

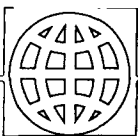
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HIV/AIDS, Human Capital,
and Economic Growth Prospects
for Mozambique

Channing Arndt

February 2003



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Mozambique
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Abstract

Using a computable general equilibrium modelling approach, the author finds that the Mozambican economy will be 14% to 20% smaller in 2010 on account of AIDS. Per capita GDP growth will be between 0.3% and 1.0% lower per annum. The main

causes of the growth slowdown are reduced productivity growth, reduced population growth and human capital accumulation, and reduced physical accumulation. Mitigating and preventive policy responses are proposed in Africa.

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HIV/AIDS, HUMAN CAPITAL, AND ECONOMIC GROWTH PROSPECTS FOR MOZAMBIQUE

Executive Summary

Introduction

As in other countries in the southern Africa region, a human development catastrophe is unfolding in Mozambique. Recently released data estimate HIV prevalence rates amongst the adult population in the year 2000 at around 12% with substantial regional variation. **Due to the magnitude of the HIV/AIDS pandemic, it has become a top priority development issue.** The goal of this paper is to try to come to grips with the economic dimensions of the pandemic. In this initial assessment, the focus is on implications for economic growth prospects. The idea is to attempt to quantify impacts on key economic variables and identify the major channels through which these impacts occur.

While the literature on HIV/AIDS and economic growth is far from conclusive on the magnitude of impact and the relative importance of the various channels through which this impact might occur, **one central conclusion does emerge from the analyses performed to date: the long duration of the pandemic is crucial.** For example, the official demographic projections for Mozambique assume a nine year time lag between infection and death. Due to this long time lag, projections of AIDS deaths to 2010 are, barring rapid advance in medical technologies, essentially programmed into the system. This is so because most of the people projected to die in this decade, including the latter parts, are already HIV positive. Since the pandemic will endure for an extended period of time, small (but long lasting) impacts on rates of accumulation of key determinants of growth (such as technical progress, physical capital, and human capital) will cumulate over time with potentially substantial implications for the economy.

In this analysis, particular attention is paid to human capital accumulation. **A considerable body of evidence points to a strong relationship between educational attainment and productivity in both rural and urban zones.** If the relationship holds, increased educational attainment adds to the productive capacity of the economy. In addition, educated people are likely to be more innovative spurring economic growth through technical progress.

The AIDS pandemic poses obvious problems to an education sector that is already struggling with severe supply-side constraints. Teachers appear to be at least as likely to be infected as the general adult population. Concerns also exist on the demand side. Cross country and Mozambican evidence indicates that orphans are less likely to attend school. Since about one child in four is projected to have lost at least one parent by 2010, the reduction in demand due to orphaning could be considerable. In sum, **AIDS can be expected to lower the school age**

population, reduce the share of the school age population that seeks to attend school, and impair the capacity of the education system to deliver on its mandate. All of these factors point to a reduced rate of human capital accumulation.

Insights from a Human Capital Transition Matrix

In order to gain a clearer picture of the implications of the AIDS pandemic for educational attainment and human capital accumulation, a simple education and skills transition matrix was estimated. For purposes of estimation, the population was divided into categories corresponding to various scholastic levels (lower primary, upper primary, secondary and tertiary) and workforce skill levels (unskilled, skilled and highly skilled). The probability of transitioning from one category to another was then estimated. For example, an individual enrolled in upper primary school could, with a certain probability, remain in upper primary school, move on to secondary school, enter the unskilled labor force, enter the skilled labor force, or die. Similar probabilities of transition were estimated for each category.

Since the effects of the AIDS pandemic were only beginning to be felt during the estimation period, the estimated transition matrix is presumed not to include the effects of HIV/AIDS. Due to demographic impacts and the issues in the education sector discussed above, AIDS is assumed to:

- a) increase the death rate in each category,
- b) increase the probability of transitioning from lower schooling levels (upper and lower primary) to the unskilled work force,
- c) reduce the probability of transitioning from secondary to tertiary schooling,
- d) increase the probability of transitioning from tertiary education to the skilled labor category (as opposed to highly skilled) and
- e) reduce the probabilities of staying in school at each scholastic level.

Changes in death rates are set to be consistent with available demographic projections. Changes in education transition probabilities are set to be consistent with the trends in education transition probabilities estimated by Arndt and Wobst (2002) for Tanzania during the 1990s—a decade containing substantial AIDS deaths in that country.

The estimated transition matrix and the AIDS manipulated transition matrix, combined with birth projections, permit one to project the evolution of the labor force under with and without AIDS scenarios. The projections illustrate that, without AIDS, the labor force is projected to skills upgrade rather rapidly. With AIDS, rates of growth for the two skilled labor categories slow very considerably but are still positive. In addition, due to the increases in school drop out rates, the unskilled labor force grows in relative terms. Given the differences in productivity between the skilled labor categories and unskilled labor, this slow down in skilled and highly skilled labor stock accumulation is significant economically.

An Education scenario, where transition probabilities between scholastic levels are maintained at estimated levels despite the pandemic, illustrates the importance of maintaining access and quality in the educational system. If transition probabilities (other than death rates and the

associated probability of staying in category) do not change, growth of the skilled and highly skilled labor stock is only mildly affected by the pandemic. The intuition behind this derives from the small size of the current highly skilled and skilled labor stocks relative to the number of potential new entrants currently engaged in the educational system. Maintaining the flow of new skilled and highly skilled workers preserves most of the growth in the stocks. Alternatively put, indirect impacts of AIDS on transition probabilities are more important than the direct AIDS impacts (death) for future higher-level student (upper primary and higher) enrollments and skilled and highly skilled labor stocks.

Insights from an Economy-Wide Model

In order to assess the impact of the pandemic on economic growth, available demographic projections, the human capital accumulation projections just discussed, and other projections are used as inputs into a recursive computable general equilibrium (CGE) model of Mozambique. CGE models simulate the functioning of a market economy, including markets for labor, capital, and commodities. They provide insight into how different factors will affect the performance and structure of the economy, how they will interact, and which are (quantitatively) the most important. The disaggregation present in CGE models-- multiple sectors, households, and factors-- constitutes their primary advantage over more aggregated macroeconomic approaches. The ability to capture compositional shifts in output turns out to be an important advantage of the CGE approach for this analysis.

The CGE analysis indicates that **impending AIDS cases and deaths could have large impacts on economic growth**. Projecting to 2010, per capita annual GDP growth rates are between 0.3% and 1.0% lower than in a fictional no AIDS scenario. The major sources of this slowdown in growth are (1) reduced productivity growth, (2) reduced population growth and human capital accumulation, and (3) reduced physical capital accumulation. All three of these effects are significant.

The results also indicate a **strong compositional shift in output due to HIV/AIDS** relative to the fictional no AIDS scenario. In particular, reduced rates of human and physical capital accumulation shift output away from sectors that intensively use those factors. On the other hand, sectors that use unskilled labor intensively tend to expand as a share of GDP.

These shifts in relative factor supplies and concomitant compositional shifts in output interact with assumptions about the nature of technical change. The empirical evidence indicates that technical progress is biased towards human and physical capital. Put simply, skilled people tend to be more innovative, and the innovations that they come up with tend to fuel demand for skilled labor and physical capital. Under these circumstances, reduced human and physical capital accumulation slows the economy-wide rate of technical progress. These **interactions between human and physical capital accumulation and technical change are important** accounting for more than 40% of the growth rate differential between the AIDS and no AIDS scenarios in 2010. It should be noted, however, that the estimates of the productivity impact are only as reliable as the underlying assumptions of “normal” growth of technical change, and the assumed reduction in this due to AIDS. Estimates of technical change and the AIDS impact are

few in number and, while the assumptions are highly plausible, they are dependent on a complex methodology. Hence these estimates should be interpreted with caution.

Policy Implications

Due to a variety of knowledge gaps, a high degree of uncertainty must be associated with these results. However, if AIDS indeed reduces per capita economic growth for extended periods of time as the analysis suggests, then initiatives that effectively combat AIDS will pay handsomely in purely economic terms. Given the nearly decade long time lags between infection and death, policy actions can be divided into two categories: a) mitigating policies to face the ramifications of the pandemic in the current decade and b) preventive policies designed to reduce HIV/AIDS prevalence in future decades.

Under mitigating policies, education policy was explicitly considered. The analysis indicates that school enrollments and human capital accumulation rates are sensitive to changes in the probabilities of remaining in school and transitioning to higher grade levels. The scenario Education, corresponding to a strong policy effort to maintain school enrollment rates, graduation rates, and quality, resulted in a 0.6% increment to GDP growth by 2010 relative to the Base AIDS scenario. This growth increment is due to the enhanced productivity of a more skilled workforce. Furthermore, this increment is likely to persist well into the future due to much larger school enrollments in 2010 (for example, enrollment in EP2 in the Education scenario in 2010 is about twice the level in Base AIDS). Assuming this 0.6% growth increment persists to 2020, net present value calculations justify incremental education expenditures on the order of 5% of GDP per year from 2002 to 2010 in order to obtain the growth increment.

Similarly, if successful preventive policies substantially reduce AIDS deaths in the next decade resulting in a growth benefit of 0.3% per year from 2010 to 2020 (corresponding to the lower end of the estimated average per capita GDP growth impact), net present value calculations justify large prevention expenditures (2.5% of GDP from 2002 to 2007) even if per capita GDP is the sole criterion for evaluating the preventive policies. Consideration of individual risk of becoming HIV positive and the human costs of AIDS would justify even higher prevention expenditures.

The lesson from these numbers is not that resource allocation on this scale should occur since absorptive capacity is an issue. Rather, the point is that initiatives that *successfully* prevent the spread of HIV and combat the economic disruptions of AIDS deaths are likely to have a high payoff. Given the extent of the payoff, imaginative initiatives, including costly ones, can be considered.

At least two themes can be identified from the literature on prevention policy. First, broad based AIDS awareness programs should focus on the young. This is a large group. The cohort under 20 represents 55% of the population, and the prevalence rate among this group is low (15-19 year olds have the highest rate of any five year cohort under 20 at 4.7 percent). Second, high-risk populations, such as sex workers, are another target group for behavior modification.

Mitigating policies highlighted for further scrutiny include: elimination of school fees (such as fees for textbooks), payments to families in the form of food or cash for enrolling children in

school, more aggressive efforts to recruit and retain qualified teachers, accelerating the general economic reform agenda, administrative and regulatory simplification, and accelerated efforts to extend labor-saving agricultural technologies.

