QA_{a,,t-1}}) - QFAC_{gov,f} . (1 - depr_f) \quad (20)$$

where PK_f is price of new capital stock, $DK_{h,f}$ is gross change in capital stock (investment in) f for household h, and $gfcfshr_{f,h}$ is share of gross fixed capital formation for household h in capital factor f. $DKGOV_f$ is gross government investment in f, $ifa_{f,a}$ is quantity of capital f per unit of government activity a, $QA_{a,t}$ is quantity (level) of activity in current period ($t - 1$is previous period), $QFAC_{gov,f}$ is real endowment of factor f for government, and $depr_f$ is depreciation rate for factor f.

The saving-investment balance focuses on the on the non-government component of savings and investment[12]. The rule adopted for the Uganda application is for an investment-driven economy. Household investment is an exogenous GDP share, with the base year share determining the evolution path, and the households saving rate is the clearing variable.

The balance-of-payment closure specifies a flexible exchange rate to clear the current account balance. The flexible exchange rate regime is a plausible assumption for the Ugandan application because the country's current exchange rate regime is flexible. Moreover, this specification allows for the simulation of increasing transfers from the rest-of-world in form of foreign aid for health. Transfers from rest-of-world are modelled as a source of additional government revenue for recurrent expenditure on HIV/AIDS interventions.

The model is calibrated from the Uganda social accounting matrix (SAM). A SAM is a comprehensive, economy-wide data framework representing the economy by capturing the financial value of transactions and transfers between all economic agents in the system, for a given period of time, usually a year. It is a square matrix with each account represented by a row (income) and a column (expenditure) i.e. the double entry system of accounting. The Uganda SAM is structured to suit the

[12] Government saving and investment are determined by other rules. Specifically, government investment expenditure is determined by the demand for capital by the different government services while the government savings depends on the closure rule adopted for the government balance.

MAMS model code[13]. The structure of the SAM for MAMS is given in the appendix to this paper. We use the MAMS dataset for Uganda taking 2009/2010 as the base year.

3.2 The dynamic baseline scenario

The baseline simulation acts as a benchmark against which the impacts of healthcare financing reform policies are measured. It serves to portray how the economy would have performed from 2009 to 2040 in the absence of additional effects accruing from HIV/AIDS and the associated healthcare costs and financing policies. The current HIV responses are assumed to prevail throughout. The baseline scenario assumes the status quo continues for internal and external factors, and policies that underpin the economy's rate of growth remain as portrayed in the 2010 social accounting matrix – the benchmark data set. The model is calibrated with a total factor productivity growth rate to generate an annual growth rate for real GDP to follow the historical path. According the national accounts GDP growth rate averaged 6-7% from 2001 to 2011 and the trend is projected to continue as per the forecasts from the World Economic Outlook of the IMF. The government spending rule governing expenditure in the baseline scenario sets the government consumption demand (service provision) to grow as a fixed share of GDP. The evolution of the government consumption demand for the period 2009 – 2040 is influenced by the initial consumption share in GDP. Government receipt items (direct taxes, indirect taxes and tariffs, transfers to government from rest-of-world, transfers from domestic non-government institutions, and government domestic borrowing) are modelled as a fixed share of GDP. The initial year shares in GDP determine the evolution of the shares for the model period 2009 – 2040. Receipts from foreign borrowing are variable and adjust accordingly, to balance the government budget. The baseline scenario population and labour force growth rate is 3% per annum, according to the UN demographic model for Uganda. The current HIV prevalence rate at 7.4% prevails for the baseline scenario.

3.3 HIV/AIDS Impact channels

The impact is captured in two sets of simulations namely: the labour force growth scenarios and the source of funding HIV interventions scenarios. The first set of simulations captures household population growth and labour supply dynamics of HIV/AIDS. Every household group is endowed with a fixed share of every labour type in the economy. Thus, the population of each household in any year is determined by the household's population in the preceding year, the growth factor of its labour force and a population scaling factor. Two cases are modelled under this assumption.

Case 1: AIDS without targeted treatment and prevention (aids-ntp): This case assumes that government does not make significant improvements towards treatment and prevention strategies for HIV/AIDS so that challenges reported in the 2013 country progress report prevail throughout. This case relates to a situation where the baseline HIV prevalence rate at 7% prevails throughout while access to ART remains at levels reported at the end of 2013 (which is below 40% for all those eligible for ART at the 2013 WHO guidelines). Similarly, the funding challenges reported in 2013 continue such that minimal proactive steps are taken towards scaling up prevention strategies. This level of HIV responses as described here generates two shocks.

First, is the impact on supply of labour whereby the overall size of the labour force declines while the age structure changes[14]. We anticipate a decline in labour force growth as more people fall sick from

[13] The SAM for Uganda MAMS was built by the Uganda Ministry of Finance under a UNDP, UN-DESA project: "Strengthening Macro-Micro Modelling Capacities to Assess Development Support Measures and Strategies in Uganda", facilitated by Martin Cicowez and Marco Sanchez.

[14] For example, as the HIV prevalence rates increase, mortality rates increase and the share of the members of a cohort entering the labour market at a given time declines. As a result the average age of the workforce

AIDS, some of whom die while others are unable to work effectively. The assumption of a declining labour force growth rate is based on empirical studies in Sub-Saharan Africa as documented in the early work on the demographic impact of HIV/AIDS. The studies simulated the HIV impact in demographic models that incorporated the epidemiological dynamics of HIV/AIDS. For instance, a demographic surveillance study in a rural ward in Tanzania found mortality rates among HIV-infected adults were 15 times higher when compared with HIV-negative adults and that HIV/AIDS was associated with about half of all deaths of people aged 15 – 44 years (Urassa et al., 2001). An epidemiological model that simulates the spread of HIV/AIDS combined with a demographic model that translates AIDS mortality rates into population outcomes projected Uganda's population to be smaller by 10% in 2020 and 14.9% in 2050 with AIDS (Bos & Bulatao, 1992). A similar study in Tanzania estimated that by 2010, the size of the working-age population (15-60 years) would be 20% smaller with HIV/AIDS than without it (Bulatao, 1990). Given the background on association of HIV/AIDS and mortality rates among the working population, Case 1 predicts a decline in labour force growth in Uganda which is modelled as a gradual reduction from the 3% baseline growth rate. That is, the Uganda model is shocked with a 2% growth rate up to 2025 and thereafter a 1% growth rate per year up to 2050.

Second, demand for healthcare increases as infected persons are treated through the existing health care system. The government faces increased healthcare spending because of higher health expenditure per infected person[15]. The HIV/AIDS impact on demand of healthcare services is taken simply as the share of patients with HIV-related illnesses in the healthcare system. Assume that all people living with HIV in Uganda will need some form of healthcare in one way or another. Consider the MoH Spectrum projected number of PLHIV in 2013 (1,618,233) and the HIV-related deaths in 2011 (72,928) and 2012 (70,262)(Uganda AIDS Commission, 2014). As a proxy for the cost of treating a patient with HIV, consider the Ugandan 'facilities' projected annual cost per ART patient (excluding ARVs)- $57, as reported in 2011 (Institute for Health Metrics and Evaluation (IHME), 2014b). Given the above considerations, it is postulated that government healthcare expenditure as proportion of GDP will increase by 4% per year. Thus, the Ugandan model is shocked with a 4% annual increase in the government health spending as a share of GDP, attributed to the additional care costs of PLHIV in the health system. The government function spending allocation is similar to the baseline scenario

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declines and consequently work experience falls as well as productivity in some sectors that require certain skills acquired on the job. A formal description of the association between HIV mortality rates and the average age of the work-force is established (Haacker, 2002).

