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Is HIV/AIDS Undermining Botswana's 'Success Story'? Implications for Development Strategy

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Development Strategy and Governance Division

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ABSTRACT

Despite its strong growth record, Botswana faces two prominent development challenges: the onslaught of HIV/AIDS and the slowdown in diamond mining. This study estimates the growth and distributional impact of the HIV/AIDS pandemic and considers its implications for the country's development prospects, using a dynamic computable general equilibrium and microsimulation model that accounts for the cost of treatment. The results of this analysis indicate that HIV/AIDS reduces GDP growth by 1.6 percent, increases the absolute poverty headcount by 1.5 percentage points and disproportionately hurts labor-intensive manufacturing. Therefore, while mining has dominated the recent slowdown in Botswana's growth, the present findings suggest that HIV/AIDS is undermining economic diversification. Although providing treatment is projected to reclaim a quarter of the lost growth and a third of the poverty caused by the pandemic, the fiscal burden of treatment will constrain diversification, thus underscoring Botswana's need for development assistance. Furthermore, focusing resources toward treatment may worsen inequality, since the primary beneficiaries will be middle-income and urban households. Therefore, while HIV/AIDS is undermining Botswana's success story, both unemployment and a stagnant rural economy will remain binding constraints against further pro-poor development.

Keywords:

1. INTRODUCTION

Due to its immense diamond wealth, Botswana has been one of the world's fastest growing economies, and the conversion of its mining-driven growth into social investments has been seen as an African 'success story' and a lesson for other developing countries (Acemoglu *et al*., 2003). However, despite Botswana's strong growth record, two prominent challenges have arisen over the last two decades that threaten to unravel its past success. First, the country has the second highest prevalence of HIV/AIDS in the world. Almost 20 percent of its total population and 30 percent of its labor force are infected, threatening the sustainability of the country's development strategy. Secondly, growth in diamond mining has stagnated as the sector has matured and production has reached a plateau. This has led to more modest economy-wide growth in recent years, which in turn has placed pressure on the government's revenues, impacting its ability to address the AIDS pandemic.[1] Furthermore, economic stagnation has increased the opportunity cost of directing resources towards the health sector at the expense of other investments that might help reestablish growth and encourage diversification. Within this context, therefore, it is important to understand not only the constraints that AIDS imposes on the country's development prospects, but also the fiscal implications of engaging the pandemic.

Here, the impact of AIDS is jointly estimated on future growth and poverty in Botswana. This is done by imbedding the projections from a demographic model within an applied general equilibrium and microsimulation model that captures many of the transmission mechanisms linking AIDS to sectoral growth and household incomes. Within this framework, the analysis also estimates the implementation impact of the government's current treatment program, taking into account fiscal constraints and foreign assistance. Section 2 describes the demographic impact of the pandemic and the associated treatment program. Section 3 reviews existing evidence and describes the methodology used to capture the economic impacts of AIDS, while section 4 presents the results and sensitivity analysis of the present work. The final section summarizes the findings and considers their implications for Botswana's development prospects.

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* This paper is part of a broader initiative funded by the United National Development Programme aimed at examining the economic impact of HIV/AIDS on Botswana.

[1] Unless stated, the term 'AIDS' is herein used synonymously with 'HIV/AIDS.'

2. THE DEMOGRAPHIC IMPACT OF AIDS AND ITS TREATMENT IN BOTSWANA

Since the first case of HIV was confirmed in Botswana two decades ago, the scale of the pandemic has escalated until almost one in every five people are infected. During this same time period, Botswana has suffered a dramatic slowdown in economic growth. GDP grew an average of 11.4 percent per year from 1960-90, but only five percent per year during the 1990s, and a low of 3.7 percent annually since then (World Bank, 2005). In addition, poverty increased during the 1990s, with the share of the population living on less than a dollar per day increasing from 19.9 percent in 1993/94 to 23.4 percent in 2002/03 (CSO, 2004). To estimate the contribution of the pandemic to these development outcomes, it is necessary to first understand its impact on population growth and on different population groups. This section describes the population profile of HIV prevalence based on recent estimates. These prevalence rates have been used to produce a set of population projections, which are described together with the government's current treatment strategy.

HIV Prevalence in Botswana

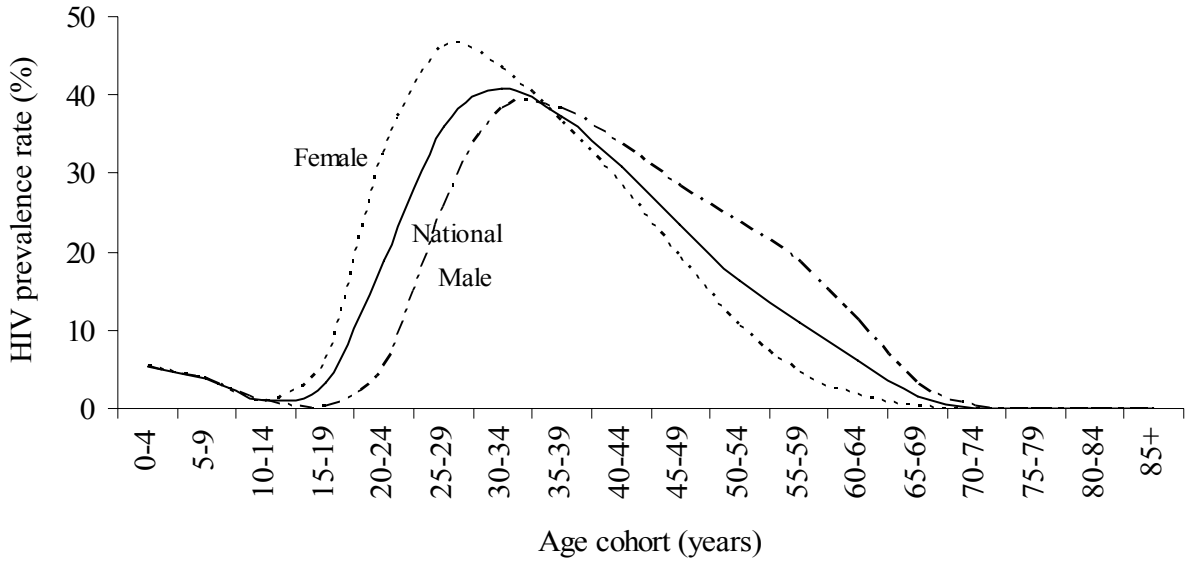
In 2004, the government of Botswana conducted its second nationally representative AIDS impact survey (BAISII) to estimate HIV prevalence and the socio-economic and behavioral characteristics of the infected population (CSO, 2005). Approximately 24,500 individuals in 7,300 households were randomly surveyed, with 60 percent agreeing to voluntary HIV testing. This survey provided more reliable estimates of HIV prevalence than those based on sentinel data derived from testing pregnant women. According to the BAISII, an estimated 17.2 percent of Botswana, out of a total population of one and a half million, were HIV positive at the time of the survey. While this estimate is lower than those obtained from the sentinel surveys, it confirmed that a large portion of Botswana's population is infected. The BAISII also indicated that the prevalence rates of HIV in Botswana varied by geographic region: they were highest in major cities (20 percent) followed by urban towns and villages (17 percent), and lowest in rural areas (15 percent). The prevalence rates in all regions were consistently highest among women, with the average female prevalence for the country as a whole being 19.9 percent compared to 14.1 percent for men. HIV was also found to infect women at an earlier age, although the prevalence rates were considerably higher for working age adults regardless of gender (cf. Figure 1).

One advantage of the BAISII was that it contained information on each individual's education and occupation, allowing additional analyses. The HIV prevalence rates were found to

be lowest among people with tertiary education, but there was no significant difference between those with primary or secondary schooling (CSO, 2005). Differences were more pronounced across occupational categories within the working population;[2] the average HIV prevalence rate for workers was 28.7 percent, but this varied from 18.8 percent for professional workers to 34.1 percent for unskilled workers.