More generally, the analysis has shown that the economic impacts of AIDS are likely to occur through channels that are well known to students of development. The major links relate to human capital, productivity, and savings/investment. These channels have been and remain the subject of considerable thought and policy dialogue. Exhortation to “do better” because of AIDS is not likely to be helpful. Many of the mitigating policies highlighted arise primarily from a re-weighting of priorities in light of the pandemic. All would deserve serious consideration even in the absence of the pandemic. Given the uncertainty associated with the pandemic in general and economic impacts in particular, focus on **policies that simultaneously address major economic implications of AIDS and major development constraints should be preferred.**

HIV/AIDS, Human Capital, and Economic Growth Prospects for Mozambique

1. Introduction

As in other countries in the southern Africa region, a human development catastrophe is unfolding in Mozambique. Recently released data estimate HIV prevalence rates amongst the adult population in the year 2000 at around 12% with the rate projected to increase to 16% by 2007 before stabilizing at about that level (Ministry of Health *et al.*, 2001). Due to the average time lag of about nine years between infection and death from AIDS, the AIDS case projections through 2010 are, barring rapid advances in medical technologies, essentially programmed into the system. Nearly all of the people projected to die in this decade, including the latter parts, are already HIV positive.

The goal of this paper is to examine the effect of HIV/AIDS on Mozambique's economic growth prospects, and to propose policy options for blunting the major negative impact channels.

The paper is structured as follows. Section two discusses the implications of recently released HIV prevalence rates and provides more detail on the expected demographic impacts of the pandemic using available demographic projections. Section three reviews literature focusing on growth and macroeconomic impacts. Section four formally analyzes implications for human capital accumulation. Section five presents the economy-wide modeling approach including critical assumptions and model scenarios. Section six discusses the major results. Section seven summarizes and section eight considers both mitigating and preventive policy implications.

Before proceeding, a word on the difficulties encountered in this analysis is appropriate. There are many. For example, one can pin hopes on the development of simple, inexpensive and effective medical technologies. While a welcome outcome, this appears to be an unwise working hypothesis. Even under the assumption of relatively constant medical technology, the demographic impacts of HIV/AIDS are quite uncertain. In addition, the links between these demographic impacts and economic impacts are far from perfectly understood.

These uncertainties must be combined with the data limitations associated with economic analysis in Mozambique. Even though Mozambique has made large strides in developing credible data systems, data gaps persist. For example, knowledge of input-output relationships, particularly for non-agricultural activities, could be improved. Also, due to the combined effects of war and the differences in data collection between centrally planned and market economies, time series are short even by African standards.

Finally, the analysis strikes against the limits of economics. Ultimately, economics is about the welfare of people; and the science of economics is poorly prepared to appropriately measure welfare in the context of a pandemic that reduces life expectancy by 15 years in the

space of a decade. For these reasons, the following analysis should be viewed as a formal means for arriving at qualitative conclusions.

2. Demographic Impacts

Adult HIV prevalence rates for the year 2000, based on observations from 20 health posts including some in rural zones, are presented in Table 1. Relatively low prevalence rates (about 6%) in some populous northern provinces bring down the national average. Rates in the central provinces (Zambezia excepted) are very high at around 20%. In the economically important South, rates are estimated at about 13%.

Table 1: Estimated prevalence rates (adult population)

Region	Province	Estimated Prevalence Rates (2002)	
		Provincial	Regional
South	Maputo City	13.0%	13.2%
	Maputo Province	14.3%	
	Gaza	16.0%	
	Inhambane	9.6%	
Center	Sofala	18.7%	16.5%
	Manica	21.1%	
	Tete	19.8%	
	Zambézia	12.7%	
North	Nampula	5.2%	5.7%
	Niassa	6.8%	
	Cabo Delgado	6.4%	
Mozambique National			12.2%

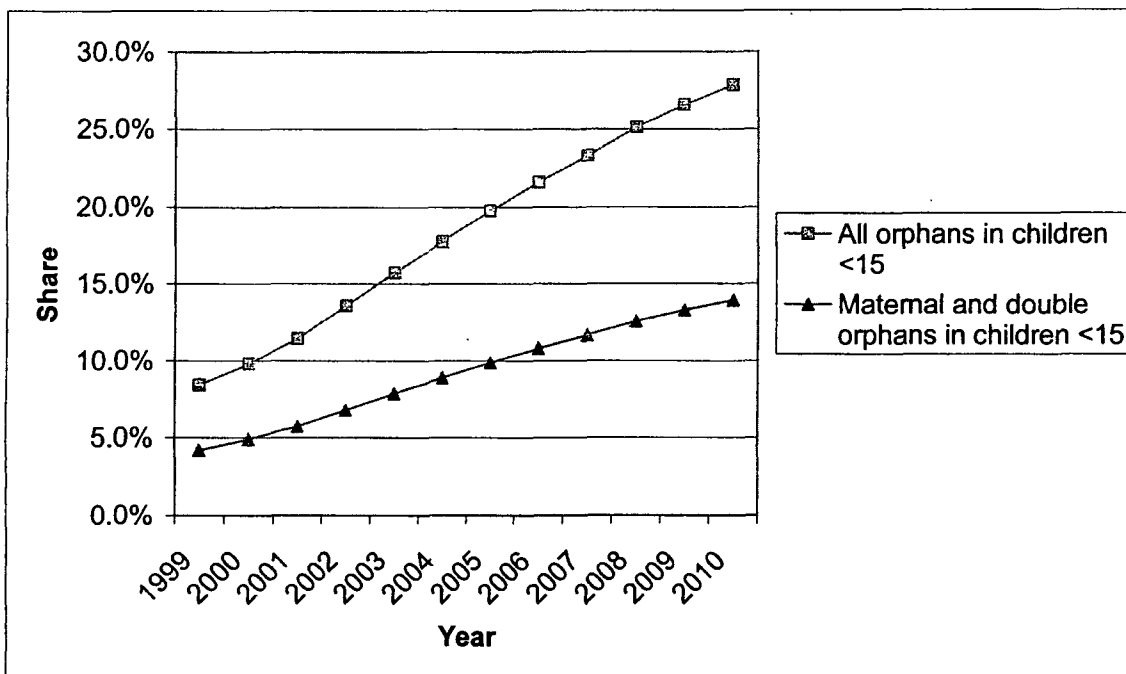
Sources: Ministry of Health (2002) and Ministry of Health et al. (2001), based on observations from 20 health posts, some of them rural.

According to the most recent data, population was about 16.9 million in 2000. This level differs relatively little from a fictional no AIDS level. By 2000, only about 100,000 Mozambicans had perished from AIDS since the beginning of the pandemic. However, over the coming decade, the number of accumulated AIDS deaths is projected to rise dramatically reaching 1.2 million deaths by 2010. Due to the implications of AIDS, projected population growth between 2000 and 2010 is expected to be about 1.6% per annum as opposed 2.5% in the absence of the pandemic. Also, by 2010, life expectancy is projected to decline to about 36.5 years as opposed to a projected 50.3 years in the absence of the pandemic (Ministry of Health et al., 2001).

As is well known, AIDS strikes primarily individuals in the 20-45 year age brackets. These are prime years both in terms of work and family responsibilities. AIDS also strikes young children through mother to child transmission (MCT). The probability that a pregnant woman who is HIV positive will infect her child, either during pregnancy, during childbirth or through breastfeeding, is roughly 30%. With prevalence rates at antenatal clinics in the range of 15% to 30% and a MCT transmission rate of 30%, between one and two children in 20 becomes HIV

positive through MCT.¹ The remaining 18 to 19 infants are highly unlikely to contract HIV until they become sexually active.

Figure 1: Children who have lost at least one parent from all causes—relevant shares



Source: Ministry of Health et al. 2002 and author’s calculations based on shares of maternal to paternal to double orphans of 25-50-25. These shares were obtained from Hunter and Williamson (2000).

With high prevalence rates in young adults and children largely not at risk (other than through MCT), the number of orphans is set to rise dramatically. Figure 1 shows orphans (maternal, paternal, and double) as a share of the population and as a share of children under 15 years of age. By 2010, about one child in four will have lost at least one parent. Since children represent a large share of the population, orphans are projected to account for about 10% of the population in 2010.

3. The Economics of HIV/AIDS: Literature Review

Efforts to comprehend the economic implications of the HIV/AIDS pandemic have been appearing in the literature for nearly a decade. Examples of early work include efforts by Bloom and Mahal (1995); Cuddington, Hancock, and Rogers (1994); Cuddington (1993); and Kambou, Devarajan, and Over (1993). In a review of this literature, the influential World Bank (1997) report, *Confronting AIDS*, contained a sub-section entitled “AIDS Has Little Net Macroeconomic Impact” (using per capita GDP as a metric) reflecting the basic consensus of the literature.

¹ Since children infected via MCT tend to develop AIDS and die much more rapidly than adults, these figures imply child mortality rates of 50 to 100 per 1000 children due to AIDS alone.

A number of more recent assessments have become considerably less sanguine. In a recent cross-country analysis, Bonnel (2000) finds a strong negative association between adult HIV prevalence and per capita GDP growth. At an adult prevalence rate of 15%, Bonnel finds that annual per capita GDP growth is reduced by about 1%.² Arndt and Lewis (2000) focus on South Africa and conclude that the macroeconomic impacts could be significant. Their base case projects an average decline in the welfare of the surviving population in 2010 of around 13% compared with a fictional no-AIDS scenario. In a more stylized analysis focused on human capital accumulation, Corrigan, Glomm, and Méndez (2000) project a decline in per capita GDP growth of 30-40% for countries with infection rates of 15-20% of the adult population.³ Bell *et al.* (2003) develop an overlapping generations model in which premature adult mortality reduces investment in education and, absent optimal spending to counteract the effects of the disease, there is a progressive collapse of human capital and productivity.

Despite all of the differences, one central conclusion does emerge from the macroeconomic analyses performed to date: the long duration of the pandemic is crucial. Since the pandemic will endure for an extended period of time, even small impacts on rates of accumulation of key determinants of growth (such as technical progress, physical capital, and human capital) will cumulate over time with potentially substantial implications for economic growth. For example, if the education system is disrupted for one year, relatively little is lost and many of these losses can be recouped in subsequent years. If the educational system is disrupted for a decade, the economy, at the end of that decade, may be significantly smaller; and, perhaps more importantly, economic prospects in subsequent decades will be seriously compromised.

Studies of AIDS and economic growth to date have typically focused on physical capital accumulation and rates of technical progress as the primary channels through which the pandemic impacts economic growth. However, for Mozambique, there are real concerns about impacts of the pandemic on the educational system and, by extension, on rates of accumulation of human capital. These concerns are treated in detail in the next section.

4. Human Capital, Development, and AIDS

4.1. *Impact of education on growth in Mozambique*

Evidence continues to mount for a strong positive association between education levels and productivity growth in both agricultural and non-agricultural sectors. Lockheed, Jamison, and Lau (1980) reviewed 18 studies on agricultural productivity and concluded that education had a substantial impact on productivity, though the evidence for Africa was thin. Recent analyses echo these results in the African context. Positive education returns were found by Weir and Knight (2000a and 2000b) for Ethiopia, Pinckney (1996) for Kenya and Tanzania, and Appleton and Balihuta (1996) for Uganda. Furthermore, these studies point to significant education externalities in agriculture.