[15] In a study to determine the burden of HIV/AIDS to the healthcare system, conducted in two districts in South Africa, it was shown that HIV- patients had higher utilisation rates of health services compared to other patient groups (Cleary, Boulle, Castillo-Riquelme, & Mcintyre, 2008). Moreover, early studies on the impact of HIV/AIDS on demand for health services and thus on the cost of service delivery indicators have shown an enormous burden exists in resource-poor settings. For example, a study on providing health care to HIV patients in Southern Africa showed that if 10% of all HIV positive people sought services of a physician, the ratio of HIV-positive patients to physicians would range from 17 (for South Africa to 250 (for Malawi)(Haacker, 2001). This was against a backdrop of the already low rates of physicians per 100,000 of population - 56 (for South Africa) and 3 (for Malawi) at the time of the study. When compared to the ratio in developed countries, the Malawi case was about 1% of the United States level. Similarly, a World Bank study in Botswana showed that given the trend of HIV prevalence at the time, 60% of all hospital beds were being allocated to patients with HIV-related illness. The study indicated that if the trend continued the number of beds required by HIV patients would exceed the total number of available beds in 2002 (World Bank, 2001). Although the cost of HIV impact on healthcare service delivery varies according to the share of government in health expenditure, typically the HIV epidemic leads to soaring costs to the health sector in resource constrained developing countries like Uganda (Over, 2004).

assumptions. In Case 1 the fiscal balance assumption is similar to the baseline scenario where foreign borrowing adjusts to balance the government budget[16].

Case 2: AIDS with targeted treatment and prevention (aids-tp): In this case we assume that government undertakes targeted strategies towards treatment of PLHIV and prevention measures to reduce the prevalence rate. This case assumes government has adequate funds to meet the NSP targets and goals achieved. For instance, the 2011/12 – 2014/15 NSP propose two thematic goals for HIV responses: (i) to reduce HIV incidence by 30% by 2015 and (ii) to improve the quality of life of PLHIV by mitigating the health effects if HIV/AIDS by 2015(Uganda AIDS Commission (UAC), 2012) . Assuming the HIV NSP target proposals are carried through, the response results in two shocks. First, the intervention strategies are assumed to reduce transmission rates as well as HIV related mortality and morbidity. The life expectancy of PLHIV is increased and the participation rate of the infected and affected people increases. These effects translate into relatively higher growth rates in labour force supply to the economy which are captured in the model as gradual increases in labour force growth from the baseline growth rate. It is further assumed that the scaling up of HIV responses is gradual and the health effects are lagged. In Case 2 therefore, labour force growth rate is assumed to increase by an additional 1% from the 3% (from the UN demographic model for Uganda) baseline rate so that the model is shocked with a 4% annual growth up to 2020. An additional labour force growth rate of 2% (from the baseline rate) is assumed to occur beyond 2020 due to higher coverage rate of HIV responses and the health effects paying off. Thus, the model is shocked with 5% annual growth for 2021–2030. Finally, the full programme of HIV responses and commensurate health effects are assumed to occur and prevail throughout. Consequently an additional 3% labour force growth rate (from the baseline rate) is assumed so that the model is shocked with a 6% annual growth for 2031-2050.

Second, the HIV intervention strategies envisaged in this model assume comprehensive treatments for PLHIV as well as prevention measures, thus generating additional costs over and above the treatment costs assumed in Case 1. In order to achieve the HIV NSP targets the NSP full funding estimates indicate that, using the 2011/12 as the base year, required funding increases by 28%, 23% and 22% for 201/13, 2013/14 and 2014/15 respectively. The absolute money estimates for full funding indicate resource estimates rise from US $589.53 million in 2011/12 to US $1,136.50 million in 2014/15. Given the increasing costs for HIV responses, the Ugandan model is shocked with a 10% annual increase in health spending, as a share of GDP. It is assumed in this model, that 50% of the health budget goes to fund HIV responses based on the findings of Amico et al (2010). The level of health spending modelled in this study is a modest increase in the health budget given the initial level of government health budget as a percentage of GDP is very low. The findings of the study on

[16] The rising demand for healthcare services by HIV-patients requires that government seeks to find more resources to produce public healthcare and meet the increased demand for healthcare. In this model set up, the government sources of revenue are fixed (except foreign borrowing). The government can choose to penalise other sectors by reducing their budgets and reallocating the resources to health or it can choose to borrow from foreign resources to balance the budget while maintaining the expenditure shares for other sectors. The assumption here is that the government balances the budget through foreign borrowing. Although the foreign borrowing, (over and above the baseline levels), is not earmarked for HIV interventions, it is clear that additional foreign borrowing to balance the budget is triggered by the need for increased government health expenditure. The impact of sources of government revenue earmarked for health (and HIV) are explored in Case 3 (foreign aid) and Case 4 (tax revenue). The impact of foreign borrowing (and domestic borrowing) earmarked for health (and HIV) will be explored in further simulations to follow in the final draft of this paper. Haacker (2015) identifies three circumstances when borrowing might be a plausible option for funding HIV. These options may apply singularly or simultaneously. Borrowing for HIV responses is plausible when it is required to manage spikes in the cost of HIV interventions, to enable HIV investments which expand fiscal space and as a means of eliciting a contribution from the beneficiaries of the current IHV investments (Haacker, 2015). However, Haacker cautions that if the spelt-out conditions underlying the plausibility of borrowing for HIV responses are not met; debt-financing of HIV cannot be justified.

the cost of comprehensive HIV treatment in Uganda suggest much higher levels of spending (Menziesa et al., 2011). The government spending allocation in this case is also similar to the assumptions in the baseline scenario and foreign borrowing adjusts to balance the budget.

The second set of simulations captures the HIV impact channels through the source of funding healthcare costs generated by HIV intervention strategies. For both Case 1 and Case 2 above, the government is assumed to be spending according to its budget. Government receipts are assumed to grow at a fixed rate determined by the GDP growth rate and the budget is balanced by foreign borrowing, as assumed in the baseline simulation. However, in the following two cases, we specify the source of additional funding for healthcare when the share of health spending is increased.

Case 3: Foreign aid funding for HIV (ttrow-hltg): Here we consider an increase in foreign transfers channelled to the financing of government health. The target is to increase government receipts while expanding government health spending. We assume that all foreign- aid for health is channelled through the government budget so that the HIV component of the aid-money is spent according to priorities laid down in the National Strategic Plan for HIV/AIDS and the Health Sector Strategic Plan. We shock the model with a 20% annual increase in foreign transfers to government from the rest of world specifically for the government health commodity. At the same time, the selected government spending rule imposes flexibility so that health spending is the budget balancing item. This model operation signifies an increase in foreign grants as share of GDP channelled to government health spending. The annual increase in foreign aid for HIV modelled in this study is in line with the suggestion by Atun et al (2015) recommending continued and where possible, increasing development-aid for health (HIV funding) to poor Sub-Saharan countries like Uganda.