In sum, the BAISII not only confirmed that AIDS is widespread in Botswana, it also revealed considerable variation across the population, especially between men and women and rural and urban areas. Furthermore, it indicated that AIDS is concentrated amongst working adults, and distorts labor markets primarily through its impact on different occupations rather than by education. These estimates therefore enabled a more accurate assessment of the demographic impact of AIDS on both population growth and labor supply.

Figure 1. HIV Prevalence Rates by Age Cohort and Gender, 2004



Source: Author's calculations using results from the Botswana demographic model (Dorrington, 2006).
Note: The demographic model is calibrated to the 2004 BAIS dataset in order to replicate observed prevalence rates.

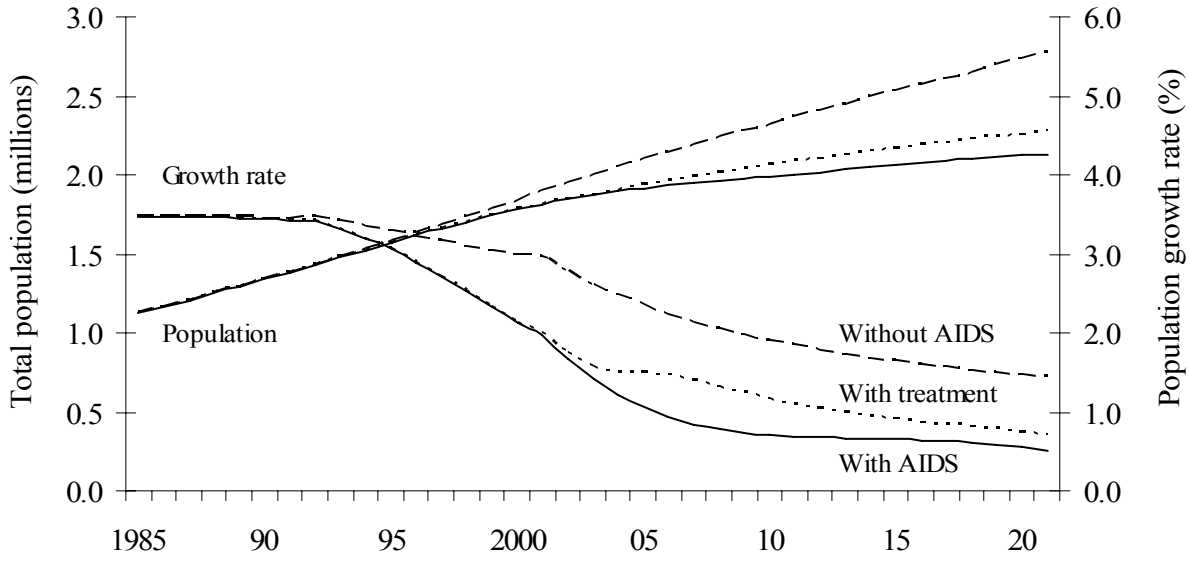
The Impact of AIDS on Population Growth

Dorrington (2006) incorporated the BAISII estimates within a demographic model in order to produce a set of population projections for 1985-2021. The first two scenarios estimated population growth in the presence and absence of AIDS (cf. Figure 2). This analysis revealed that the impact of AIDS on Botswana's total population is considerable, with the average annual

[2] The 'prime age' working population is defined here as the economically active population aged 20-64.

growth rate for 2003-21 falling from 2.0 percent under the *Without AIDS* scenario to 0.9 percent under the *With AIDS* scenario. This implies that, in the absence of treatment, the population of Botswana will be 23 percent smaller in 2021 than it would have been in the absence of AIDS. The demographic model also suggests that HIV prevalence may have peaked around 2000, with prevalence rates projected to decline slightly over the next two decades.[3] This leads to an increase in average life expectancy from a low of 42 years in 2003 to 49 years by 2021. However, the number of infected people will continue to rise and life expectancy will remain substantially below the 60 years achieved in the early 1980s. Therefore, the transition to a post-AIDS Botswana will be slow, even though the number of new infections is projected to decline. Furthermore, beyond its immediate impact on mortality, the pandemic is also expected to increase the population of orphans, who already numbered 36,000 in 2003 (Dorrington, 2006).[4] The resulting increase in the average dependency ratio will exacerbate the high burden placed on remaining households and the government. In light of these immediate and long-term impacts, the country has recently renewed its strategy to combat the pandemic and mitigate its demographic impact.

Figure 2. Population Projections, 1985-2021



Source: Author's calculations using results from the Botswana demographic model (Dorrington, 2006).

Note: 'With treatment' is based on expected prevalence rates under the government's treatment program: 2006-09 National Strategic Framework.

[3] The peaking of the pandemic is supported by survey estimates from anti-natal clinics.

[4] Orphans are herein defined as children who have lost both parents (i.e. 'double orphans'). Dorrington (2006) estimates that an additional 325,000 children will be either maternal or paternal 'AIDS orphans' by 2021.

The National Strategic Framework

The government's reaction to the pandemic has evolved over the last two decades (World Bank, 2001). Early responses focused on preventing new infections by promoting education, awareness and behavioral change, while more recent approaches have been broadened to include treatment, primarily through the provision of anti-retroviral therapy (ART). The 2003-09 National Strategic Framework (NSF) is a comprehensive and multi-sectoral strategy with interventions extending beyond the health ministry (NACA, 2003). It includes expanding the provision of free ART and HIV testing, preventing new infections by addressing mother-to-child transmission and broadening education, and supporting households with orphans and infected members. While the cost of the treatment program will primarily fall on the government, it is expected that the country will continue to receive financial assistance from its development partners (IMF, 2004).

Assuming that the treatment program continues beyond 2009, the demographic model estimates that population growth will increase from 0.9 to 1.2 percent per year during 2003-21 (Dorrington, 2006). This projection assumes that 80 percent of the infected population will eventually receive ART. In the absence of treatment, AIDS increases the average deaths per thousand people from 5.3 to 17.2 per year, while treatment lowers this average death rate to 13.7.[5] However, in line with a gradual implementation of ART, most of the projected acceleration in population growth under the *Treatment* scenario will take place prior to 2010 (cf. Figure 2), because although ART extends the life expectancy of the currently infected population, it does not prevent AIDS-related deaths. Therefore, provision of treatment only partially alleviates the negative demographic impact of AIDS during 2003-21. While these demographic projections reveal the scale of the pandemic in Botswana, they do not explain how it will affect economic outcomes, such as growth and poverty. In assessing the contribution of AIDS to Botswana's development prospects, the present study sought to develop an analytical framework that translates the demographic impact of AIDS and treatment into its economic impact on growth and poverty.

[5] HIV prevalence rates will increase as a result of treatment, since the life expectancy of the infected population will increase.

3. MODELING THE IMPACT OF AIDS ON GROWTH AND POVERTY IN BOTSWANA

Numerous microeconomic studies have confirmed the detrimental effects of AIDS on households; these include the displacement of human and financial resources towards health care, increased vulnerability from deteriorating livelihoods, heightened stigmatism and fragmentation of social networks, and lower investments in human capital and nutrition.6 These household-level effects must be aggregated in order to estimate the overall impact of the pandemic. Furthermore, while AIDS directly affects households, there are also implications for the economy as a whole. A macroeconomic assessment, therefore, should not only account for households, but should also include other actors or institutions, including firms, markets and the government. However, a broad analysis usually means that a macroeconomic study must exclude certain microeconomic impacts, especially those relating to social or non-income dimensions. It is this attempt to capture the economy-wide impact of AIDS, albeit at the expense of certain transmission channels, that distinguishes the macro and micro strands of the literature.