² Dixon, McDonald, and Roberts (2001) use a panel data approach. They are far from optimistic about potential macroeconomic impacts, but are unable to identify the macroeconomic impact of the pandemic given available data.

³ The dynamic analysis by Wils *et al.* (2001), on the other hand, gives a fairly sanguine base case scenario.

In Mozambique, analysis of the 1997 household survey finds evidence of strong returns to a complete primary education (completion of EP2) in both rural and urban areas. Households with at least one member who has completed primary school exhibit substantially higher levels of per capita consumption (Handa, Omar, and Ibraimo 1998).

Occupation and wage data for Mozambique also support the notion of strong returns to education. The wage for the 60,000 Mozambicans with tertiary education exceeds the wage for unskilled agricultural labor by a factor of 35 (Ibraimo 2000 and author's calculations). As a result of high wages, total payments to highly skilled labor represent about 14% of the total wage bill even though the population share of Mozambicans with tertiary education is very small. Returns to skilled labor, defined as individuals with an education level of at least EP2 but less than tertiary, are also relatively high. In urban zones, the skilled wage is on average more than three times the unskilled wage (derived from the 1997 social accounting matrix and census employment data).

Since educational attainment is very low and the returns to education are high, there is great scope for education to stimulate economic growth and poverty reduction. For example, simulations based on estimated relationships from the 1997 household survey indicate that ensuring that at least one adult completes primary school increases per capita household consumption by about 24% which in turn reduces the overall poverty rate by between 19% and 36% depending on the poverty measure employed and the zone (Datt *et al.*, 1998). Evidence such as this has made education a key priority (Republic of Mozambique, 2001). The AIDS pandemic, however, poses a threat to enhancing educational attainment from both the supply and demand sides.

4.2. Impact of AIDS on supply and demand constraints in education

The AIDS pandemic poses obvious problems to an education sector that is already struggling with severe supply-side constraints. Data from the 1997 household survey indicate that, in rural Mozambique, approximately two in three households have access to a basic primary school (EP1) in their village, but only 17% have an upper primary school (EP2), and only 2% a secondary school in their village (Handa, Omar, and Ibraimo 1998).⁴

A dearth of teachers is among the key constraints to further expansion of the education system, and AIDS will worsen this constraint because HIV prevalence rates among teachers are probably at least as high as those of the rest of the adult population. Indeed, there is some reason to fear that the rate might be higher.⁵

Concerns also exist on the demand side. For villages with schools, the main reason cited in 1997 (prior to the pandemic) for not attending school was the need for children to work (Handa, Omar, and Ibraimo 1998). As the AIDS pandemic matures and parents fall ill and die,

⁴ It should be noted that the 1997 household survey employed a different definition of a rural household than the census. According to the household survey definition, about 80% of the population is rural as opposed to 71% from the census. Enhancing access to education in rural areas is thus crucial to expanding average educational attainment.

⁵ See Badcock-Walters and Whiteside (2000) and Gregson, Waddell, and Chandiwana (2001). In Zambia, the AIDS death rate among educators in 1998 was 70% higher than that of the 15-49 age group in the general population.

the need for children to work will become more pressing. In a review of the literature, UNAIDS (1999) finds that taking children out of school is one of the four most common household responses to stresses induced by AIDS. In addition, with the large volume of orphaning that is projected, one can expect large numbers of children to be living with friends and relatives. A probit analysis of the 1997 household data conducted by the author indicates that children who are not the direct biological descendant of the household head are significantly less likely to attend school.

In sum, AIDS can be expected to lower the school age population, reduce the share of the school age population that seeks to attend school, and impair the capacity of the education system to deliver on its mandate. All of these factors point to a reduced rate of human capital accumulation. Furthermore, demand constraints are likely to bind in some areas and supply constraints in others, leaving the system operating well below potential capacity.

4.3. Estimation of an Education and Skills Transition Matrix

In order to gain a clearer picture of the implications of the AIDS pandemic for educational attainment and human capital accumulation, a simple education and skills transition matrix was estimated. For purposes of estimation, the population was divided into eight categories. An additional category allows for the possibility of death or permanent retirement from the labor force (category nine). The categories are as follows:

- 1) not working and not in school (children)
- 2) enrolled EP1
- 3) enrolled EP2
- 4) enrolled secondary school
- 5) enrolled tertiary school and higher
- 6) unskilled labor
- 7) skilled labor
- 8) highly skilled labor
- 9) death or permanent retirement from the labor force.

One can then postulate the following transition matrix T giving probabilities of moving from one category to the next from period t to period $t+1$. All blank elements in the matrix are assumed to have value zero.

$T =$	T_{11}	T_{12}				T_{16}		T_{19}
		T_{22}	T_{23}			T_{26}		T_{29}
			T_{33}	T_{34}		T_{36}	T_{37}	T_{39}
				T_{44}	T_{45}		T_{47}	T_{49}
					T_{55}		T_{57}	T_{58}
						T_{66}		T_{69}
							T_{77}	T_{79}
								T_{88}
								T_{89}

The rows of the transition matrix T sum to one. This implies that the entire population in each category must be accounted for. Consider row 1. This corresponds to the category “children who are not working and not in school” (for whatever reason) in period t . According to row 1, individuals in this group could remain not working and not in school (T_{11}), enroll in primary school (T_{12}), begin working as unskilled labor (T_{16}), or die (T_{19}). This group cannot leap to upper primary (EP2), secondary or tertiary school or join the workforce as skilled or highly skilled labor. The remaining rows can be similarly interpreted.

Once the transition matrix has been estimated, the evolution of the workforce proceeds as follows. Assume that the period under consideration is one year. Therefore, T_{ij} represents the probability of moving from category i to category j in one year. It is assumed that the population grows only through births of children. Let E_t be a nine element column vector with births in year t in the first element and zeros elsewhere. The number of individuals in each category in period $t+1$ is then $S_{t+1} = T'S_t + E_t$.

The T matrix was estimated using data on enrollment from the Ministry of Education, on educational attainment and births from the 1996 census, and on the labor force from Ibraimo (2000) and the national accounts. The estimation period was from 1996 to 1999. A minimum cross entropy approach (Judge, and Miller (1996) was used to handle data gaps and to incorporate prior information on transition probabilities. The latter probabilities were derived from Verde Azul (2000) and World Bank (2000), and are presented in Appendix A, together with the estimation procedure.

The estimated transition matrix is reported in Table 2. In interpreting the probabilities, it is useful to recall that these are annual probabilities. For example, EP2 (upper primary school) contains only two grade levels while EP1 (lower primary school) contains five. A passing student will finish and leave EP2 in two years whereas EP1 would take five. The longer duration of EP1 compared with EP2 explains much of the higher probability of remaining enrolled on an annual basis in EP1 compared with EP2 (T_{22} compared with T_{33}).

Table 2: Estimated annual transition probabilities

	Notschool	EP1	EP2	ESG1_2	Tertiary	Unskilled	Skilled	HSkilled	Exit
Notschool	84.1%	9.8%				3.7%			2.4%
EP1		88.1%	4.3%			6.5%			1.1%
EP2			70.3%	13.0%		7.8%	7.8%		1.0%
ESG1_2				89.7%	5.0%		4.8%		0.5%
Tertiary					67.7%		2.3%	28.8%	1.2%
Unskilled						98.1%			1.9%
Skilled							98.9%		1.1%
HSkilled								99.0%	1.0%
Exit									

Since the effects of the AIDS pandemic were only beginning to be felt during the estimation period, the estimated transition matrix is presumed not to include the effects of HIV/AIDS.

Now, two AIDS scenarios are worked out. In the first, called "Base AIDS", the pandemic is assumed to:

- (a) increase the death rate in each category,
- (b) increase the probability of transitioning from lower schooling levels (EP1 and EP2) to the unskilled work force,
- (c) reduce the probability of transitioning from secondary to tertiary schooling,
- (d) increase the probability of transitioning from tertiary education to the skilled labor category (as opposed to highly skilled); and
- (e) reduce the probabilities of staying in school at each scholastic level.

Projected AIDS mortality rates by age class were mapped to the various educational and occupational categories. These AIDS death rates were added to the estimated death or permanent retirement rates shown in the last column of Table 1.

Due to the supply side constraints and massive orphaning mentioned above, the probabilities of remaining in school and of transitioning to the next higher educational level are assumed to decline. These probabilities were adjusted by a maximum of two percentage points as a function of the magnitude of the AIDS death rate for the adult population in that year relative to the maximum AIDS death rate for the adult population over the 1997-2010 period [$T_{ij} \cdot .02 \cdot (\text{AIDS death rate in } t / \text{maximum AIDS death rate})$]. Instead of transitioning to a higher level of schooling, these individuals were assumed to transition to the lower labor skill level. The magnitudes of these effects are basically consistent with the estimates of transition probability trends for Tanzania obtained by Arndt and Wobst (2002).

A higher proportion of students enrolled in tertiary education are also expected to leave school due to stresses induced by the AIDS pandemic. To reflect this, the probability of remaining in school was reduced by an estimate of the AIDS death rate for the 20 to 24 year old age group.

A second AIDS scenario, labeled Education, is also developed. In this scenario, a strong policy effort to maintain enrollments and educational quality is assumed while the demographic effects of AIDS are assumed to remain in place. In this case, apart from AIDS deaths, children and university students are just as likely to remain in school and to transition to higher levels of schooling as before. In terms of the transition matrix, AIDS increases death rates and commensurately reduces the probability of remaining in category, but other transition probabilities are unaffected.

Results from the three analyses are shown for all three occupational categories and for upper primary school (EP2) enrollment. These results are presented in Figures 2, 3, 4, and 5. The figures illustrate that, under the estimated transition probabilities and without AIDS, the skills of the labor force will upgrade rapidly. The stock of highly skilled (tertiary educated)

labor more than doubles and the stock of skilled labor expands by more than 50% in the no AIDS scenario by 2010. In the Base AIDS scenario, the rates of growth slow considerably but are still positive for the two skilled labor categories.