Case 4: Tax revenue for HIV (dtax-hltg): In this case, we consider an increase in domestic direct tax revenue as a source of additional health spending. The model manipulation is similar to Case 3 except that the government receipts are increased by direct tax revenue. Therefore, the model is shocked with a 10% annual increase in direct tax revenue as share of GDP and the adjustment in government health spending clears the government budget. The 10% annual growth rate in direct tax to GDP share is selected on the basis that effective rates will adjust so that the base year share of direct tax to GDP is more than double by 2040. This level of additional revenue generation is in line with the government aim to achieve the National Strategic Plan for HIV/AIDS target of 15% government contribution towards the National Priority Action Plan for HIV/AIDS resource requirements. Additionally, the selected growth rate in direct tax revenue aims to achieve additional revenue towards the 25% potential share of total tax revenue in GDP. It has been suggested that Uganda has the potential to raise tax revenue share in GDP from the current 13.4% to 25% (World Bank) Using this estimated revenue potential for Uganda, Remme et al (2015) calculated the additional fiscal space for HIV that would accrue from this growth in tax revenue. The authors found that Uganda has the potential to spend an additional $23 per PLHIV per year (2014 – 2018) from government tax revenue generation.

4. Results and discussion

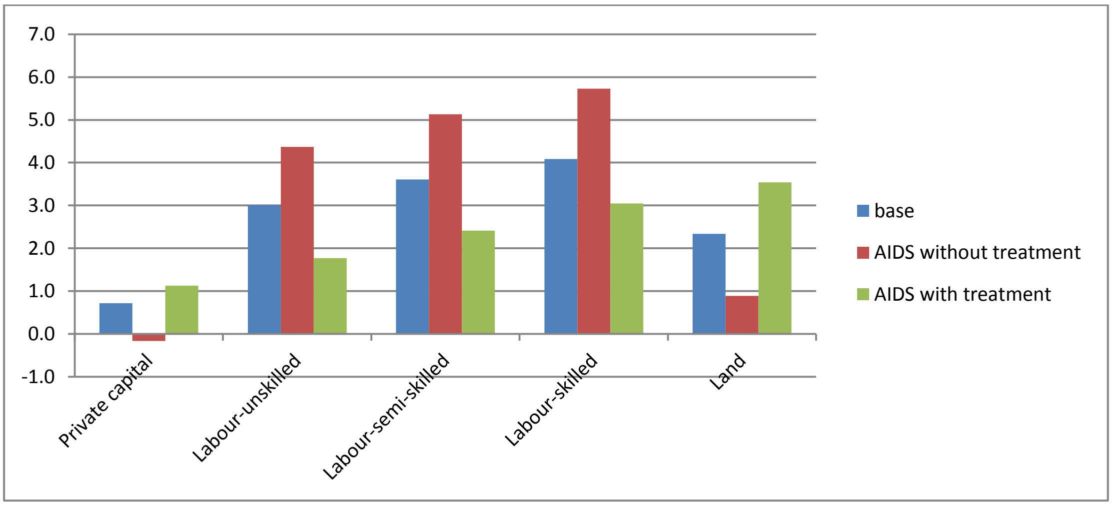
Model simulations were performed and results presented as comparative growth rates for the period 2009 – 2040. The impact of HIV/AIDS –with no intervention is contrasted with the baseline results. Similarly the impact of HIV/ AIDS-with intervention and different sources of financing the cost of intervention is contrasted with the baseline. Results present the baseline growth path and deviations from the baseline caused by changes in exogenous variables, holding other factors constant. Specifically, results show the impact on growth rates in GDP, and as a share of GDP, growth in consumption (private and government), investment (private and government), exports and imports, domestic and foreign debt. At the intermediate level, the impact on economy-wide wages/rents, exchange rate movements, sectoral growth rates, sector shares as well as the government budget performance are presented.

4.1 Wages/rents

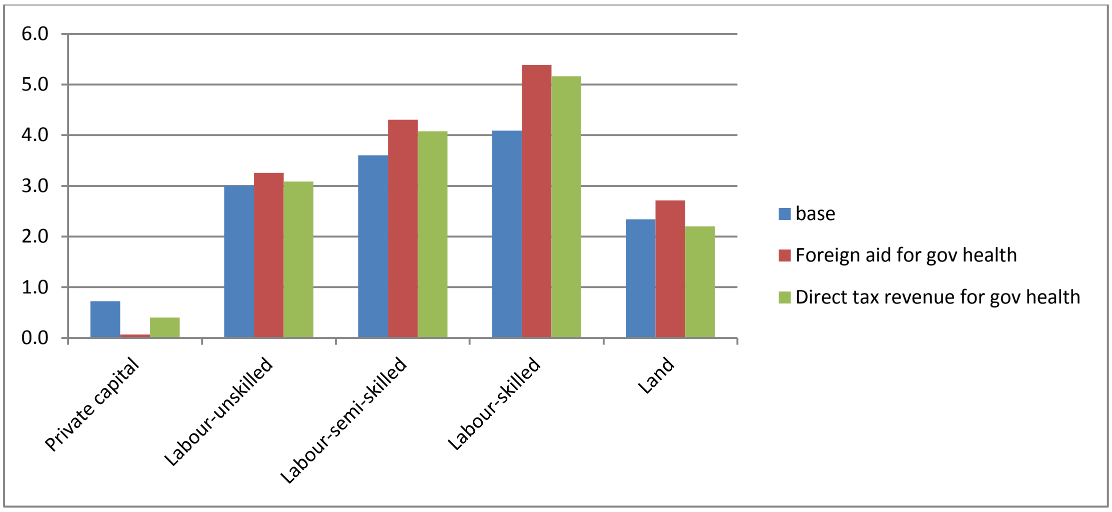
For purposes of this modelling exercise, labour classification is based on completed years-of-schooling for the individual. Labour is classified as unskilled for working people who completed less than secondary education, semi-skilled for working people who completed secondary education and skilled for working people who completed tertiary education. Factor markets clear through relative price changes. For the Ugandan application presented in this paper, the average growth rate in real wages increases under the aids-no-treatment scenario and declines under the aids- with-treatment scenario, relative to the base. Figure 1 shows the growth in wages/rents for the period 2009 -2040 while Table 2 shows the deviations in growth rates relative to the base under each of the two financing scenarios. Under the aids-no-treatment case, the relative increase in growth rate for wages is about 1.4% for unskilled, 1.5% for semi-skilled and 1.6% for skilled labour. The rise in wages is consistent with the assumption that AIDS prevalence without targeted treatment and prevention strategies would lead to a decline in the labour force growth rate. As the growth in labour force declines, demand for labour surpasses the supply and drives up wages in the labour market. On the other hand, the relative decline in wages growth rate is 1.2% for unskilled and semi-skilled labour, and 1% for skilled labour under the aids-treatment case. This is due to the abundance of labour from the model assumption that AIDS prevalence with targeted treatment and prevention strategies would result in increased labour participation rates and labour force growth rates. Consequently, an abundance of labour in the economy drives down wages relative to the base.