Previous Studies and Methodologies

The most common approach to estimating the macroeconomic impact of AIDS has been the use of a Solow growth model to capture changes in labor supply and productivity. These models are often augmented to include additional transmission mechanisms, such as savings or human and physical capital formation. The first of these studies in Botswana estimated that AIDS reduced GDP growth by 0.8 to 1.9 percentage points per year, depending on the assumed productivity losses (BIDPA, 2000). More recent studies using variants of this model have estimated larger impacts on growth, up to three percent per year (MacFarlan and Sgherri, 2001; World Bank, 2001; IMF, 2004). However, while these models indicate that the economy would grow faster in the absence of AIDS, the population shows a similar growth, leading to declines in per capita GDP under less pessimistic conditions of growth or productivity losses. This suggests that while AIDS reduces economic growth, it may increase income on an average per capita basis. The disconnect between these findings and the severe impacts observed at the household level suggests that an aggregate growth-accounting framework may not satisfactorily capture important distributional effects of the AIDS pandemic. Therefore, while aggregate growth models indicate that AIDS will not cause economic collapse – a conclusion that has so far been borne out

[6] See Casale and Whiteside (2006) for a comprehensive review of the literature.

in Southern Africa – they are unable to estimate the impact of the pandemic on poverty and inequality.[7]

Some studies have sought to close this gap by examining the distributional impacts of AIDS. For example, Greener *et al*. (2000) developed a survey-based microsimulation model that first estimated the probability of individuals being infected, and then considered the impact on households by drawing on the results from BIDPA (2000). The results from this study indicated that AIDS increased the national incidence of poverty by between four and six percentage points, but had no effect on income inequality. However, the macroeconomic impacts in this study were still drawn from an aggregate model, and thus failed to capture structural changes in growth and employment. Other approaches have been used elsewhere in Southern Africa to disaggregate the impact of AIDS on growth. For example, Arndt and Lewis (2001) use a computable general equilibrium (CGE) model of South Africa to jointly estimate impacts on producers and households, while explicitly capturing cross-sectoral linkages and labor markets. While this approach accommodated structural change, the use of aggregate representative households precluded the *explicit* measurement of poverty effects. In an effort to overcome these limitations, the methodology adopted in the present work combines the above approaches by developing a disaggregated dynamic CGE and microsimulation model that is capable of capturing the effect of AIDS on the level and structure of growth while also assessing its economy-wide impact on poverty and inequality.

Description of the Model

This study extends previous aggregate growth models of Botswana by estimating the impact of AIDS on individual sectors. To reflect the heterogeneity of Botswana's producers, the CGE model is calibrated to a purpose-built 2002/03 social accounting matrix (SAM) that distinguishes between 26 productive sectors.[8] Segmented markets are assumed for the 30 different labor types identified in the model. Given the different prevalence rates from the BAISII survey, labor is disaggregated across five occupational categories (professional, managerial, clerical, manual, and unskilled), three geographic regions (cities, towns/villages, and rural areas), and male and female workers. Unemployment rates are held constant, while labor is considered to

[7] Two recent studies have focused on estimating the long-run impact of AIDS on human capital formation. Bell *et al*. (2003) used an overlapping generations model for South Africa, and showed that AIDS may undermine educational transfer and halve per capital income during 1960-2060. In contrast, Young (2006) used a Ramsey-style growth model for South Africa to show that per capita income may be higher during 1995-2145 as a result of AIDS, as limited resources are distributed among a smaller population.
[8] See Dervis *et al*. (1982) for a description of this class of models, and Lofgren *et al*. (2002) for a mathematical description of a static version of the model.

be fully employed and mobile across sectors, with flexible real wages.[9] By contrast, capital is immobile, earning flexible activity-specific returns. Although producers maximize profits, they are constrained by imperfect factor markets, such as segmented markets for skilled and unskilled labor. A nested production system is employed. At the lower levels, a constant elasticity of substitution function is used to define factor demand, while at the highest level, fixed-share intermediates are combined with factor value-added. Within the regional nesting of labor demand, a worker's occupation is considered more important than his or her gender. The model disaggregates production across sectors, thus capturing the changing structure of growth caused by the pandemic. Furthermore, detailed labor disaggregation allows the model to incorporate differences in prevalence rates among workers and the effect of the pandemic on employment and wages.[10]

In order to capture the economy-wide impact of AIDS, the model considers a number of 'institutions', including the government, enterprises and households. Enterprises are divided into three categories (mining, private non-mining, and public non-mining). The 60 household groups in the model are derived from the 2002/03 Household Income and Expenditure Survey (HIES) (CSO, 2004), and are disaggregated according to geographic region, the gender of the *de jure* household head, and national expenditure deciles. In short, households and enterprises receive income in payment for producers' use of their production factors. These income patterns depend on a given household's physical and human capital endowments, as reported in the survey. Both types of institutions pay taxes to the government (based on fixed tax rates), save (based on marginal propensities to save), and make transfers to the rest of the world. Enterprises pay their remaining income to households, which then use their incomes to consume commodities under a linear expenditure system. The government receives income from direct and indirect taxes, and then makes transfers domestically and abroad. The government also purchases commodities in the form of consumption expenditure, and then saves the remaining income. Fiscal expenditure is disaggregated by administration, health and education functions. All private and public savings and foreign inflows are collected in a savings pool from which current investment is financed. By disaggregating households according to their income and expenditure patterns, the model captures

[9] The assumption of full employment may appear overly rigid, but this allows the labor supply to adjust exogenously in response to the demographic projections. The assumption effectively implies that current unemployment rates are maintained (or do not change dramatically) and that new workers find some form of employment. In other words, if formal labor demand is insufficient, the model assumes that workers find jobs in lower paying informal sectors.

[10] International trade is also modeled explicitly. Export supply is governed by a constant elasticity of transformation function based on endogenous relative prices. Import demand, for final and intermediate usage, is governed by an Armington function. Under the small country assumption, foreign prices are fixed and include relevant taxes and transaction margins.

how AIDS affects households and regions differently. Furthermore, the detailed treatment of public expenditures and tax incidence allows the model to capture the fiscal implications of AIDS and additional health costs under the treatment program.

The model has three macroeconomic accounts (the savings and investment account, the current account, and the government account), and a set of 'closure' rules ensures macroeconomic balance. A savings-driven closure is assumed for the savings-investment account, whereby the marginal propensities of households and enterprises to save are fixed, and real investment quantities are adjusted to ensure that the level of investment and savings are equal at equilibrium. For the current account, it is assumed that the *real* exchange rate adjusts to maintain a fixed current account balance measured in foreign currency. Finally, for the government account, tax rates and real government consumption expenditure are fixed. Public administration and economic spending are considered a fixed share of the total expenditure, while education and health spending are taken as following the population growth (plus any additional health spending under the treatment program). Under this closure, the fiscal surplus adjusts to ensure that revenues equal recurrent expenditures and public investments. Collectively, these closures allow the model to capture the crowding-out effects of government spending, the impact of savings on investment and growth, and the effect of foreign development assistance on the real exchange rate.

The model is recursive dynamic, implying that parameters in the current period are determined by results from previous periods. New capital stocks are endogenously determined by past levels of savings and investment, with new capital allocated across sectors according to differences in profit rates. The model thereby captures the impact of AIDS on physical capital accumulation. The model is exogenously updated to reflect changes in population based on demographic projections (cf. Section 2). The demographic model projects annual population growth by age cohort and gender. These disaggregated growth rates are mapped onto households in the microsimulation model according to their initial demographic structure. Survey sample weights are then updated each year to capture different population growth scenarios. Similarly, labor supply is estimated based on the demographic projections, but its mapping to the microsimulation model is restricted to the economically active population and reflects the prevalence rates of different occupational groups and geographic regions. These population and labor supply projections from the demographic and microsimulation models are then aggregated to determine the growth rates for the representative households and labor categories in the CGE

model.[11] Finally, labor and total factor productivity (TFP) are updated exogenously according to the assumed impacts of AIDS (cf. Section 4).[12]

The model is initially calibrated to the information contained in the 2002/03 SAM. The dynamic model is then solved for the 2003-21 period as a series of equilibria, each one representing a single year. By imposing forecasted GDP growth from Botswana's 2003-09 National Development Plan (NDP9) (MFDP, 2003) as well as the population and labor supply projections from the demographic model, the CGE model produces a counterfactual growth path consistent with the current *With AIDS* scenario (cf. Figure 2). This scenario reflects the current growth path of the economy in the presence of AIDS, but in the absence of treatment. Two additional scenarios (*Without AIDS* and *With Treatment*) are expressed through changes in population, labor supply, productivity and government expenditure. The model is then re-solved for a new series of equilibria, and the differences between these alternative growth paths and the counterfactual are interpreted as the economy-wide impact of AIDS and its treatment. Finally, changes in poverty and inequality in the microsimulation module are measured using the same survey that was used to construct the SAM and CGE model. Analogous to sample weights, each representative household in the CGE model is an aggregation of a larger number of households in the survey. Since poverty is defined in this study according to per capita expenditure, changes in each household's expenditure in the CGE model are passed down to the survey, where the poverty measures are updated and poverty and inequality is recalculated.