Figure 2: Estimates of the evolution of the highly skilled labor force

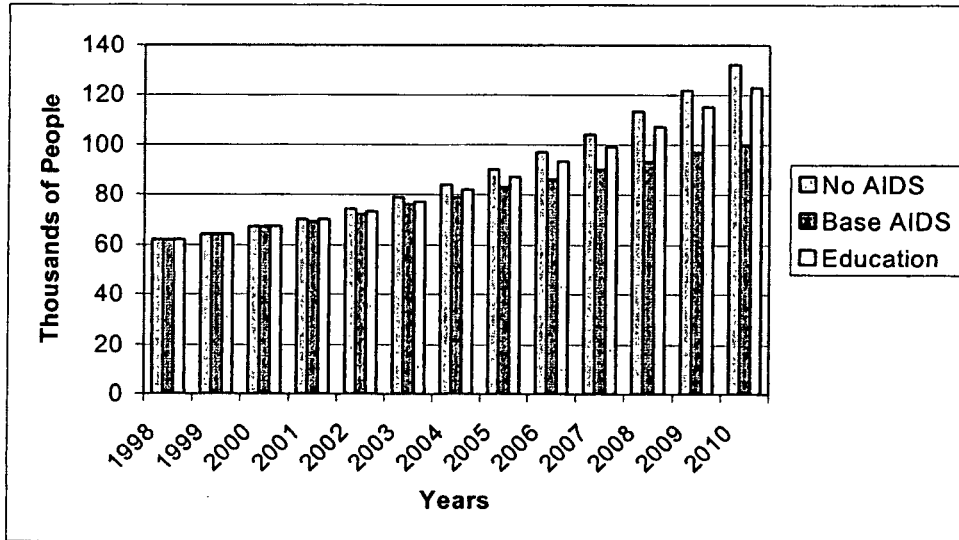


Figure 3: Estimates of the evolution of the skilled labor force

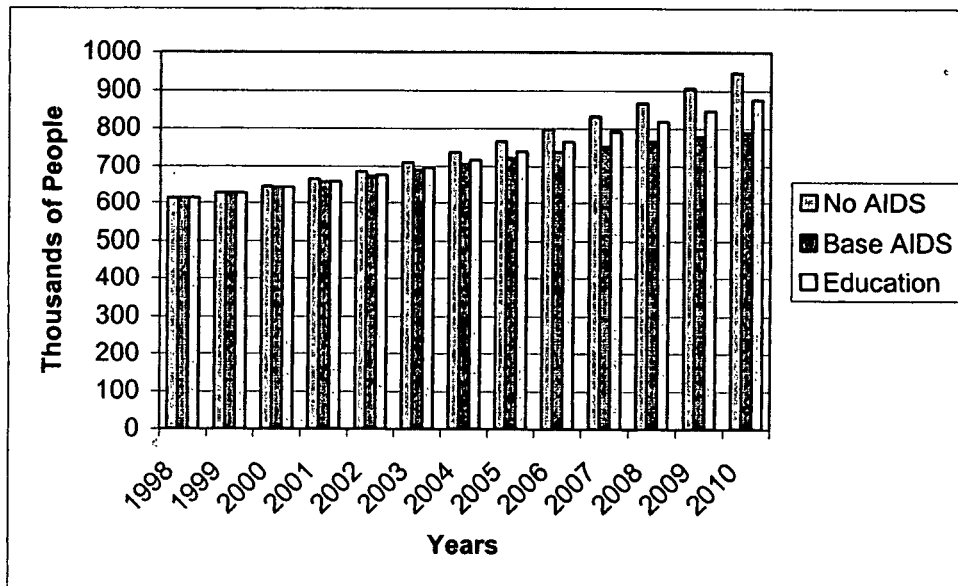


Figure 4: Estimates of the evolution of the unskilled labor force

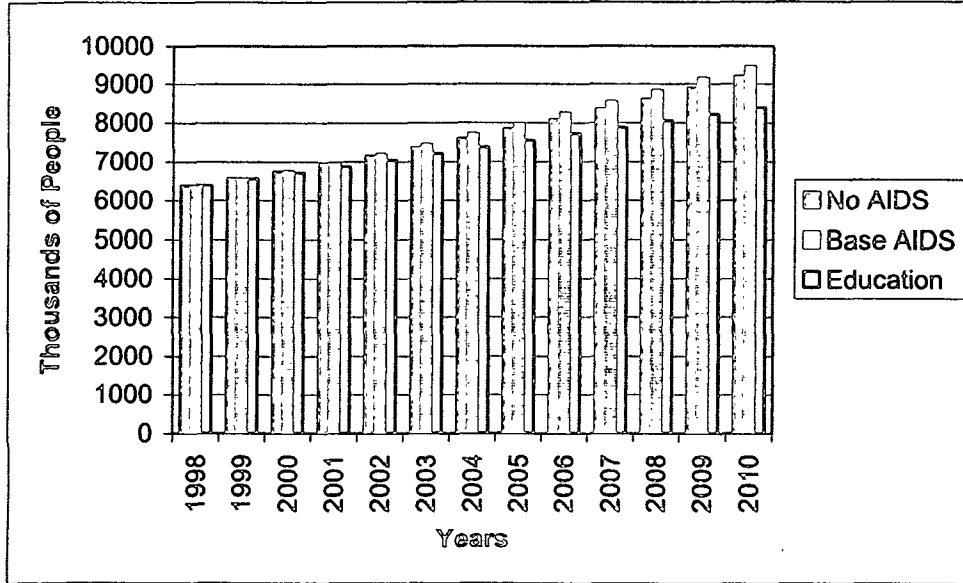
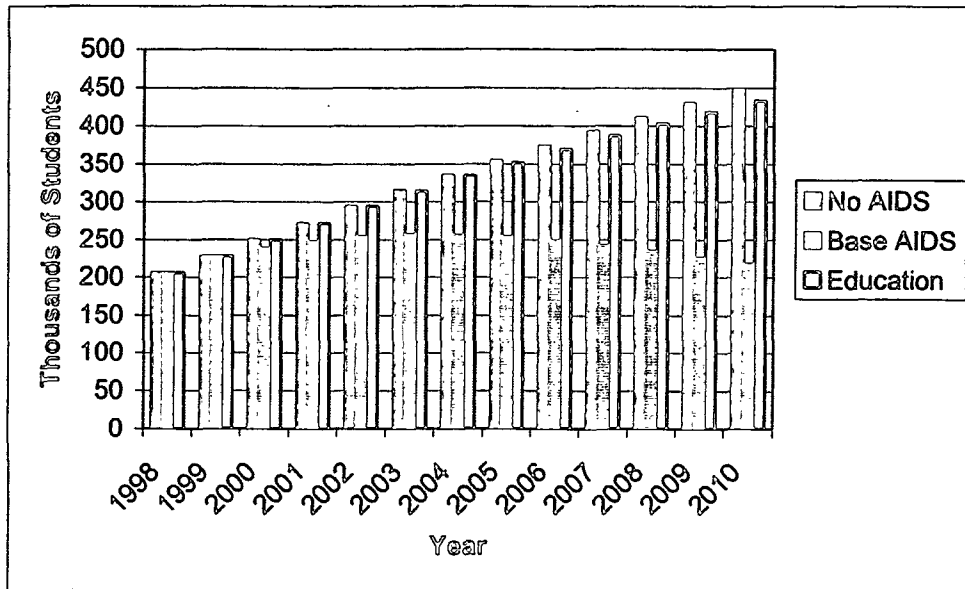


Figure 5: Estimates of enrollment in EP2



The Education scenario illustrates the importance of maintaining access and quality in the educational system. If transition probabilities (other than death rates and the associated probability of staying in category) do not change, growth of the skilled and highly skilled labor stock is only mildly affected. The intuition behind this derives from the small size of the current

highly skilled and skilled labor stocks relative to the number of potential new entrants currently engaged in the educational system. Maintaining the flow of new workers preserves most of the growth in the stock. Alternatively put, indirect impacts of AIDS on transition probabilities are, in this analysis, more important than the direct AIDS impacts (death) on higher-level student (EP2 and higher) and highly skilled and skilled labor stocks.

The evolution of primary school enrollment and the evolution of the unskilled labor force are closely related. In the base AIDS scenario, large numbers of students quit schooling early in order to join the labor force. As a result, the unskilled labor force stock is actually larger in the Base AIDS scenario than in the hypothetical no AIDS scenario. Maintaining transition probabilities, as in the Education scenario, keeps children in school and reduces the size of the unskilled labor stock in 2010 by 11% relative to the Base AIDS scenario. Given the importance of unskilled labor in value added, this difference in unskilled labor stocks is also economically important.

The trends in unskilled labor stocks are inversely reflected in primary and secondary school enrollments. For example, consider EP2 enrollments as shown in Figure 5. In the Base AIDS scenario, enrollments actually decline due to the movement of students into the unskilled labor force. In the Education scenario, enrollments are maintained at a level quite close to the mythical no AIDS level, reflecting again the primacy of transition probabilities in determining enrollments at the EP2 level and higher.

These alternative labor stock accumulation scenarios will have large economic impacts. The method for assessing these impacts is presented in the following section.

5. Economy-wide Modeling Approach

The impact of the HIV/AIDS pandemic is simulated using an economy-wide or computable general equilibrium (CGE) model of Mozambique. CGE models have a number of features that make them suitable for examining “cross-cutting” issues such as the impact of AIDS.

- They simulate the functioning of a market economy, including markets for labor, capital, and commodities, and provide a useful perspective on how changes in economic conditions will likely be mediated through prices and markets.
- Because they can be fairly disaggregate, CGE models can provide an economic “simulation laboratory” permitting a quantitative examination of how different factors and channels of impact will affect the performance and structure of the economy.

The disaggregation present in CGE models-- multiple sectors, households, and factors-- constitutes their primary advantage over more aggregated macroeconomic approaches. As will be shown in the results section, AIDS induced reductions in rates of physical and human capital accumulation generate substantial shifts in the composition of output towards sectors that use unskilled labor more intensively. These compositional shifts in output interact strongly with biased rates of technical change by factor to produce stronger impacts on rates of growth than

projected in previous analyses. The ability to capture these compositional shifts in output represents the primary advantage of the CGE approach for this analysis.

For the reader wishing more details on CGE models, Appendix B contains an overview of static CGE models. Löfgren *et al.* (2001) provide a complete review of the basic CGE model that was adapted for this analysis. These adaptations as well as the data underlying the CGE model are in focus in the next section.

5.1. The Mozambique CGE Model

The model version employed here contains 19 productive sectors; six primary factors of production (highly skilled, skilled, and unskilled non-agricultural labor; skilled and unskilled agricultural labor; and physical capital); and two household categories representing rural and urban households.⁶

Technical details on the model follow. Firms are assumed to maximize profits under translog technology while households maximize a Cobb-Douglas utility function. The government deficit is fixed in nominal terms. All tax rates are fixed as well. Total government consumption varies with tax revenue. The commodities composition of government consumption is determined through a fixed expenditure shares allocation rule.

The savings-investment “closure” is savings-driven: in other words, the resources available for investment each year are determined by the sum of savings generated by groups within the economy (households, enterprises, and government) plus any net foreign capital inflow. Foreign savings are by far the largest source of investment finance. In any particular year, net foreign savings and all savings rates are fixed exogenously, and the exchange rate varies to achieve external balance. In common with other CGE models, the model only determines relative prices and the absolute price level must be set exogenously. In this case, the aggregate consumer price index is fixed, defining the *numeraire*.