Figure 1 Real average wage/rent by factor: annual growth for the period 2009-2040 (%)

Panel 1: AIDS case with and without intervention compared to the base



Panel 2: Funding sources compared to the base



Note: gov health= government health

The adjustment in skilled labour wages is worth noting in relation to the dynamics of expanding a skill oriented service (health) sector. The rise in wages is highest for skilled labour under the aids-no-treatment case. This is in part, attributed to the skill-intensive nature of the expanding health sector due to increased demand for healthcare. In order to produce more units of healthcare to meet the increased demand, a larger quantity of inputs is required. Skilled labour constitutes a relatively large proportion of the input requirements for healthcare production in Uganda. Similarly, under the aids-treatment case the decline in wages rates for skilled labour is relatively smaller compared to other labour categories. This is due to the fact that even if the overall economy-wide labour supply is growing, the expansion in healthcare labour is lagged because doctors and nurses training takes relatively long time to qualify. Moreover, in Uganda there is never an abundance of skilled healthcare workers so that their wages are sticky downwards.

Table 2 Real wages: annual growth for the period 2009-2040 (%) - deviation from the base

	Simulation			
	AIDS without additional treatment and prevention	AIDS with additional treatment and prevention	Foreign aid for government health	Direct tax revenue to government health
Factors of production	(Case 1)	(Case 2)	(Case 3)	(Case 4)
Capital - private	-0.88	0.41	-0.65	-0.32
Labour – unskilled	1.37	-1.23	0.25	0.08
Labour – semi-skilled	1.52	-1.20	0.70	0.48
Labour – skilled	1.64	-1.04	1.30	1.08
Land	-1.45	1.20	0.38	-0.13

Note: ROW = Rest of world
Labour – unskilled (completed less than secondary education), Labour – semi-skilled (completed secondary education), Labour – skilled (completed tertiary education)

When the wages growth rate is compared among funding sources for an expanding health sector, the biggest rise is observed under the aid-scenario compared to the tax scenario. The aid-scenario stimulates growth in wages to rise above the base by 0.25% for unskilled, 0.7% for semi-skilled and 1.3% for skilled labour. On the other hand, the tax scenario generates wage growth rates of 0.08%

for unskilled, 0.48% for semi-skilled and 1.08% for skilled labour. In both cases, the skilled-labour wages adjustment is relatively large because of an expanding skill-intensive health sector.

4.2 Factor demand by sectors

The demand for factors by different sectors adjusts in response to the intensity in use of the factor by the adjusting sectors and the factor price. Table 3 presents results for factor employment by sector. The aids-no-treatment scenario results in an overall decline in employment of all factors of production by sectors relative to the base. The decline in factor demand is relatively larger for labour categories and government capital compared to private capital. The decline in demand for labour follows from the observed increase in labour wages implying that the relatively more expensive labour factor is substituted away for cheaper private capital whose price declines under the same scenario. For instance, labour employment in the agricultural sector declines by 1.67% while private capital demand declines by only 0.55%.

Government employment of capital declines in the aids-no-treatment case for all public services activities including health. This observation reflects the shift in government allocation of resources towards recurrent expenditure relative to capital expenditure. The reallocation of expenditure is spurred by increasing costs of palliative care for PLWHIV so that the government healthcare budget increases its consumption of health commodities. This trend is also reflected in the GDP share of health service provision for the government spending in Table 6. Government spending on health service provision as a share of GDP increases from 0.09% in the base scenario to 1.21% in the aids-no-treatment scenario while government investment in health declines from 0.06% to 0.05% for the same scenario. This pattern also reflects that at low levels of government spending as a share of GDP (17.65% in Table 6) government tends to invest less in capital stocks for public health services.

On the other hand, when government implements targeted treatment and prevention strategies, the health sector expands its demand for factors of production relative to the base. Specifically, government services demand for labour increases by 1.62% for unskilled, 1.8% for semi-skilled and 1.7% for skilled while demand for health capital investment increases by 6.42% compared to the base (see aids-tp scenario). Higher employment of factors in the health sector suggests higher production inputs and increasing healthcare output. The increasing healthcare output implies that more people are treated (and healed) so that labour participation rates also increase in other sectors of the economy. Moreover, the government's deliberate policy for treatment and prevention of HIV/AIDS is seen to result in a growing supply of labour and declining wages. Consequently sectors can now hire more factor inputs more cheaply compared to the base. Additionally, the government investment in health capital increases suggesting that there is a commitment to long-term development of the health sector. At higher levels of total government spending as a share of GDP (21-24%) government investment in health increases (see Table 6).

We notice that there is a decline in employment of government capital for the other government services sectors, except other-infrastructure. The extent of variation in demand for capital depends on the mode of funding employed to get the additional revenue for health expenditure. For instance, while aid-funded health expenditure generates a 0.54% decline in demand for capital in the primary education sub-sector, the tax-funded health reduces the same demand by 0.4%. Similarly, aid-funded health reduces capital demand in the water and sanitation sector by 0.11% while the tax-funded health option reduces demand by 0.21%. This suggests that the health sector takes precedence in the government resource allocation formula and the affected sectors could be contracting while the health sector expands.

Table 3 Employment by factor and sector: annual growth for the period 2009 -2040 (%)

Factor of production	Activity/Sector	base	AIDS without additional treatment and prevention (Case 1)	AIDS with additional treatment and prevention (Case 2)	Foreign aid for government health (Case 3)	Direct tax revenue to government health (Case 4)
Capital – education gov - primary	Education – gov - primary	4.05	1.79	5.60	3.50	3.65
Capital –education gov - secondary	Education – gov - secondary	4.57	2.44	6.13	4.35	4.46
Capital – education gov - tertiary	Education – gov - tertiary	4.34	2.16	5.90	3.98	4.10
Capital – health - gov	Health - gov	3.87	2.37	10.29	11.47	11.47
Capital – Other infrastructure	Other infrastructure	6.58	6.25	6.86	7.01	6.83
Capital - private	Agriculture	3.83	3.33	4.38	4.37	3.90
	Industry	6.38	5.83	6.48	6.07	6.60
	Industry - mining	5.14	4.41	5.85	5.51	5.26
	Industry - manufacturing	6.40	5.86	6.49	6.08	6.62
	Services	5.93	5.65	6.26	6.57	6.21
	Services – non-gov	5.93	5.65	6.26	6.57	6.21
Capital – public administration	Public administration	4.65	2.69	5.97	4.12	4.21
Capital – water and sanitation	Water and sanitation	4.67	3.32	5.76	4.56	4.46
Labour – unskilled	Agriculture	2.86	0.92	4.53	2.90	2.76
	Industry	4.60	2.53	5.82	3.59	4.58
	Industry - mining	3.95	1.68	5.77	3.64	3.84
	Industry - manufacturing	4.61	2.55	5.82	3.59	4.60
	Services	4.65	2.88	6.11	4.79	4.82
	Services – non-gov	4.59	2.80	6.03	4.64	4.67
	Services - gov	5.24	3.65	6.86	6.02	6.08
Labour – semi-skilled	Agriculture	2.14	0.09	3.82	1.90	1.74
	Industry	2.20	0.13	3.73	1.53	1.84
	Industry - mining	3.22	0.85	5.05	2.64	2.81
	Industry - manufacturing	2.18	0.11	3.69	1.50	1.81
	Services	3.95	2.10	5.50	4.04	4.05
	Services – non-gov	3.79	1.90	5.25	3.58	3.57
	Services - gov	4.44	2.71	6.24	5.24	5.28
Labour – skilled	Agriculture	1.71	-0.41	3.27	1.04	0.86
	Industry	1.91	-0.25	3.28	0.75	1.10
	Industry - mining	2.78	0.34	4.50	1.78	1.92
	Industry - manufacturing	1.88	-0.26	3.25	0.72	1.08
	Services	3.61	1.73	5.18	3.64	3.64
	Services – non-gov	3.04	1.14	4.38	2.50	2.43
	Services - gov	3.99	2.13	5.69	4.32	4.35
Land	Agriculture	3.00	3.00	3.00	3.00	3.00