In summary, the CGE-microsimulation model is an advance over previous methodologies because it captures the detailed sectoral structure of Botswana's economy and the linkages between producers, markets, households and government. It is based on new estimates of HIV

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[11] Changes in household sizes were calculated by multiplying each member of a sample household by its projected population growth rate, mapped according to each individual's gender and age cohort. Population projections were pre-adjusted to reflect differences in HIV prevalence rates. Population growth rates were multiplied by the ratio of each region's average prevalence rate to the national average. A similar exercise was conducted for labor force growth rates, although in this case an individual's projected population growth rate was pre-multiplied by the ratio of his or her occupation's average HIV prevalence rate with respect to the national average. Population growth rates were taken from the demographic model, regional and occupational prevalence rates were taken from the BAISII survey, and the initial demographic structure of households was taken from the household income and expenditure survey. The integration of the demographic, CGE and microsimulation models makes full use of the available information. However, it assumes that the demographic structures in the survey remain representative over time, and in spite of AIDS. In other words, any combining or fragmentation of households randomly nets out and does not dramatically alter the composition of the true population represented by *households* in the survey sample. Since the survey was conducted at the apparent peak of the pandemic, it should remain sufficiently representative over the coming years.

[12] The demographic model projects the number of people who are HIV positive and who are suffering from full-blown AIDS. Changes in labor productivity (as opposed to TFP) assume that people with full-blown AIDS are 50 percent less productive during the final stages of infection.

prevalence and integrates the relevant demographic and economic models. The CGE model *exogenously* captures a number of transmission mechanisms linking AIDS to growth and poverty, including: (i) changes in household populations and national demographic structure due to increased mortality; (ii) shifts in the level and skill-composition of labor supply; (iii) falling labor productivity due to morbidity and the productivity losses associated with systemic shocks to the economy; and (iv) changes in the level and composition of government expenditure. The model also *endogenously* captures other mechanisms, such as changes in savings and their impact on investment and capital accumulation. Although not exhaustive, these transmission mechanisms provide a reasonable approximation of the main impacts of AIDS on growth, poverty and inequality in Botswana.

4. MODEL RESULTS

Three scenarios are presented. The *With AIDS* scenario captures the current growth path given existing prevalence rates, but in the absence of the government's new treatment program. The *Without AIDS* scenario captures how the current growth path would have differed had AIDS never existed. The final *Treatment* scenario starts with existing HIV prevalence rates and then considers the impact of the government's current treatment strategy.

The Current 'With AIDS' Scenario

The previous section identified four exogenous transmission mechanisms that are used in the model to simulate the impact of AIDS, namely population, labor supply, productivity, and fiscal expenditure. The *With AIDS* scenario draws on the demographic model, national growth projections, and past trends to determine how these factors change over time (cf. Table 1). Despite the dominance of mining and the importance of agriculture for rural livelihoods, a majority of Botswana's one and a half million people live in urban areas. However, most members of the urban population live in towns and villages rather than in the two main cities. Based on the projections of the demographic model, the urban population is expected to grow faster than the rural population during 2003-21, even though the urban population has a higher HIV prevalence rate. Labor supply grows evenly across the different occupational groups, with the exception of manual labor, which includes agricultural workers and mirrors slower rural population growth, and unskilled labor. Both labor-specific and total factor productivity remain unchanged, reflecting the general slowdown in the economy. Government expenditures on education follow recent trends. Health expenditures increase because they include the projected cost of orphans and health services in the absence of anti-retroviral and other treatments (Kinghorn, 2006).[13] These four sets of assumptions are combined with the sectoral growth projections from the 2003-09 National Development Plan (NDP9) to capture Botswana's current growth path without the effects of treatment.

[13] The fiscal implications of providing (or not providing) treatment are discussed below under the *Treatment* scenario.

Table 1. Comparison of the Model Scenarios

Transmission channel	Initial value, 2003	Initial HIV prevalence rate (%)	Annual growth rate, 2003-21 (%)		
			With AIDS	Without AIDS	Treatment
Population (1000 people)	1,861	17.2	0.9	2.0	1.2
Urban areas	1,043	18.2	1.0	2.3	1.4
Cities	422	20.0	1.1	2.6	1.6
Villages and towns	621	17.0	0.9	2.0	1.2
Rural areas	818	15.0	0.7	1.6	1.0
Labor supply (1000 workers)	462	28.7	1.2	2.5	1.7
Professional	57	18.8	1.2	2.2	1.7
Managerial	13	24.2	1.3	2.7	1.8
Clerical	89	30.4	1.1	2.6	1.7
Manual	100	28.6	1.5	2.8	2.0
Unskilled or elementary	204	34.1	0.9	2.8	1.5
Productivity					
Labor	-	-	0.0	0.5	0.2
TFP (labor and capital)	-	-	0.0	0.4	0.2
Government expenditure (Mil. Pula)					
Education and social services	3,112	-	2.8	4.0	3.2
Health	773	-	5.7	2.7	7.2

Source: Botswana CGE-microsimulation model, 2002/03 Household Income and Expenditure Survey (Government of Botswana, 2004a), and 2004 Botswana AIDS Impact Survey (Government of Botswana, 2006).

Note: Education and health spending are 24.5 and 6.1 percent of total government expenditures, respectively.

Under the current scenario, GDP grows at three percent per year during 2003-21, driven by strong growth in investment and government expenditures (cf. Table 2). This is in line with past trends and current forecasts. Investment growth accounts for the fast accumulation of capital stocks at 3.7 percent per year. Slower growth in labor supply and productivity partly reflects the impact of AIDS and suggests that production will become increasingly capital-intensive as producers overcome labor constraints by utilizing more machinery. At the sectoral level, public services grow alongside government consumption expenditure. Manufacturing and private services expand more quickly than overall GDP, with the former benefiting from the availability of capital. In contrast, agriculture and mining grow slowly at two percent per year, in line with recent trends and the depletion of natural resources.

Table 2. Macroeconomic and Growth Results

	GDP share, 2003 (%)	With AIDS 2003-21	Without AIDS 2003-21	Treatment 2003-21
		Average annual growth rate (%)		
GDP at market prices	100.0	3.0	4.6	3.4
Private consumption	26.6	2.2	4.4	2.9
Government	34.7	3.1	4.5	3.6
Investment	27.7	4.0	5.7	4.1
Exports	43.2	2.6	4.1	2.9
Imports	32.2	2.8	4.6	3.2
GDP at factor cost	100.0	3.0	4.6	3.4
Capital stock	73.0	3.7	4.3	3.7
Labor employment	27.0	1.2	2.5	1.7
TFP (residual)	-	0.0	0.8	0.3
GDP factor cost	100.0	3.0	4.6	3.4
Agriculture	3.1	2.0	4.3	2.4
Mining	38.3	2.0	2.4	2.2
Manufacturing	4.3	3.5	6.6	4.0
Other industry	7.9	4.0	5.8	4.3
Private services	25.1	4.0	6.5	4.5
Public services	21.4	3.0	4.4	3.5
		Point change in share of GDP by 2021 (%)		
Savings or investment	27.7	2.4	4.4	1.1
Public savings	12.0	1.2	1.9	-1.0
Private savings	22.5	1.7	1.7	1.7
Foreign inflows	-6.7	-0.5	0.9	0.4

Source: Botswana CGE-microsimulation model (present study).