The features described up to now apply to a basic single-period “static” CGE model. But, because the HIV/AIDS story is inherently a dynamic one, the model must be capable of moving forward and looking at growth trajectories. So, the model must be “dynamized” by building in a set of accumulation and updating rules (e.g. investment adds to capital stock, after depreciation; labor force growth by skill category; productivity growth). In addition, expectation formation must be specified.

The latter point, expectations formation, represents a major distinguishing feature of many macroeconomic models. For the CGE model employed here, a simple set of adaptive expectations rules are employed. Adaptive expectations rules were chosen for two reasons. First, local analysts, particularly in the Ministry of Planning and Finance, viewed adaptive expectations as the most appropriate mechanism for the Mozambican context. Second, there are likely to be only small differences between a simple adaptive expectations formations approach and more complex rational

⁶ The basic model data is derived from a 1997 Social Accounting Matrix estimated by the author. The SAM very closely reflects national accounts data. Additional work was performed to disaggregate labor by skill category and between agricultural and non-agricultural sectors. While some regional production data has been gathered, the SAM is national.

expectations approaches. Unlike sudden events, such as the Asian financial crisis, where forward-looking agents might be expected to behave very differently from agents who use solely the past as a guide, the AIDS pandemic will unfold slowly. As a result, recent trends and/or current results will be reasonably good guides to economic performance in the near term. As a result, forward-looking and backward-looking behavior might not differ substantially.

Under adaptive expectations, agents use rules to guide their behavior based upon the past. Dynamic paths can then be traced through a series of solutions of a static model. Following each solution, relationships are specified to “update” various parameters and variables from one time period to the next. For the most part, these relationships are straightforward. Growth in the total supply of each labor category is specified exogenously using the estimates obtained from the transition matrix described in the previous section. Migration of labor between rural and urban zones is permitted in response to changes in wage differentials. Foreign capital inflows and domestic savings rates are allowed to adjust in response to the rate of return to capital (the exact specifications are scenario dependent and are discussed in the next sub-section). The stock of foreign owned capital is tracked throughout the simulation period. Each year, foreign investors are assumed to repatriate the full value of the return to foreign owned capital from the previous year. Sectoral capital stocks are adjusted each year based on investment, net of depreciation. The model adopts a “putty-clay” formulation whereby new investment can be directed to any sector in response to differential rates of return; however, installed equipment must remain in the same sector (e.g., a brewery cannot be converted into a railroad). Sectoral productivity growth is specified exogenously with the possibility of different rates of productivity growth by factor.

5.2. *Key Assumptions of the CGE model*

In the model, there are three major modes through which the HIV/AIDS pandemic affects economic growth. They are:

1. productivity growth effects,
2. population, labor and human capital accumulation effects, and
3. physical capital accumulation effects.

These are treated in turn.

1. Productivity growth. There are good reasons to believe that productivity growth will slow considerably due to the HIV/AIDS pandemic. Primary reasons include:
 - disruption of productive activities due to AIDS-related morbidity and deaths at all levels of the workforce,
 - disruption and reduced efficiency in the provision of government services,
 - a younger, inexperienced labor force with less opportunity for mentoring/training on the job,
 - a decline in the health of the population, even those not afflicted with the virus, as AIDS-related care overwhelms the resources of the health care system,
 - reduced incentives for investment in training due to curtailed life horizons,
 - uncertainty associated with the formation of long-term contracting arrangements, and

- reduced workplace productivity stemming from coping strategies at home, such as attending funerals and arranging for care for orphans and AIDS sufferers.

Papers documenting these productivity effects at the firm level have begun to appear in the literature. For example, Aventin and Huard (2000) find explicit cost increases at three manufacturing firms in Côte d'Ivoire with HIV prevalence rates of 10% to 15% amongst workers. Morris, Burdge, and Cheevers (2000) document significant costs associated with HIV/AIDS for a sugar mill in South Africa. Whiteside (2000) reviews a series of studies that document AIDS related costs to business across a variety of industries and afflicted countries in sub-Saharan Africa. The World Bank (1997) presents results of a business survey that addressed AIDS and worker turnover in selected African countries. These effects vary widely but none are positive. For example, the World Bank survey (conducted in 1994) found that, while high HIV prevalence rates are associated with higher rates of employee turnover, the increment to the turnover rate due to HIV/AIDS did not appear to be particularly large relative to average turnover. Simon *et al.* (2000) find evidence of cost-avoidance strategies-- such as reductions in benefits, more rigorous screening of job applicants, production outsourcing, and increasing the capital intensity of production-- among large formal sector companies in Africa. In addition, the impact of AIDS can be quantified in the form of absenteeism, health and life insurance rates, and AIDS-related deaths.

Another effect that is amenable to quantification is workforce experience. Elias (2000) considers AIDS impacts on the structure of the workforce in the mining sector of Botswana. In Botswana in 2000, the average age (mean and mode) of a mine-worker was 40 years with about 60% of workers falling in the 35 to 45 year age bracket. Only about 3% of mine workers in 2000 were under 24 years of age. Simulations by Elias (2000) indicate that, by 2015, about one third of miners will be under 24 and nearly 60% will be under 30 years of age. Productivity will likely diminish owing to the decline in worker experience and mentoring.⁷

For the agricultural and rural non-farm sectors, Yamano and Jayne (2002) document strong and enduring impacts of prime-age adult deaths (with most of these caused by AIDS) using a panel data set of rural households in Kenya. For example, the death of a male household head aged 16 to 59 is associated with a 68% reduction in the net value of crop production by the household. Furthermore, the magnitude of the impact of a prime-aged adult death does not depend on whether the death occurred in the previous year or three years earlier suggesting that the impacts of prime-aged adult deaths endure for a considerable period of time.

At the aggregate level, health has been found to be a significant contributor to growth in a number of studies. Bloom, Canning and Sevilla (2001) and Mayer (2001) have sought to isolate the impact of health on productivity. Bloom, Canning, and Sevilla use cross-country panel data from 1960 to 1990, using life expectancy as the proxy variable for health. They find that one year of increased life expectancy leads to a 4% increase in output. Mayer uses a cross-country panel for Latin America from 1950 to 1990 and proxies health using a probability of survival variable (by cohort). He finds a large and enduring impact of improved health on economic

⁷ Bils and Klenow (1998) report a fairly strong positive association between experience and wages suggesting a positive relationship between experience and productivity.

growth. Reversing the logic to declining health, these studies suggest that the negative productivity effects of HIV/AIDS are large.

While a number of indicators point to a potentially significant impact on productivity growth, the evidence remains indirect. Empirical studies of the impacts of AIDS on productivity growth do not yet exist. There are two reasons for this. First, measuring productivity growth is itself extremely difficult. Separating out the myriad direct and indirect effects of AIDS adds further complications. Second, even though the pandemic is now more than two decades old, the long lags between acquisition of the virus and diagnosis of AIDS leaves the empirical database rather thin. For example, a 1997 study of firm impacts in Botswana, a country that currently has a mature and severe AIDS epidemic, found relatively few effects primarily because high HIV prevalence rates had not yet translated into a large number of AIDS cases (Greener, 1997). Due to these limitations, productivity effects are speculative. The particular assumptions follow.

Since productivity growth rates are better understood in the “no AIDS” context, it is easier to start from those and work backwards. In the no AIDS scenario, technical change is assumed to be human capital using. This is consistent with the observation that, in many countries, wages of highly skilled people have stayed constant or increased in real terms despite dramatic increases in the stock of human capital.⁸ Specifically, the productivity of highly skilled workers in the no AIDS scenario is assumed to grow at 4% per annum. Productivity of skilled and unskilled labor increases at 3% and 2% per annum respectively in both agriculture and non-agriculture. The productivity of capital is assumed to increase at 3% per annum.⁹ This amounts to a total factor productivity (TFP) growth rate of about 2.7% (using 1997 value added shares). This rate is roughly consistent with the TFP growth rates estimated by Arndt, Robinson, and Tarp (2002).

The effect of AIDS is to reduce productivity growth rates for all factors of production. Productivity growth for each factor is assumed to decline linearly with the share of the relevant adult population that has AIDS.¹⁰ So, if one percent of the adult population has AIDS in year t , TFP growth rates between year t and year $t+1$ are adjusted downward by one percentage point.

2. Population, labor and human capital. Population forecasts are simply taken from Ministry of Health *et al.* (2001). Labor force projections are taken from the estimates derived from the transition matrices discussed in the previous section. A migration function, based on changes in rural and urban wages, divides the unskilled and skilled labor stocks between rural and urban zones. The elasticity of response to wage changes is assumed to be low at 0.2.

⁸ Lawrence and Slaughter (1993) provide a detailed analysis for the United States. Krugman (2000) provides a more general analysis. The upshot of these analyses is that factor-biased technical change provides the only consistent explanation for the maintenance/growth (depending on the country) of real returns to human capital over the past 50 years despite the rapid increase in supply of human capital. The CGE model employed for this analysis reproduces this effect. Without human capital using technical change, returns to human capital would fall to unacceptably low levels.

⁹ These rates of growth maintain relative factor returns in acceptable ranges.

¹⁰ An approximating function that reduces productivity growth rates is required. The following function, [no AIDS rate – (target adult population with AIDS)/(total target population)], is effective within the relevant range. The maximum subtraction factor does not exceed 0.015.

3. Physical capital accumulation. As indicated earlier, the model closure is savings driven. So, the pool of savings determines investment. In the 1997 SAM, foreign savings, comprised mainly of grants and concessional loans, were the most important source of investment funds. Beyond this source, private capital inflows to fund a series of large investment projects, called the mega-projects, are expected to be significant in the next decade. Mega-project investment is assumed to occur regardless of HIV/AIDS. Government expenditure is assumed to vary with revenue, keeping the government deficit constant in nominal terms. Consequently, mega-project investment and government savings do not contribute to differentials across scenarios.

Changes in foreign savings inflows (non-mega project) and domestic savings rates of enterprises and households contribute to differentials across scenarios. In the Base AIDS scenario, foreign savings inflows are assumed to remain constant at 1997 levels in real foreign currency terms. Also, urban and rural household savings rate are set at one percent of gross income while enterprise savings rates are set at 5.9% of gross income. These are approximately the rates observed in the 1997 SAM. In the no AIDS scenario, foreign savings inflows and household and enterprise savings rates are set as inelastic functions (elasticity of 0.5 for foreign savings and 0.25 for domestic savings rates) of changes in rates of return to capital. Rates of return to capital in year t higher than the base rate from 1997 generate higher foreign savings inflows and higher savings rates for households and enterprises in year $t+1$.¹¹

A further word on the mega-projects is necessary. Forecasts of mega-project activity and structure were obtained from Andersson (2001). He considers Mozal (including the planned expansion); hydroelectric investment at Cahora Bassa and Mepanda Uncua; the Temane and Pande natural gas projects; the Maputo Iron and Steel project; and the Corridor Sands titanium project. Should all of these projects materialize, they would result in large investment capital inflows. These flows are shown in Table 3. Mega-projects are modeled parsimoniously by including a single mega-projects activity.