Note: gov = government

4.3 Impact on GDP growth rates

The impact of HIV on real macro aggregates for the simulated impact channels are shown in Table 4. The factor price and factor demand adjustments discussed in Section 4.1-4.2 are reflected in growth rates of GDP at factor cost. The reduction in labour supply growth under the aids-no- treatment scenario (aids-ntp) results in declining GDP growth rates relative to the base. On the other hand, the targeted treatment and prevention scenario (aids-tp) results in higher GDP growth rates relative to the base. The growth rate in GDP at factor cost declines by 0.82% under the aids-no-treatment scenario while it increases by 0.62% under the aids-treatment scenario, all relative to the base growth rates. The impact from funding sources shows that the aid-funded scenario generates slightly higher GDP growth rates relative to the base rate - 0.21% compared to 0.14% for the tax-funded scenario.

Table 4 Real macro aggregates (% growth): 2009 and2040

	UGX (millions)	2040 (rate)				
Indicator	2009	base	AIDS without additional treatment and prevention (Case 1)	AIDS with additional treatment and prevention (Case 2)	Foreign aid for government health (Case 3)	Direct tax revenue to government health (Case 4)
Absorption	38922.93	6.36	5.57	7.12	6.91	6.54
Consumption - private	27447.81	6.34	5.58	6.97	6.81	6.35
Consumption - government	3349.86	4.55	2.51	6.60	5.48	5.50
Fixed investment - private	6122.05	7.35	6.79	7.89	8.01	7.73
Fixed investment - government	1903.49	5.59	4.38	7.53	6.46	6.32
Exports	7185.19	8.48	7.63	8.75	7.91	8.53
Imports	11640.78	6.62	5.90	7.30	7.14	6.80
GDP at factor cost	31644.88	6.90	6.08	7.52	7.12	7.05
Real exchange rate (index)		-0.59	-1.14	-0.39	-1.14	-0.88

Note: UGX = Uganda Shillings

It is imperative to consider the underlying sector growth rates so as to fully comprehend the basis of the observed GDP growth rates. Figure2 illustrates the annual growth in GDP at factor cost by sector, comparing the aids-no-treatment and aids-treatment cases with the base results (panel 1) and the funding sources comparison to the base (panel 2). A comparison of health-funding sources shows differential impacts in growth rates of sector value-added. The aid-funded scenario stimulates higher growth rates in 'the services sector' compared to the tax-funded scenario. The growth rate in services value-added increases by 0.4% relative to the base growth rate, for the aid-funded scenario, compared to 0.17% relative increase under the tax-funded scenario. The relatively higher growth in services value-added under the aid-funded scenario is attributed to the relatively higher growth in employment of private capital: 0.65% compared to 0.28% under the tax-funded scenario. This finding suggests a crowding-out effect when private investment is displaced by increased government spending (for health) which is funded through increased tax revenues.

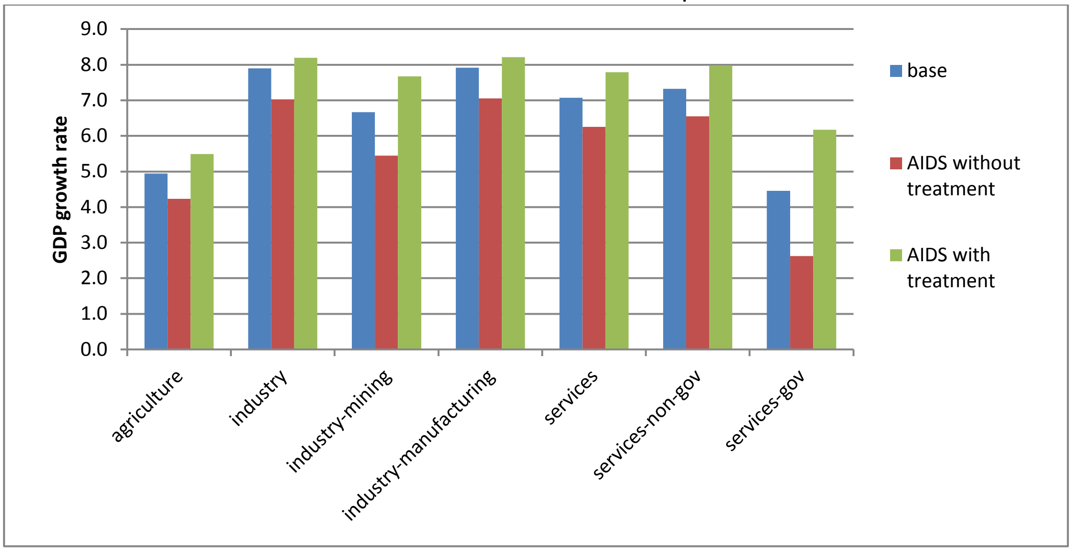
Table 5 GDP at factor cost: annual growth for the period 2009-2040(%), deviation from the base

Activity/Sector	AIDS without additional treatment and prevention (Case 1)	AIDS with additional treatment and prevention (Case 2)	Foreign aid for government health (Case 3)	Direct tax revenue to government health (Case 4)
Agriculture	-0.71	0.55	0.08	-0.03
Industry	-0.87	0.30	-0.45	0.16
Industry-mining	-1.22	1.01	0.14	0.00
Industry-manufacturing	-0.86	0.29	-0.46	0.16
Services	-0.82	0.72	0.40	0.17
Services non-government	-0.77	0.64	0.40	0.15
Services government	-1.83	1.71	0.43	0.45