Capital-intensive growth is less likely to translate into broad-based increases in household incomes. This is reflected in the slower growth in private consumption compared to other components of GDP. The combination of private consumption growth (2.2 percent) with national population growth (0.9 percent) implies that mean per capita incomes increase by 1.3 percent in the *With AIDS* scenario. However, despite rising average incomes, the share of the population living on less than one dollar a day falls only slightly, from 23.4 percent in 2003 to 20.7 percent in 2021 (cf. Table 3). This decline in the poverty rate is insufficient to offset population growth, with the result that the number of poor people is projected to increase by 90,000 during 2003-21. Furthermore, because industrial growth is concentrated in urban areas, the decline in national poverty is dominated by falling urban poverty, which is already less severe than that in rural areas. Rural poverty falls more slowly due to the poor performance of agriculture. Notably, however, male-headed households benefit as much as female-headed

households, despite the latter having fewer working members and women themselves facing higher unemployment.

Table 3. Poverty Results

	Poverty rate, 2003	Final year poverty rate, 2021		
		With AIDS	Without AIDS	Treatment
Poverty headcount (%)	23.4	20.7	19.2	20.2
Rural areas	36.1	34.4	35.7	35.0
Urban areas	13.5	10.5	7.6	9.5
Cities	5.1	3.8	2.2	3.4
Villages and towns	19.3	15.1	11.7	14.0
Male-headed households	20.6	18.2	15.9	17.5
Female-headed households	26.4	23.5	22.9	23.4

Source: Botswana CGE-microsimulation model (present study).

The *With AIDS* scenario captures the slowdown in Botswana's mining sector and the impact of AIDS on economic growth. Based on the projected level and structure of growth, poverty will decline only slightly and the benefits of growth will not be distributed evenly across the population. Urban poverty will decline due to manufacturing growth and employment, but a sluggish agricultural sector will constrain rural poverty reduction. These findings suggest that Botswana's current growth path is less geared towards benefiting the poor. However, it is unclear which of these development prospects are a result of AIDS versus the weak performance of the mining sector and a lack of alternative sources of growth. The next scenario addresses this question by removing the effects of AIDS from the current path, thereby allowing estimation of the pandemic's contribution to the current slowdown of development in Botswana.

The Hypothetical 'Without AIDS' Scenario

The *Without AIDS* scenario is identical to the previous scenario except that it removes the impact of the pandemic on population growth, labor supply, productivity and fiscal expenditure (cf. Table 1). In this scenario, both labor supply and productivity grow faster, directly increasing production and incomes (cf. Table 2).[14] Higher incomes and savings encourage investment and capital accumulation, while faster economic growth raises government revenues. However, while health costs are lower without the existing AIDS-related expenditures, the overall population size

[14] HIV/AIDS is assumed to affect productivity in two ways, namely by affecting labor productivity itself, and affecting broader total factor productivity. The latter includes a labor productivity dimension, implying that labor productivity is affected twice, while non-labor factors are affected by only TFP changes. This explains why the final combined change in TFP (cf. Table 2) is not equal to the sum of assumed labor and total productivity changes (cf. Table 1).

increases. Since education and social spending are tied to the size of the population, the decline in health cost is partially offset, causing only a slight improvement in the fiscal surplus (i.e. public savings) relative to the *With AIDS* scenario. Furthermore, while private savings increase in absolute terms, they do not rise as fast as the GDP, causing the private sector's share of investment to remain constant. The net effect is an acceleration of GDP growth from 3.0 percent under the *With AIDS* scenario to 4.5 percent under the *Without AIDS* scenario. AIDS therefore lowers Botswana's growth rate by approximately 1.6 percent per year.

AIDS also has implications for Botswana's interactions with foreign countries, as well as its overall structure of production. Slower mining sector growth lowers exports, while import-intensive investment encourages import demand. This places pressure on the current account and causes a slight depreciation of the *real* exchange rate. This depreciation, together with higher labor supply and productivity, favors the labor- and export-intensive sectors. Manufacturing exports are particularly reliant on urban labor, especially workers in lower-skilled occupations for whom the prevalence of HIV is highest. Accordingly, under this scenario, manufacturing grows more rapidly than the other sectors. Higher economy-wide growth also causes an expansion of private services. Despite the stronger performance of agriculture and manufacturing, these two sectors are unable to absorb the increase in labor supply, and some workers are forced to work in lower paying informal services. Furthermore, although the mining sector benefits from rising productivity, it is constrained by limited natural resources, meaning that additional growth remains marginal. The stronger performance of the non-mining sectors under the *Without AIDS* scenario suggests that the pandemic has not only lowered growth, but has also been a constraint to economic diversification.

Previous studies based on aggregate growth models have typically used per capita GDP to measure the impact of AIDS on households. However, a more relevant measure is private consumption, which reflects how much of the growth translates into household incomes. This is especially important in Botswana, where GDP growth is typically dominated by government and investment spending. Under the *Without AIDS* scenario, the increase in the labor supply exceeds the increase in capital stocks, leading to a less capital-intensive growth path. Since households are more reliant on labor incomes, this shift in the structure of growth means that households are more likely to participate in the growth process. For this reason the increase in the growth rate of per capita consumption is larger than that for per capita GDP. Therefore, not only would growth have been higher in the absence of AIDS, but more of this growth would have reached households.

Rising average per capita consumption also leads to further declines in poverty under the *Without AIDS* scenario (cf. Table 3). The national incidence of poverty falls to 19.2 percent by 2021 compared to 20.7 percent under the *With AIDS* scenario. However, this decline in the poverty rate is offset by a larger population; while 638,000 fewer people die in the absence of AIDS, 90,000 of these people are from below the poverty line. The smaller number of poor people in the presence of AIDS does not suggest a 'gift from the dying'. The lower poverty rate under the *Without AIDS* scenario indicates that around 43,000 *uninfected* people have been pulled into poverty due to the slower economic growth caused by AIDS. This is equivalent to 2.3 percent of Botswana's current population. Furthermore, not all groups are affected equally. Rural poverty is higher in the absence of AIDS, since there are fewer employment opportunities in rural areas, and because increases in the rural labor force and rural incomes are more than offset by a larger rural population. This suggests that, even in the absence of AIDS, agricultural growth and rural development would remain the binding constraint to broad-based poverty reduction. In contrast, urban households benefit more from the absence of the pandemic, since urban areas have the highest prevalence rates and the increased labor supply is matched by better urban employment opportunities and wages. These distributional differences suggest that AIDS may have in fact narrowed the gap between urban and rural poverty. However, this decline in regional inequality has come at the cost of increased mortality and higher overall poverty.

These results indicate that AIDS reduces GDP growth and raises the incidence of poverty in Botswana. Furthermore, each transmission mechanism contributes differently to these outcomes (cf. Table 4). Holding other mechanisms constant, changes in TFP generate most of the additional 1.6 percent GDP growth, while changes in labor supply have the largest impact on poverty. The latter is driven by the greater reliance of poor households on labor endowments and incomes. However, not all mechanisms have positive effects. The larger population under the *Without AIDS* scenario reduces GDP growth, since the decline in the fiscal surplus caused by increased education expenditures crowds-out the benefit of increased private investment. The converse is true for health expenditures, which decline under the *Without AIDS* scenario. The expansion of the population also causes an increase in the poverty rate, since it raises dependency ratios.[15] However, in the combined scenario this is more than offset by a larger supply of labor and higher productivity.