¹¹ The cross-country evidence indicates that domestic savings rates tend to respond only weakly to changes in the rate of return to capital (Schmidt-Hebbel, Serven, and Solimano, 1996).

Table 3: Value and timing of mega-project investment in USD millions

	Mozal	Mepanda Uncua	Temane and Panda	Maputo Iron and Steel	Corridor Sands	Total
1997						0
1998	220					220
1999	875					875
2000	245					245
2001	150		250		100	500
2002	600		350	200	300	1450
2003	150		190	600	100	1040
2004				200	50	250
2005		300			50	350
2006		400			50	450
2007		600		300	50	950
2008		400		400	50	850
2009		300		300	50	650

Source: Andersson (2001).

5.3. Scenarios

Three AIDS scenarios are presented labeled: Base AIDS, LessEffect, and Education.

- *Base AIDS.* This scenario adopts the standard assumptions described above.
- *LessEffect.* This scenario provides some sensitivity analysis of the Base AIDS scenario. The AIDS-induced effects on productivity and transition probabilities in education and skills acquisition are halved; and foreign savings inflows and domestic savings rates remain sensitive to rates of return on capital but with elasticity values set at half the levels of the no-AIDS scenario.
- *Education.* This scenario takes all inputs as in Base AIDS except the labor stock evolution, which is taken from the transition matrix Education scenario. In addition, educations spending rises. This increment in education funding is assumed to amount to 25% and 50% of the base funding level over the first two years of the simulation period respectively, which amounts to about 1% of GDP. The amount then increases by 3% per year in real foreign currency terms for the remainder of the simulation period. These increases in education funding are financed through direct taxes on urban households.

In addition to the three AIDS scenarios, a mythical no AIDS scenario is also run for purposes of comparison. Unless specifically noted (as in Education), policies across the scenarios are assumed to remain constant.

It was decided not to run an additional scenario modeling a massive HAART (highly active anti-retroviral therapy) approach, as the costs are prohibitive: given an HIV positive population of 1.2 million and a cost of HAART of \$500 per person per year, the treatment cost in terms of drugs alone would be \$600 million annually. But drug costs are not the only barrier to HAART. Distribution mechanisms of the required magnitude are unavailable and would be very costly. Effective distribution of drug therapies to even a relatively small percentage of the population would require massive investment in delivery infrastructure and years of effort on top of the drug costs. Finally, the effectiveness of HAART is receiving renewed scrutiny even in developed countries. Recent evidence indicates that “gold standard” HAART as practiced in the United States increases life expectancy on average by only four to six years. In developing countries, where patient care management will not be as intensive, the average increment to life expectancy is likely to be only about two years (Freedburg, 2002). This implies amortizing investments in delivery infrastructure over a relatively small increment to life expectancy. Hence a massive effort to deliver HAART is considered impractical and is not modeled explicitly.

6. Results

The economic impact of HIV/AIDS is potentially very large. Real GDP growth rates in the Base AIDS, LessEffect, and no AIDS scenarios are depicted in Figure 6. Growth rates are variable over the projection period in all scenarios due to the influence of mega-project investment. For example, the largest volume of mega-project investment, nearly \$1.5 billion dollars, occurs in 2002 as shown in Table 2, and adds to productive capacity in 2003, so the growth of GDP between 2002 and 2003 is rapid.

HIV/AIDS gradually reduces growth rates relative to the no-AIDS scenario over the entire projection period. By 2010, the differences in growth rates relative to no-AIDS are about 4.3% and 2.8% for the Base AIDS and LessEffect scenarios respectively. Relative to the findings of earlier analyses, these are large differences in growth rates. For example, Arndt and Lewis (2000) find for South Africa a maximum difference between their AIDS and no AIDS scenarios of 2.6%.

The large gap in Mozambican real GDP growth rates for 2010 is attributable to the interacting effects of reduced rates of human and physical capital accumulation combined with factor-specific rates of technical change that are biased towards human and physical capital. Table 4 illustrates the shifts in economic structure that underlie these interactions. The Table illustrates the initial structure of GDP at factor cost by sector and the factor intensities by sector. In addition, the Table shows the ratios of real value added by sector between the Base AIDS and no AIDS scenarios in 2010. These ratios indicate that, while all sectors are smaller in the Base AIDS scenario compared with the no AIDS scenario, the economic impacts of HIV/AIDS differ strongly by sector.

Table 4: Economic structure and relative performance by sector

	Base/ No AIDS VA Ratio (2010)	Factor Contribution to VA (1997)				Share of VA in GDP _{fc} (1997)
		Unskilled	Skilled	Highly	Capital	
Crops	0.85	0.74	0.08	0.00	0.18	0.27
Livestock	0.84	0.74	0.08	0.00	0.18	0.02
Forestry	0.83	0.70	0.07	0.00	0.23	0.03
Extraction	0.77	0.14	0.20	0.11	0.54	0.04
Food Proc.	0.84	0.34	0.22	0.12	0.32	0.03
Bev./Tobacco	0.82	0.07	0.08	0.04	0.81	0.01
Prim. Prod. Proc.	0.77	0.21	0.25	0.14	0.40	0.02
Chemicals	0.75	0.08	0.15	0.08	0.70	0.01
Other Manuf	0.58	0.17	0.29	0.16	0.37	0.01
Other Services	0.80	0.41	0.26	0.14	0.19	0.08
Construction	0.52	0.12	0.19	0.11	0.58	0.07
Commerce	0.78	0.29	0.21	0.12	0.38	0.20
Trans./Comm.	0.77	0.21	0.26	0.14	0.38	0.09
Ins./Finance	0.72	0.11	0.23	0.13	0.54	0.05
P. Admin./Defense	0.73	0.21	0.50	0.28	0.00	0.03
Education	0.74	0.20	0.45	0.25	0.11	0.02
Health	0.74	0.22	0.50	0.28	0.00	0.00
Lab. Int. Serv.	0.87	0.21	0.51	0.28	0.00	0.02
Average	0.76	0.29	0.25	0.13	0.33	
Correlation		0.51	-0.17	-0.22	-0.28	
Weighted Avg.	0.78	0.40	0.19	0.09	0.31	
Weighted Corr.		0.68	-0.36	-0.43	-0.61	

Notes:

Column 1 contains the productive sectors (excluding big projects, which did not contribute to GDP in 1997 and had a real value added ratio of one between the Base AIDS and no AIDS scenarios in 2010). Abbreviated sector names are Beverages and Tobacco, Primary Products Processing, Transport and Communication, Insurance and Finance, Public Administration and Defense, and Labor Intensive Services.

Column 2 shows the ratio of real value added for the Base AIDS relative to the no AIDS scenario by sector in 2010.

Columns 3-6 show the contribution of each factor to sectoral in value added in 1997. Agricultural and non-agricultural labor categories are aggregated for both the unskilled and skilled labor classes.

Column 7 shows the contribution of each sector to real GDP at factor cost.

Correlations are between the real value added ratio in 2010 and the factor contributions by sector.

Weighted averages and correlations are developed using the sectoral shares in real GDP at factor cost (column 7) as weights. The weighted correlations are maximum likelihood estimates (no degrees of freedom correction in variance and covariance estimates).

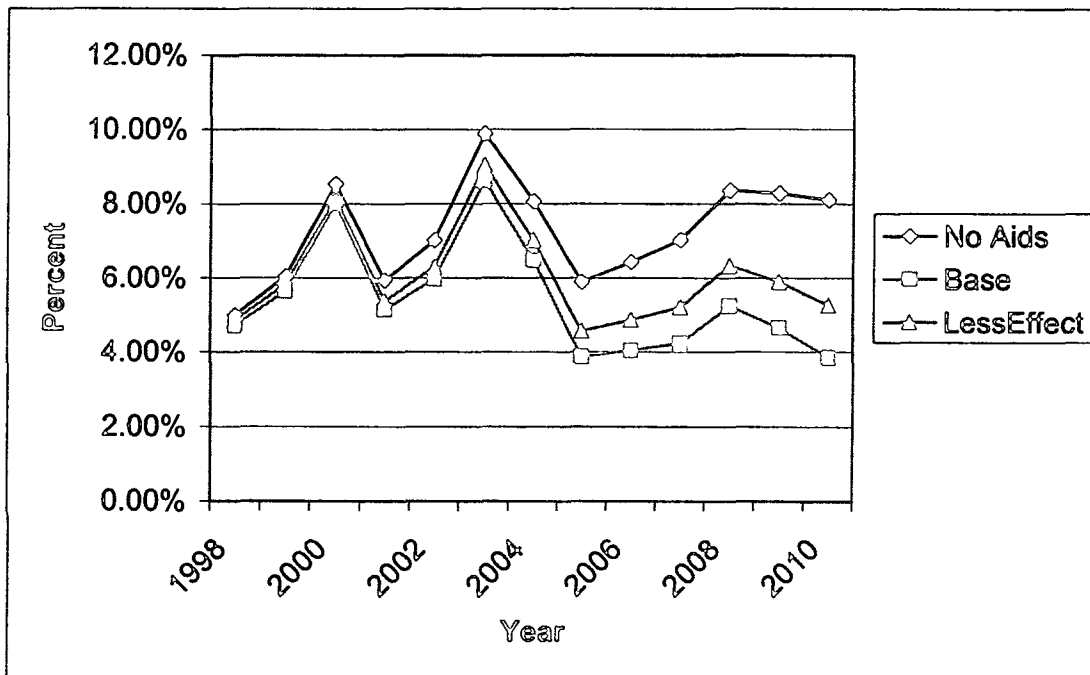
VA refers to sectoral value added and *GDP_{fc}* refers to GDP at factor cost.

Sectors that provide investment goods, such as construction and other manufactures, are particularly hard hit. However, relative factor intensities also play a role. For example, there are,

by 2010, one third fewer highly skilled workers in Base AIDS compared with no AIDS scenarios while the stock of unskilled workers is roughly the same between the two scenarios (see figures 2 and 4). As one would expect given these changes in relative factor supplies, correlation analyses (both simple and weighted by initial sectoral shares in GDP at factor cost) indicate that sectors that use highly skilled labor intensively tend to be more strongly impacted by the AIDS pandemic. The same is true of skilled labor and capital. On the other hand, sectors that use unskilled labor intensively, such as the agricultural sectors, tend to be less strongly affected.