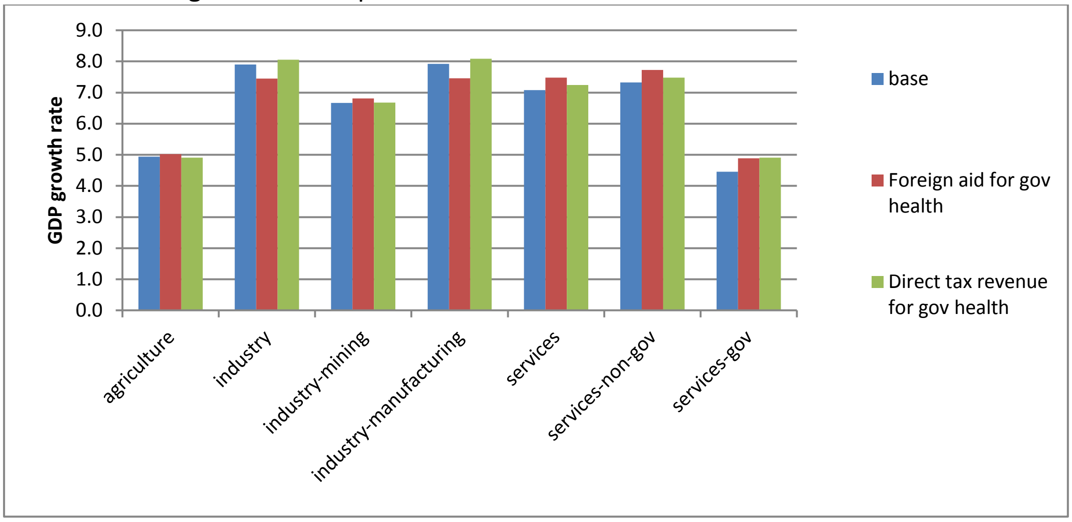
The relative growth rate in value-added by the industrial manufacturing sector declines by 0.46% under the aid-funded scenario while it increases by 0.16% under the tax-funded scenario. The contraction of the manufacturing sector is also reflected in the sector factor employment whereby the annual growth in private capital declines by 0.32% under the aid-funded scenario while it increases by 0.22% under the tax-funded scenario, relative to the base.

Figure 2 Real GDP at factor cost: annual growth from 2009-2040 (%)

Panel 1: AIDS with and without intervention compared to the base



Panel 2: Funding sources compared to the base



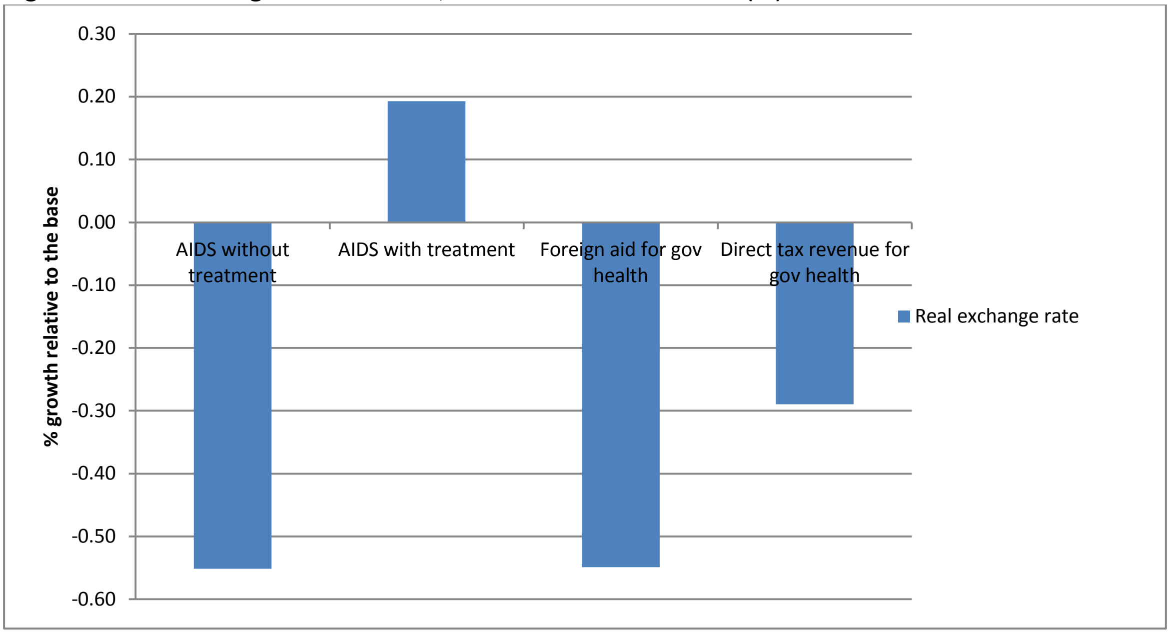
Note: gov health = government health, services-non-gov = non-government services, services-gov = government services

The results in Table 5 highlight the importance of sectoral disaggregation in evaluating the impact of fiscal space for HIV. The sectoral difference can be obscured by aggregating the impact. Whereas at the aggregate level the growth in GDP at factor is about the same for both aid-funded and tax-funded HIV interventions, there are differences at sector level. The industry value-added declines when HIV intervention is funded through foreign-aid-funded. This decline is attributed to the fall in value-added in manufacturing of 0.46% when compared to the base. On the other hand, growth in agricultural value-added declines by 0.03%, compared to the base, when HIV interventions are funded through taxation.

4.4 Exchange rate

The government closure rule assumed that foreign borrowing balance the budget in both the aids-no-treatment scenario and the aids-with-treatment scenario. Given this assumption the government borrowing is in foreign currency implying that there is an increased inflow of foreign currency. As a result of the increased in-flow of foreign currency the Uganda shilling appreciates in value. An appreciating shilling hurts the export sector as it renders the Ugandan exports less competitive on the world market. When the increased foreign currency-inflow is combined with declining labour supply growth rate due to HIV prevalence without targeted treatment and prevention (aids-ntp scenario), the impact on the exchange rate is large when compared to the base as seen in Figure 4. In Figure 4, the positive bars denote depreciation while the negative bars denote an appreciation. The dampening effect of an appreciating shilling is combined with a decline in labour force growth rate leads to decline in the exports growth when compared to the base growth (see Table 5). However, when the government decides on targeted treatment and prevention strategies for HIV, the depressing effects of increased foreign currency are counteracted by an increasing labour force growth. The overall effect is that of a depreciating shilling and higher growth in exports when compared to the base.

Figure 3 Real exchange rates in 2040, deviation from the base (%)



Note: gov health = government health

The effect of aid-funded HIV programmes is also to increase foreign currency inflows. However, since the aid inflow is targeted towards importation of medicines for treating PLHIV the net effect on the balance of payments and hence the exchange rate is much lower than the gross figures would suggest. In addition, the effect of spending flows of aid in part on local goods and services is mitigated by the benefits of a growing labour force supply. Conventionally, an appreciating exchange rate implies cheaper imports relative to domestically produced goods. The non-tradable sector is deemed to be more profitable which, consequently leads to a shift in resources from the tradable sectors to the non- tradable sectors. However, in Uganda's case the shift in resources is limited by the degree of substitutability between factors in the two types of sectors. The non-tradable sector is relatively skill intensive and highly specialised. Secondly, many import categories do not have domestically produced counterparts and so they would not be substituted any way. Therefore, the economy continues to thrive, mainly propelled by the increased health status of the labour force as treatment for PLHIV becomes accessible to all who need it. The tax-funded HIV scenario also generates an appreciation of the exchange rate, although to a smaller extent compare to the aid-funded scenario.