15 This is based on the assumption that the additional population does not join the labor force and find employment. The latter falls within the 'labor supply' mechanism.

Table 4. Contribution of Various Transmission Channels to Changes in Growth and Poverty Rates

	Change in GDP growth rate (%)		Change in poverty headcount (%)	
	Without AIDS	Treatment	Without AIDS	Treatment
Total point change	1.6	0.4	-1.6	-0.5
Labor supply	0.5	0.2	-4.2	3.3
Labor productivity	0.2	0.1	-1.3	0.8
Total factor productivity	1.2	0.5	-2.2	2.2
Health expenditure	0.7	-0.1	-0.6	-0.6
Population growth	-1.0	-0.3	6.7	-6.3

Source: Botswana CGE-microsimulation model (present study).

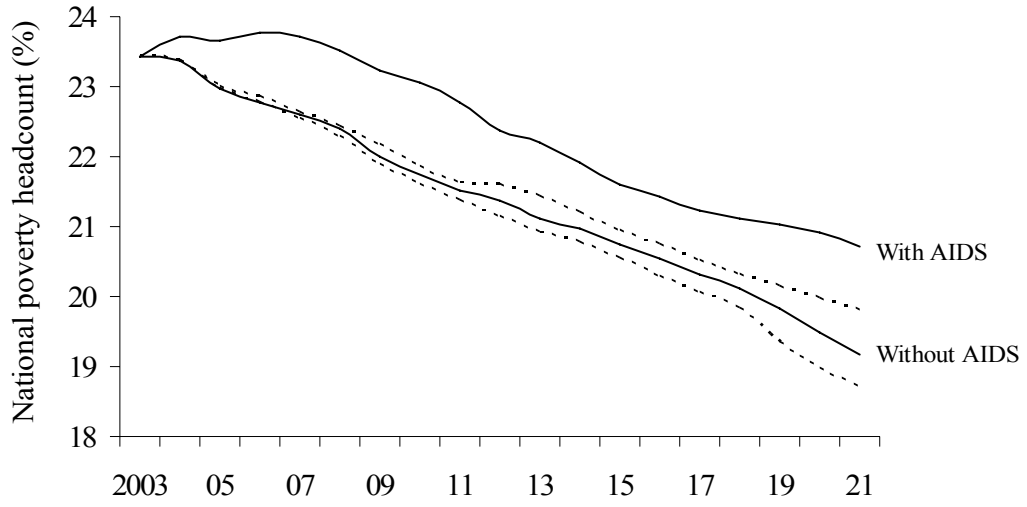
Note: *Growth rate* is the average rate for 2003-21, while *poverty rate* is the overall change in national headcount.

The importance of individual transmission mechanisms highlights the importance of sensitivity analysis. Some of the model's assumption are more robust than others, such as those based on more reliable projections or impacting only a small segment of the population. For example, labor supply and population growth are taken from the demographic projections, while AIDS-related health expenditures are based on detailed cost projections. Furthermore, while it is assumed that workers with full-blown AIDS have 50 percent lower labor productivity, this is a modest estimate for this late stage of the virus, and is expected to affect around 15 percent of the infected adult population. Accordingly, the sensitivity analysis focuses on TFP, which has a larger effect on the results and has the most tenuous assumptions.[16] Two further scenarios are run that are identical to the *Without AIDS* scenario except that the gain in TFP growth ranges between 0.6 and 0.9 percent per year (i.e. a 25 percent confidence interval around the initial estimate of 0.4 percent TFP growth). Under these alternative assumptions, the decline in GDP growth caused by AIDS ranges between 1.4 and 1.8 percent. The effect on poverty is more pronounced, with the overall increase in the headcount caused by AIDS ranging from 0.9 to 2.0 percentage points (cf. Figure 3). While these upper and lower bounds reflect the difficulty of estimating the impact of the pandemic, they do confirm that AIDS has a negative impact on growth and poverty even under less stringent assumptions.

[16] MacFarlan and Sgherri (2001) assumed a range of TFP losses from zero to 50 percent during 1999-2010. BIDPA (1999) assumed a 0.5 percentage point fall in TFP growth during 1996-2021. World Bank (2001) applied a 20 percent drop in TFP during 1996-2021. The present work assumes a 0.4 percentage point drop in TFP growth (i.e. a seven percent absolute loss during 2003-21).

The findings estimate that AIDS will reduce GDP growth in Botswana by around 1.6 percent per year during 2003-21. This implies that the economy would be a third larger in 2021 in the absence of the pandemic. Furthermore, the presence of AIDS limits diversification into non-mining labor-intensive sectors. Accordingly, AIDS has a pronounced impact on poverty, since labor earnings directly affect household incomes, especially amongst the poor. However, while AIDS clearly has a detrimental impact on growth and poverty, it only explains part of Botswana's failing development prospects. The results of this scenario suggest that it is the acceleration and diversification of growth (especially in rural areas) that is the binding constraint to broad-based poverty reduction. Despite these broader development challenges, however, this analysis shows that AIDS is undermining Botswana's development prospects, with the loss of life, the worsening of poverty, and the decline in growth emphasizing the need to engage the pandemic.[17]

Figure 3. National Poverty Headcount



Source: Botswana CGE-microsimulation model (present study).

Note: The poverty line is one international dollar per day in 2003 prices or 104.1 Pula per adult per month. The fainter lines for the *Without AIDS* scenario show the upper/lower bounds from assuming 20 percent weaker (above) or stronger (below) total factor productivity growth.

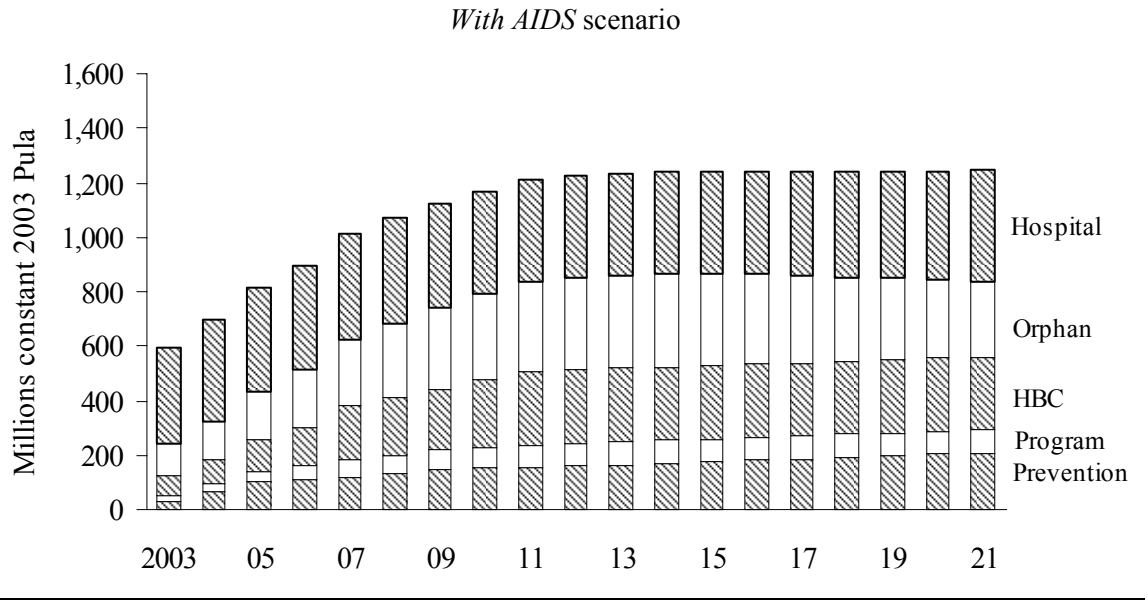
The 'Treatment' Scenario

The previous scenario estimated the impact of AIDS on growth and poverty by removing its effect on Botswana's current growth path. However, it is necessary to distinguish this