The results indicate a compositional shift in output in Base AIDS relative to no AIDS towards sectors that intensively use factors with low productivity growth rates (unskilled labor) and away from sectors that intensively use factors with high productivity growth rates (skilled labor, highly skilled labor, and capital). Over time, these differences in economic structure become more profound and growth rates diverge. In earlier studies, in contrast, technical progress is typically assumed to be Hicks-neutral. As a result, these interactions, and their effects on growth, were not captured. Indeed, if the assumption of Hicks-neutral technical progress is imposed (at the average rate implied by the biased, factor-specific technical change rates weighted by 1997 factor shares) on the Base AIDS and no AIDS scenarios, the maximum differential in the real GDP growth rate shrinks to 2.5% (slightly less than the maximum differential found by Arndt and Lewis (2000)).

Figure 6: HIV/AIDS and Real GDP growth



The differences in growth rates shown in Figure 6 cumulate into large differences in GDP. By 2010, the economy is between 14% (LessEffect) and 20% (Base AIDS) smaller compared to the no AIDS scenario. On a per capita GDP basis, the effect of AIDS is

considerably less pronounced due to differentials in population growth (the population is projected to be 10% smaller). Per capita GDP in 2010 is between 4% (LessEffect) and 12% (Base AIDS) lower compared with the no AIDS scenario. Commensurately, per capita GDP growth rates are between 0.3% (LessEffect) and 1.0% (Base AIDS) lower.

Box 1: What about Uganda?

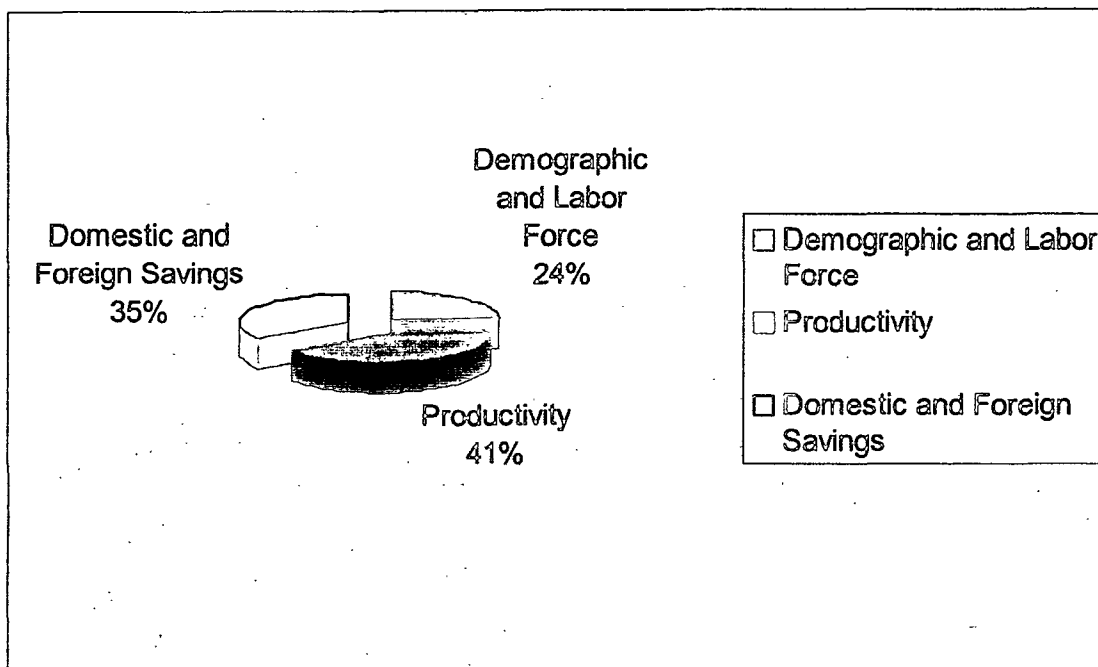
Uganda's experience could be taken as an indication that the relationship between AIDS and economic growth might be weak. Prevalence rates at surveyed ante-natal clinics in urban areas of about 30% were observed in the late 1980s and early 1990s. This implies a substantial number of AIDS deaths particularly in the mid and late 1990s. Despite these deaths, Uganda's economy grew at an average rate of 6.7% from 1990 to 2001 (World Bank, 2002).

However, there are several reasons to expect less severe economic impacts in Uganda. First, to Uganda's credit, the pandemic never reached severe levels in rural areas, where the vast bulk of the population resides. A recent study by Parkhurst (2002) estimated that the overall adult prevalence rate in Uganda may never have attained the rate currently estimated for Mozambique and may have been, even at its maximum, considerably less. Second, the economic structure of Uganda points to less profound economic impacts. The primary agriculture share in GDP in Uganda (about 45%) is substantially higher than the share in Mozambique (less than 30%). Also, with more people on a much smaller land area and, by extension, a relatively intensive agriculture, AIDS deaths in Uganda imply more land per person and an increase in labor productivity. In contrast, with the highly extensive agriculture practiced in Mozambique, AIDS deaths imply a reduced ability to farm the available area. The loss of production due to AIDS deaths is mitigated little by increased productivity. Finally, while not conclusive, the Ugandan data indicate a slow down in economic growth in the latter half of the 1990s, which is when AIDS effects could be expected to manifest themselves most strongly. From 1990 to 1995, the Ugandan economy grew at an average annual rate of 7.5% (International Monetary Fund, 2002). From 1995 to 2001, the rate declined to 6.3%.

The major impacts on GDP can be decomposed into their component parts. This is done for the Base AIDS scenario and is shown in Figure 7. All of the effects – reduced productivity growth, reduced population growth and human capital accumulation, and reduced physical capital accumulation – are important. The most important is the productivity effect. Two caveats should be cited. The first is technical. Since educated people will be the primary generators and adaptors of improved technology, the decomposition of human capital and technology effects is somewhat artificial.¹²

¹² More formally, the decomposition is path dependent. Sensitivity analysis revealed no changes in qualitative results across different paths.

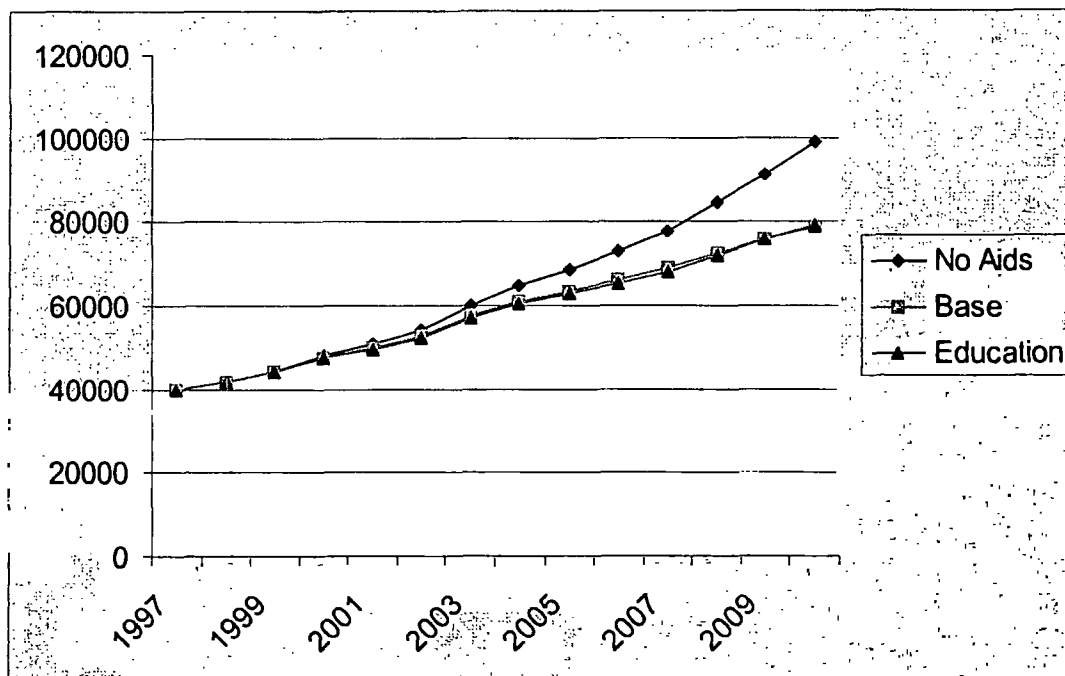
Figure 7: A decomposition of HIV/AIDS impacts for the Base AIDS scenario



The second caveat applies to implications beyond 2010 (e.g., beyond the simulation period). As illustrated in Figure 5 HIV/AIDS might substantially reduce the number of children enrolled in school. If it does this, growth prospects will be harmed well beyond the 2010 time horizon employed in this paper. Even if an inexpensive AIDS vaccine materialized towards the end of the decade, economic effects emanating from reduced school enrollments would continue for at least another decade.

This final point is worth bearing in mind when one compares the Education scenario with the Base AIDS scenario. As illustrated in Figure 8, the Education and Base AIDS scenarios are nearly indistinguishable in terms of GDP. However, they are quite different in terms of output per worker. As can be deduced from Figures 2, 3, and 4, the labor force in 2010 is considerably smaller in the Education scenario compared with the Base AIDS scenario. The smaller labor force reflects the much larger number of young people enrolled in school. However, output per worker is 11% higher. This is due to greater stocks of human capital (as shown in the figures) and a larger endowment of capital per worker (10% higher).

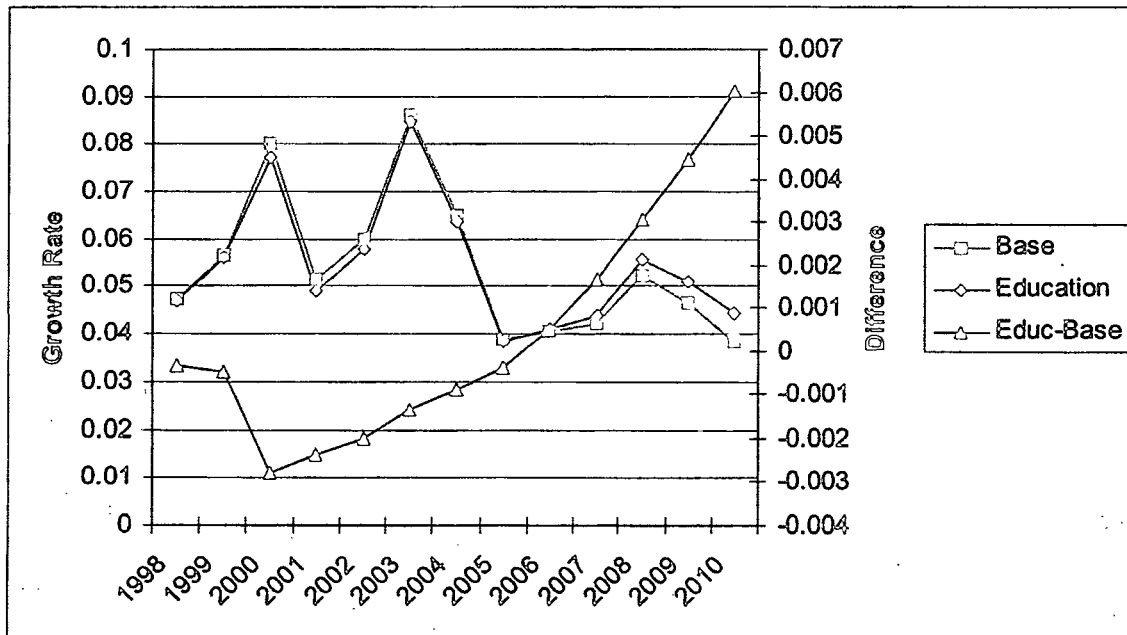
Figure 8: Comparing GDP impacts between Education and Base AIDS scenarios



The Education and Base AIDS scenarios also differ considerably in wages. For example, by 2010, the wage for unskilled agricultural labor in the Education scenario is 14% higher than the wage in the Base AIDS scenario. This wage difference more than offsets the quantity difference so that the share of unskilled agricultural labor in nominal GDP at factor cost is actually higher in the Education scenario than in the Base AIDS scenario. This is an interesting result. It indicates that the benefits from leaving school early and joining the labor force are likely to be partially offset by declines in the unskilled wage.