Overall, the proposed government intervention for HIV would support all the social and economic pillars of HIV/AIDS as laid down in the National Priority Action Plan for HIV/AIDS (NPAP), irrespective of funding source. The NPAP achievement targets include health system improvements. The health system improvements under the HIV interventions have spill-over effects in improving access and utilisation of health services for the entire population. Consequently, the benefits of a healthy population are transmitted to better living standards and economic growth for Uganda.

4.5 Government consumption and investment

The HIV impact on government consumption and investment is varied across scenarios. Table 6 presents results for the detailed government budget performance under different scenarios. A notable feature from the results in Table 6 is that the aids-no-treatment scenario compels government to reallocate more resources for recurrent health expenditure as it reduces investment expenditure in health and other government functions. A reduction in capital investment for government functions could be precarious in the long-term, as it may hamper continued provision of quality government services overall.

Table 6 Government budget (% of GDP): 2009 & 2040 by simulation

Indicator		2009	base	AIDS without additional treatment and prevention (Case 1)	AIDS with additional treatment and prevention (Case 2)	Foreign aid for government health (Case 3)	Direct tax revenue to government health (Case 4)
Income	Capital - households	2.31	2.31	2.31	2.31	2.31	2.31
	Capital - rest of world	2.49	0.35	0.14	4.35	0.35	0.35
	Capital -private	0.04	0.001	0.001	0.001	0.001	0.001
	Households	0.35	0.35	0.35	0.35	0.35	0.35
	Rest of world	2.66	2.66	2.66	2.66	8.86	2.66
	Tax-direct	4.01	4.01	4.01	4.01	4.01	10.02
	Tax-import	5.92	5.92	5.92	5.92	5.92	5.92
	Tax-VAT	2.27	2.27	2.27	2.27	2.27	2.27
	Total	20.04	17.86	17.65	21.86	24.07	23.87
	Gov Services						
Spending	Education primary	1.68	1.68	1.68	1.68	1.68	1.68
	Education secondary	0.34	0.34	0.34	0.34	0.34	0.34
	Education tertiary	0.48	0.48	0.48	0.48	0.48	0.48
	Health	0.95	0.95	1.21	3.04	6.94	6.60
	Other infrastructure	0.03	0.04	0.06	0.03	0.05	0.04
	Public administration	6.24	6.24	6.24	6.24	6.24	6.24
	Water and sanitation	0.01	0.01	0.01	0.01	0.01	0.01
	Others						
	Households	3.68	3.68	3.68	3.68	3.68	3.68
	Interest-domestic	0.95	0.98	1.14	0.88	0.96	0.97
	Interest-foreign	0.17	0.16	0.09	0.51	0.15	0.15
	Gov Investment						
	Education primary	0.31	0.08	0.03	0.16	0.05	0.06
	Education secondary	0.08	0.02	0.01	0.04	0.01	0.02
	Education tertiary	0.10	0.02	0.01	0.05	0.02	0.02
	Health	0.32	0.06	0.05	0.90	0.59	0.66
	Other infrastructure	2.19	2.19	2.19	2.19	2.19	2.19
	Public administration	2.21	0.82	0.38	1.45	0.58	0.64
	Water and sanitation	0.31	0.11	0.07	0.18	0.09	0.10
	Rest of world	0.01	0.01	0.01	0.01	0.01	0.01
	Total	20.04	17.86	17.65	21.86	24.07	23.87

Note: Interest-domestic = net domestic interest payments (to domestic private sector), interest-foreign = net foreign interest payments (to RoW), investment = investment-capital for government activities

4.5 Government debt: domestic and foreign

The impact on government debt varies accordingly. When government is faced with escalating healthcare costs arising from palliative care for PLHIV, under the aids-no-treatment scenario, government adjusts its spending pattern by reallocating the available resources and borrowing from foreign sources only when there is a shortfall in the budget. This adjustment generates foreign debt as a share of nominal GDP at 8.4% in 2040, as shown in Table 7. The foreign debt share of GDP is a reduction of 6.48 percentage points from the base share. For the same simulation scenario, domestic borrowing (i.e. domestic capital transfers which constitutes income from households through sales of government bonds) as a fixed share of GDP is 2.31% per year. With this level of government borrowing from domestic sources the domestic debt as share of GDP rises to 21.2% in 2040 under the aids-no-treatment scenario. Notice that for the same simulation scenario the GDP share of government spending on investment in public services declines relative to the base while commodity consumption remains the same, except for healthcare and other-infrastructure. This suggests that given the available resources, government reallocates spending to health commodity consumption while reducing spending for investment in other public services.

Table 7 Macro aggregates as share of nominal GDP (%)

		2040				
Indicator	2009	base	AIDS without additional treatment and prevention (Case 1)	AIDS with additional treatment and prevention (Case 2)	Foreign aid for government health (Case 3)	Direct tax revenue to government health (Case 4)
Absorption	112.93	98.49	99.41	101.94	106.24	99.58
Consumption - private	79.63	67.69	68.90	67.39	69.20	62.75
Consumption - government	9.72	9.73	10.01	11.81	15.73	15.39
Investment - private	17.76	17.76	17.76	17.76	17.76	17.76
Investment - government	5.52	3.31	2.74	4.98	3.54	3.69
Exports	20.85	29.88	27.77	27.43	20.77	27.09
Imports	-33.77	-28.37	-27.17	-29.38	-27.01	-26.67
GDP at market prices	100.00	100.00	100.00	100.00	100.00	100.00
Net indirect taxes	8.19	8.19	8.19	8.19	8.19	8.19
GDP at factor cost	91.81	91.81	91.81	91.81	91.81	91.81
Foreign savings	8.49	6.35	6.14	10.35	6.35	6.35
Gross national savings	15.08	14.72	14.36	12.39	14.95	15.10
Gross domestic savings	10.65	22.58	21.09	20.80	15.06	21.87
Foreign government debt	15.88	14.89	8.40	46.31	13.46	14.01
Foreign private debt	0.03	16.45	17.61	15.24	15.46	15.85
Domestic government debt	17.69	18.34	21.20	16.46	18.02	18.02

When government undertakes targeted treatment and prevention strategies (aids-tp) foreign debt as a share of nominal GDP rises to 46.31% in 2040. This result resonates with the finding by Atun et al (2015) indicating that new funding obligations for HIV treatment in Uganda were estimated to raise the debt to GDP ratio from 39% to 59% in 2050. However, the result from this paper also shows that additional funding for HIV, whether from aid or from domestic taxation, mitigates the escalation of the debt to GDP ratio. When the additional health expenditure is funded through foreign-aid in grant form, the government debt to GDP share falls relative to the base. Foreign debt share falls to 13.46% while domestic debt share falls to 18.02% in 2040. Similarly, if additional funding is generated through increase in direct tax revenue, the government debt to GDP share falls relative to the base - 14.01% for foreign debt share and 18.02% for domestic debt share in 20140. The mitigation in the escalating debt to GDP ratio is made possible by a combination of both lower borrowing rates (and lower interest payments) and the relatively higher growth rates in GDP.