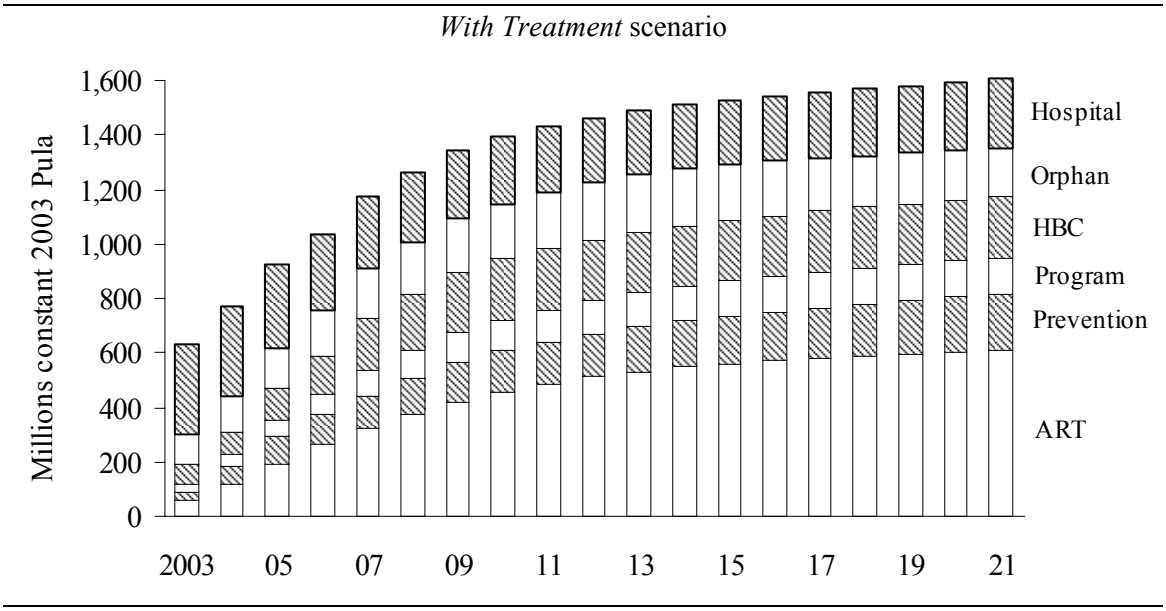
[17] While the model captures the general equilibrium effect of HIV/AIDS on incomes and growth, it does not capture how lower incomes and poverty influence HIV/AIDS prevalence rates. In other words, the model captures a one-way link from HIV infection to poverty, but not how worsening poverty might increase an individual's susceptibility to infection and the harmful effects of HIV/AIDS. While the second effect is likely to be smaller than the first, it would undoubtedly increase the estimated impact of HIV/AIDS.

hypothetical *Without AIDS* scenario from what is actually achievable. Accordingly, the final scenario simulates the impact of implementing the government's treatment program as outlined in the national strategic framework (cf. Section 2). Even under a comprehensive strategy, the population remains well below what it would have been in the absence of AIDS (cf. Figure 2). Given treatment, the population growth rate increases from its current 0.9 percent to 2.0 percent per year (cf. Table 1). However, the *Treatment* scenario should not be seen as a scaled-down version of the *Without AIDS* scenario, because these two scenarios have very different implications for Botswana's demographic structure. For instance, average dependency ratios are lower under the *Treatment* scenario because ART does not cure AIDS, but rather extends the average life of working age population.[18] As such, the labor supply growth rate increases by more than the population growth rate.

Figure 4. Projected Annual Government AIDS-Related Expenditures



[18] Since ART slows the progression of HIV into full-blown AIDS, the *Treatment* scenario effectively increases the average age of the infected population (i.e. it shifts the peak of Figure 1 to the right, but has little effect on the tails).



Source: Author's calculations using information from Kinghorn (2006).

Notes: Orphan is based on the annual cost to the government per child; prevention includes expenditure on mother-to-child transmission; program includes management and overhead costs; HBC is home-based care expenditures; and ART is anti-retroviral treatment and includes the cost of anti-retroviral drugs along with laboratory and consultation fees.

The *Treatment* scenario includes the annual cost of implementing the program, which according to Kinghorn (2006) will reach 1.6 billion Pula or two percent of the GDP by 2021 (cf. Figure 4). However, providing treatment reduces some of the fiscal costs incurred under the *With AIDS* scenario. For instance, while the provision of ART raises government expenditures, it also reduces the number of orphans and the required number of hospital beds (cf. Figure 4). This lowers the opportunity cost of the treatment program such that the additional or net fiscal burden reaches a maximum of 360 million Pula by 2021. Furthermore, in line with recent trends, it is assumed that one fifth of AIDS-related costs will be borne by Botswana's development partners. The *Treatment* scenario therefore incorporates both demographic and financial projections into the CGE model when estimating the economic impact of the government's treatment program.

The initial impact of providing treatment is an increase in labor supply, as life expectancy rises amongst the more heavily infected working population. The provision of ART also stalls the onset of full-blown AIDS, thus alleviating some of the decline in labor productivity.[19] This enhances the country's productive capacity and accelerates GDP growth (cf. Table 2). While economic growth raises incomes and savings, investment remains unchanged since increased health expenditures reduce the fiscal surplus and lower the government's capital expenditures.

[19] ART delays and shortens the final stage of infection and alleviates its symptoms. Therefore, labor productivity is assumed to fall by 25 percent for workers on ART and by 50 percent for those with full-blown AIDS.

This is partly offset by the inflow of foreign funds to help finance the treatment program. However, development assistance causes a slight appreciation of the *real* exchange rate, which encourages import demand rather than export growth. Therefore, unlike the *Without AIDS* scenario, the non-traded service sectors benefit as much as the capital- and export-intensive manufacturing sectors under this scenario. This suggests that the treatment program recovers only part of the loss in economic diversification caused by AIDS. Differences in investment and export outcomes under the *Treatment* scenario also underline the importance of considering the fiscal implications of providing treatment. However, after accounting for these costs, the treatment program still increases GDP by an additional 0.4 percent per year during 2003-21, which is one-quarter of the growth currently being lost to AIDS.[20] As in the previous scenario, most of this additional growth arises from higher TFP, although this is now dampened by increased health and education expenditures (cf. Table 4).

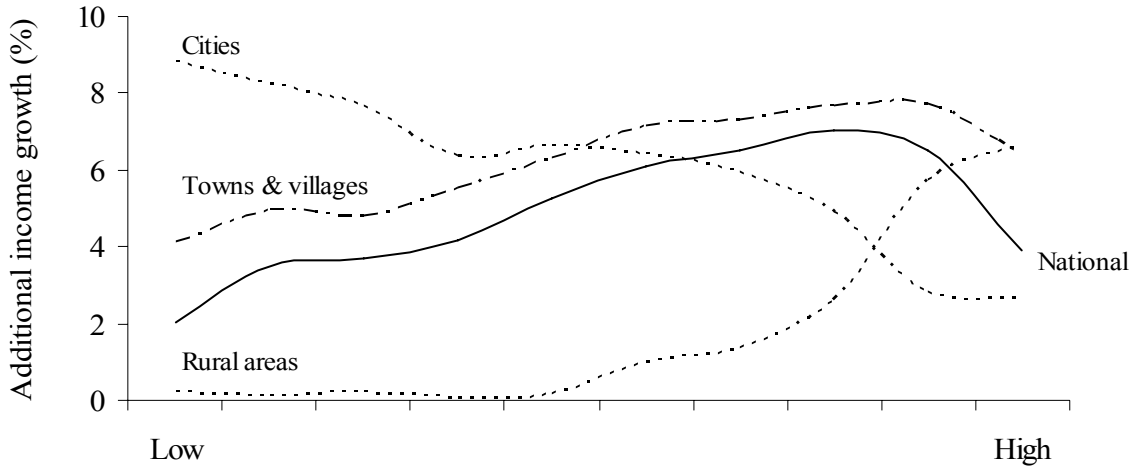
The larger labor force caused by reduced mortality generates a more labor-intensive growth path under the *Treatment* scenario. This favors household incomes and private consumption, both of which accelerate more rapidly than overall GDP. Rising average consumption spending also translates into a decline in poverty. The national incidence of poverty falls from 23.4 percent in 2003 to 20.2 percent in 2021 (cf. Table 3).[21] By reducing the poverty rate by a further 0.5 percentage point compared to the *With AIDS* scenario, the treatment program reduces the negative impact of AIDS by one third. However, the immediate increase in the population resulting from treatment causes the absolute number of poor people to remain almost unchanged by 2021. The larger decline in the poverty rate relative to the increase in the growth rate is driven by declining dependency ratios, since ART allows the infected population to continue working during their most productive years, but does not increase the average life expectancy beyond retirement.