Targeted treatment and prevention of HIV generates higher growth rates in labour supply to the economy leading to faster growth in GDP.

5. Conclusion and Policy implications

HIV/AIDS remains a challenge in as far as it affects the most productive segments of society. The problem is even larger for resource-poor countries of Sub-Saharan Africa despite scientific advances in treatment of the epidemic. Poor countries simply cannot afford the long-term liability of ART and hence a call for the moral duty to rescue those infected with HIV in poor Sub-Saharan countries. The devastating effects of HIV on an economy have been demonstrated with an application to Uganda. The prevalence of HIV without targeted treatment and prevention programs is detrimental to Uganda as it slows down the rate of economic growth. It is shown that if there is no deliberate programme for treating the infected and prevention of HIV, there will be a gradual decline in labour supply growth in the economy. As a result, wage rates rise thereby increasing the cost of production particularly for labour intensive sectors. For example, the agricultural sector production capacity shrinks and even lays off the very expensive skilled labour as shown by the decline its demand for skilled labour.

On the other hand, when government undertakes treatment and prevention programmes for HIV, the economy thrives as shown by relatively higher GDP growth rates when compared to the base. The treatment for PLHIV translates into higher rates of life expectancy of PLHIV as well as increased participation in productive activities for both the infected and affected people. This paper has also demonstrated that the source of fiscal space for HIV has implications for the rate of GDP growth and country's debt to GDP ratio. Model results have shown that the aid-funded HIV programmes and the tax-funded HIV programmes generate similar growth in GDP – 7.12% and 7.05% respectively. Similarly, when compared for the impact on debt as share of GDP, the two funding sources generate very similar rates of foreign debt as a share of GDP (13.46% for the aid funded programme compared to 14.01% for the tax-funded HIV programme) and the same level of domestic debt as a share of GDP (18.02%). However, in terms of sectoral impacts by the funding sources, when compared to the base, the aid-funded HIV programmes scenario generates a decline in GDP at factor cost for industry of 0.45% while the tax-funded scenario generates a decline of 0.03% in agriculture. The difference between the sectoral outcomes for each financing scenario is however relatively modest.

This research provides evidence for the case for donors and policy-makers to frontload investment in HIV treatment and prevention, by showing the significant economic benefits from doing so. It has been demonstrated that foreign aid is a valid source of funding HIV in LICs like Uganda. Given the scarcity of resources and the benefits of increasing spending on effective prevention and on treatment as soon as possible, it is desirable that development-aid for health be increased in order to limit the future HIV/AIDS obligations and facilitate the ability of governments to meet these. It should be noted that we have assumed that all foreign aid for health is channelled through the government budget so that aid-money is spent according to priorities as laid down in the National Strategic Plan for HIV/AIDS and the health sector strategic plan. However, it is also acknowledged that some donors still prefer to channel aid to specific projects and that the sustainability of aid-inflows cannot be guaranteed.

The paper has also shown that LICs like Uganda have the capacity for domestic resource mobilisation through direct taxation to fund HIV programmes. It is therefore imperative that policy makers – in Uganda and other LICs grappling with similar challenges - devise means to increase revenue for which the most obvious source would appear to be direct taxes particularly tapping into the large informal sector. We recognise that raising taxation is a sensitive political issue. However, taxation that is anchored to quality health service delivery can be attractive to the citizenry. It is therefore crucial that while taxes rates are increased, the quality and quantity of health services should be stepped up.

For future research, we propose to analyse other HIV intervention channels, such as modelling the impact of consumption taxes (value-added tax - VAT) as a source of fiscal space for HIV. It is also plausible to investigate the impact of funding sources for HIV on poverty rates in Uganda. Additionally, the model will be applied to different countries with different resource constraints.

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Appendix

Appendix 1.1 Structure of a stylized Macro SAM for MAMS

A SAM is the benchmark data set to which the CGE model is calibrated. The activity accounts represent production entities while the commodity accounts are activity outputs. The row entries of the commodity accounts represent payments from commodity demanders while the column entries show payments to the suppliers and indirect taxes. The SAM for MAMS is similar to the standard SAM for CGE models except for some unconventional features that are required when running the MDG module of the MAMS model. These features include specifying the production and delivery of services that are provided by both the government and the private sector, such as education. Hence, where data exists, activities are distinguished between private and public the distinction. The accounts for government activity and commodity are disaggregated by function. In the factor accounts, private capital[17] is distinctively entered while Labour is entered by education levels that match the education system of the country. For the set of institutions – households, government and rest-of-world, in each institution, a current account and a capital account links to the investment accounts and the capital accounts of other institutions. The account of interest payments links payment from borrowers to lenders. Note that the interest account does not capture the interest payments and debts linking domestic non-government institutions. Instead, the rows of capital accounts for non-government institutions accounts record their financing sources, including own savings and net borrowing from selected other institutions. Table A1 gives an overview of a macro SAM for MAMS and the narrative for the SAM accounts and cell entries is given in Table A2.

Table A1 SAM for MAMS

	a-prv	a-gov	c-prv	c-gov	f-lab	f-capprv	hhd	gov	row	tax-dom	tax-imp	int-dom	int-row	cap-hhd	cap-gov	cap-row	inv-prv	inv-gov	dstk	total
a-prv			prod																	
a-gov				prod																
c-prv	io	io					con		exp								inv	inv	dstk	
c-gov								con												
f-lab	va	va																		
f-capprv	va																			
hhd					va-h	va-h		trns	trns			intd								
gov						va-g	trns		trns	itax+dtax	mtax									
row			imp				trns	trns					intr							
tax-dom	atax		ctax			incf	itax													
tax-imp			mtax																	
int-dom								intd												
int-row							intr-h	intr-g												
cap-hhd							sav									borr				
cap-gov								sav						borr		borr				
cap-row									sav											
inv-prv														inv-p		inv-p				
inv-gov															inv-g					
dstk														dstk-h	dstk-g					
total																				

[17] The MAMS data set includes a mapping of one type of government capital per government activity, but this is not represented in the SAM because typically, government capital does not earn value-added.

Table A2 Accounts and cell entries in the Macro SAM

Account	Narrative	Cell entry	Narrative
a-prv	Activity - private production	bor	Borrowing
a-gov	Activity - government production	cons	Consumption
c-prv	Commodity - private production	dstk	Stock (inventory) change
c-gov	Commodity - government production	exports	Exports
f-lab	Factor - labour	imports	Imports
f-capprv	Factor - private capital	intrdom	Interest on domestic government debt
hhd	Households	interm	Intermediate inputs
gov	Government	intrror	Interest on foreign debt
row	Rest of world	inv	Gross fixed capital formation
tax-dom	Taxes - domestic and trade	output	Production output
Tax-imp	Import tariffs		
intr	Interest (on domestic and foreign debt)	sav	Savings
cap-hhd	Capital account - household	taxes	Taxes (direct and indirect)
cap-gov	Capital account - government	trnsfr	Transfers
cap-row	Capital account - rest of world	va	Value added
inv-prv	Investment - private capital	yrow	Factor income from the rest of world
inv-gov	Investment government capital		
dstk	Stock (inventory) change		