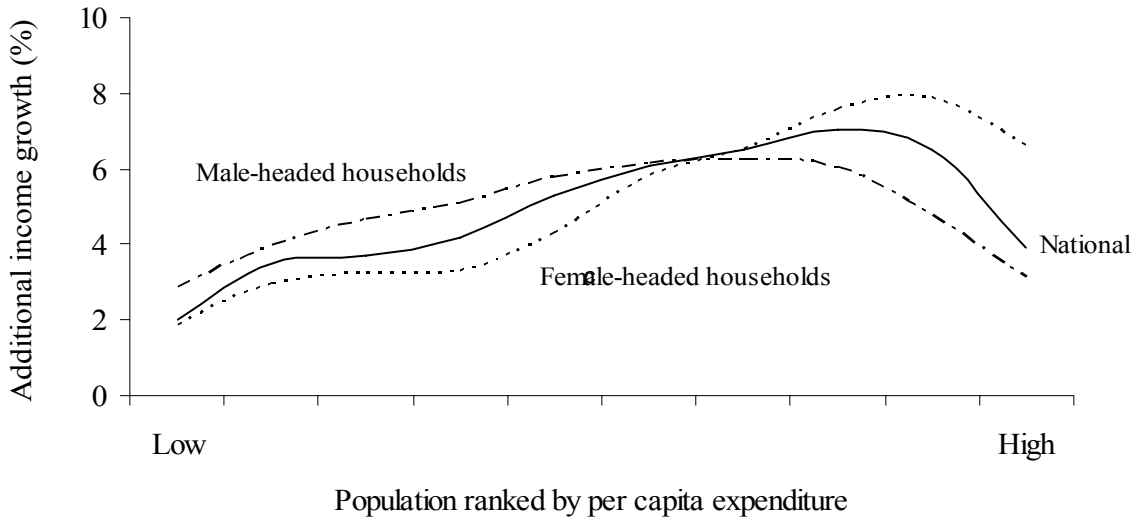
The distributional impact of the treatment program is shown using growth incidence curves (cf. Figure 5). These curves show the total additional per capita expenditure resulting from treatment for each percentile of the population, ranked according to their initial expenditures. The positive national curve throughout the expenditure distribution suggests that all households benefit, either directly through receiving treatment or indirectly through higher economy-wide

[20] This increase in the GDP growth rate ranges from 0.3 to 0.5 percent depending on an assumed ten percent lower and higher take-up of ART respectively. This sensitivity analysis accounts for changes in population, labor supply, labor productivity and treatment costs under the different assumed take-up rates.
[21] The poverty outcomes are sensitive to changes in the assumed take-up of ART. For instance, increasing the take-up of ART by ten percent of the infected population causes poverty to decline an additional 0.5 percentage point.

growth. However, the upward sloping curve indicates that higher-income households benefit more than lower-income households. Furthermore, the higher curves for urban areas suggest that they benefit more than rural areas. This increase in inequality is determined by the structure of employment within each region, and by the initial occupational prevalence rates. Prevalence is highest amongst unskilled and clerical urban workers, whose incomes primarily benefit middle-income households. Furthermore, only those households with working members are able to translate increased life expectancy into higher incomes. As such, higher-income households experience the largest increases in per capita expenditures. Furthermore, lower-skilled workers fall into the lower end of the expenditure distribution within cities, but into higher percentiles within towns, villages and rural areas. Since these workers are the largest beneficiaries of treatment, inequality rises in towns and rural areas but falls in cities. Finally, male and female-headed households benefit equally under the *Treatment* scenario. However, higher-income female-headed households rely more heavily on incomes from lower-skilled workers, and therefore benefit more than higher-income male-headed households.

Figure 5. Growth Incidence Curves for the *Treatment* Scenario, 2003-21





Source: Botswana CGE-microsimulation model (present study).

Note: Populations are ranked *within* their reported group (i.e. low expenditure households in cities may earn more than households in the middle of the rural distribution).

These results collectively suggest that even a comprehensive treatment program will not eliminate the detrimental impact that AIDS has on Botswana's development prospects. However, providing treatment is projected to reclaim approximately one-quarter of the growth lost to the pandemic, partly reverse the negative impact on economic diversification, significantly increase life expectancy, and eliminate a third of the AIDS-induced increase in the poverty rate. Despite the decline in poverty, the treatment program results in increased inequality, but this outcome is driven by the regional, demographic and occupational distributions of infection rather than the nature of the government's intervention.

5. CONCLUSIONS

This study has estimated the economic impact of AIDS in order to determine the contribution of the pandemic to Botswana's failing development prospects. A dynamic CGE and microsimulation model is used to capture the various transmission mechanisms linking AIDS to growth, poverty and inequality. The model extends previous methodologies and demonstrates the importance of incorporating endogenous distributional change when estimating the impact of AIDS. The results indicate that in the absence of treatment, Botswana's current growth path is unlikely to significantly reduce poverty, and rural areas are less likely to participate in the growth process. AIDS is contributing to the slowdown in the economy by reducing economic growth by approximately 1.6 percent per year. AIDS also limits economic diversification, especially into more labor-intensive sectors. Therefore, while the mining sector is responsible for most of the decline in growth over recent years, the AIDS pandemic has hindered alternative sources of growth. These results indicate that slower labor-intensive growth will cause the national poverty rate to be two percentage points higher in 2021. Furthermore, AIDS will have pulled an additional 43,000 uninfected people into poverty through its negative impact on growth. However, the rural poverty rate would increase in the absence of AIDS, since increases in labor supply would be offset by weaker employment opportunities and a larger rural population.

Although the government's current treatment program cannot eliminate the pandemic, it can mitigate some of its detrimental impacts. Apart from reducing mortality, the results from the present analysis indicate that providing treatment will reclaim a quarter of the decline in growth and a third of the poverty caused by AIDS. However, financing the treatment program crowds out investment and constrains growth in non-mining industrial sectors. Foreign assistance is therefore important in alleviating the fiscal burden of treatment and avoiding its negative consequences for economic diversification and longer-term development. Although providing treatment is good for growth and poverty reduction, it primarily benefits the employed and higher-income households, resulting in an increase in inequality. Urban households are the main beneficiaries, since both prevalence rates and employment opportunities are highest in these areas. The AIDS treatment program is thus 'pro-poor' in *absolute* terms, since all households benefit, but not in *relative* terms, since inequality rises (Ravallion and Chen, 2003).

Although the model did not estimate the impact of Botswana's stagnating mining sector, the findings suggest that HIV/AIDS has contributed to the deceleration of economic growth seen in this country since the 1980s. However, the findings also suggest that HIV/AIDS is not chiefly

responsible for persistent poverty, especially in rural areas. Therefore, while the challenges posed by the mining sector and HIV/AIDS are indeed undermining Botswana's success story, the present findings also underscore the longer-term importance of reestablishing pro-poor growth. Accordingly, while the country's development strategy should continue to attach a high priority to treatment provision, it should not allow health expenditures to direct resources away from efforts to address urban unemployment and a stagnant rural economy.

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