While the level of GDP between the Education and Base AIDS scenarios looks very similar on a graphical scale, there are in fact interesting differentials in growth rates between the two scenarios. This is shown in Figure 9. Growth rates in the Education scenario are actually slightly lower compared with Base AIDS in the early portion of the simulation period due to the GDP contributions of children who are working (counted in GDP) rather than attending school (not counted in GDP). However, relative to Base AIDS, growth rates in the Education scenario gradually increase. By 2010, the real GDP growth rate is about 0.6 percentage points higher in Education compared to Base AIDS. This reflects the benefits of more rapid accumulation of human capital. In addition, in the Education scenario, the load of potential human capital enrolled in the school system is much higher making growth prospects much brighter in the subsequent decade and beyond.

Figure 9: Comparing GDP growth rates between Education and Base AIDS scenario



7. Summary

The major findings of this report can be compactly summarized.

- The HIV/AIDS pandemic could have large economic impacts. Comparing two alternative AIDS scenarios with a fictional no AIDS scenario to the year 2010, GDP growth rates diverge substantially over the period reaching a gap of between 2.8% and 4.3% per annum in 2010. Due to these growth differentials, the economy is between 14% and 20% smaller in 2010 relative to the no AIDS scenario. Differences in population growth rates mute the differences in per capita GDP growth rates. Over the projection period, cumulative per capita GDP growth rates are between 0.3% and 1.0% lower per annum.
- The major sources of this slowdown in growth are (1) reduced productivity growth, (2) reduced population growth and human capital accumulation, and (3) reduced physical capital accumulation. All three of these effects are significant, but the productivity effect is the most important. It should be noted, however, that the estimates of productivity growth are only as reliable as the underlying assumptions of “normal” growth of technical change, and the assumed reduction in this due to AIDS. Estimates of technical change and the AIDS impact are few in number and, while the assumptions are highly plausible, they are dependent on a complex methodology. Hence these estimates should be interpreted with caution.

- Impacts on school enrollments are potentially very large with implications for growth rates in the latter part of this decade and beyond. If pandemic related problems on the supply and demand side of the education sector result in a reduced probability of staying in school, growth in school enrollments and human capital stocks is strongly muted. Conversely, if policy actions maintain current transition probabilities, the rate of GDP growth by 2010 is 0.6% faster than in the Base AIDS scenario.
- Due to the long time lags between infection and onset of AIDS, the AIDS case projections that drive these results are, barring rapid advance in medical technologies, essentially programmed into the system through the duration of the simulation period (out to 2010). Successful actions to prevent the spread of HIV today will bear fruit in terms of reduced numbers of AIDS cases and AIDS deaths in approximately eight years.

As emphasized in the introduction, a high degree of uncertainty must be associated with these results. Nevertheless, with respect to the AIDS pandemic, three general policy conclusions emerge from this analysis.

- Aggressive actions to limit the scope, duration, and economic impacts of the AIDS pandemic should be undertaken.
- Maintaining school enrollment rates, graduation rates, and quality, along with other efforts to maintain or increase the stock of human capital, should figure prominently among these actions.
- Macroeconomic planners should reduce their expected growth rates. Very rapid growth rates (e.g., eight percent per year) are unlikely to be realized.

The following section considers policy implications in more detail.

8. Policy Implications

The preceding analysis has focused on implications of the HIV/AIDS pandemic given observations on HIV prevalence rates in 2000 and demographic projections of the implications of these prevalence rates through 2010. More detailed policy implications are now drawn from the analysis. Given the time lags inherent in the pandemic, policy actions can be divided into two categories: a) mitigating policies to face the ramifications of the pandemic in the current decade and b) preventive policies designed to reduce HIV/AIDS prevalence in future decades. Both categories of policy responses are considered below. A summary of policy implications derived from this section and earlier sections is presented in Table 5.

Table 5: Summary of policy measures considered for countering HIV/AIDS.^{1,2}

Policy Measure	Issue Addressed	Timing of Benefit Stream	Cost Effective
HIV prevention.	Root cause.	Delayed. Primary benefits in next decade.	Likely. Experiences in other countries valuable.
Widespread HAART. ³	Onset of AIDS.	Depends on targeting of recipients. Could be immediate.	Unlikely. Expensive and very difficult to administer.
Maintain enrollments and educational quality.	Human capital accumulation.	Delayed. Primary benefits in next decade.	Likely. Costs of inaction could be very high.
Accelerate policy reform.	Productivity and investment.	Relatively near term and extending into the future.	Likely.
Administrative and regulatory simplification.	Productivity and investment.	Relatively near term and extending into the future.	Likely.
Accelerated extension of labor-saving agricultural technology.	Agricultural productivity and poverty.	Relatively near term and extending into the future.	Merits further consideration.

¹This is not an exhaustive list of potential policy responses.

²More detail can be found in the main body text and in the policy implications section.

³HAART: highly active anti-retroviral therapy.

Before proceeding, a further word on medical technology, in the context of policy responses, is worthwhile. In the Introduction to this document, the assumption of constant medical technology was adopted. Nevertheless, over time, the likelihood increases that a vaccine (or similar technology in terms of outcome) will emerge. Currently some potential technologies are proceeding to human trials (a fairly advanced stage of testing). But an AIDS vaccine is not currently available and one may not come available for a considerable period of time (see www.iavi.org).

Under these circumstances, the prudent operational assumption is the one that has been maintained so far, namely that medical technologies will not thwart the pandemic before 2010. Hence it is appropriate to pursue mitigating policies designed to blunt the negative impacts of the pandemic over the coming decade.

Over the longer term (the next decade and beyond), prospects for effective medical technologies brighten considerably. Some combination of improved medical technology, behavior modification (catalyzed through AIDS awareness/education programs or simple observation), and pure Darwinism are likely to eventually bring down HIV/AIDS prevalence rates to low levels. Adopting the view of the AIDS crisis as severe and long-lasting but nevertheless finite has important implications for policy. Under this view, policy seeks to limit the impact and shorten the duration of the pandemic.¹³ Once the brunt of the pandemic has passed, the policies can then, in principle, be discontinued.

8.1. Mitigating policy responses

Under the broad category of mitigating responses, education policy was considered explicitly in the scenario Education. In the Base AIDS scenario, deaths of teachers and widespread orphaning is assumed to reduce the probability of staying in school and of transitioning to higher grade levels. In the Education scenario, (tax financed) budgetary increases are assumed to permit the education sector to maintain these probabilities at current (relatively low) levels. As a result, school enrollments and human capital stocks are projected to rise. Given a successful program to maintain or increase school enrollments, fewer children and young adults are working, which, by itself, reduces GDP. However, the GDP effects of a smaller workforce are largely offset by human capital accumulation and improved physical capital to worker ratios. By the end of the simulation period (2010), GDP growth rates in the Education scenario exceed GDP growth rates by 0.6%, reflecting the higher productivity of more a skilled workforce. Finally, holding children in school supports the unskilled wage during the simulation period. In the Education scenario, the rise in the wage more than offsets the decline in unskilled labor supply leaving total payments to unskilled labor slightly higher than in the Base AIDS scenario.

Some additional calculations permit one to assess the benefits of a 0.6% increment to growth beyond 2010. Some additional assumptions are necessary. First, we assume that the

¹³ Taking the alternative view, a total inability to modify behavior or treat the disease resulting in high AIDS death rates in perpetuity, could have radically different policy implications. For example, the economically optimal rate of investment in human capital would decline since the expected lifespan of educated people would be considerably reduced.

Education scenario yields a GDP growth rate of 4.6% over the period 2010 to 2020, compared with 4.0% in the base. From 2021 to 2040 (the terminal year), growth rates are constant at 4.0% in both the Education and the Base AIDS scenarios. However, since the Education scenario has a higher level of GDP in 2021, differences in GDP between the scenarios persist to the terminal year. Using a discount rate of 10%, net present value calculations yield willingness to invest figures of up to 5.3% of GDP in *incremental* education expenditures each year over the period 2002 to 2010 in order to obtain the 0.6% increment to GDP growth over the 2010 to 2020 period (see Appendix C for more details).

The point of this exercise is not necessarily that resources to the education sector should be massively increased since absorptive capacity is an issue. Rather, the point is that initiatives that successfully maintain or increase enrollments and quality in the educational system are likely to have a high payoff. Given the extent of the payoff, imaginative education initiatives, even costly ones, can be considered. The perceived costs of sending children to school might be reduced, by waiving textbook fees, for example. In the 1997 national household survey, monetary costs were cited frequently by rural households as a primary reason for not sending children to school (Handa, Omar, and Ibraimo 1998).

In order to encourage AIDS afflicted families to continue sending children to school, a food (or cash) for education program might be considered. These programs provide an allotment of grain (cash) to families of targeted students provided those students attend school. A recent evaluation of a food for education program in Bangladesh found the program to be “highly successful in increasing primary school enrollment, promoting school attendance, and reducing dropout rates” with the enrollment rate increase being larger for girls than for boys (Ahmed and del Ninno, 2002).

Stoking demand for education is unlikely to be effective if concerns on the supply side are not addressed. In the short run, there is no alternative but to recruit and retain more teachers from the small pool of qualified people available. This probably involves some combination of increasing pay, benefits, and working conditions. In the longer run, taking steps to ensure that universities and teacher colleges function adequately will help to increase the supply of teachers. To the extent that the capacity of universities or teaching colleges are impaired due to AIDS deaths among faculty or administrators, there is a strong rationale for technical assistance to fill the breach. The same holds for management positions in the Ministry of Education.

The costs of the education policies mentioned above are considerable. The cost of the Bangladeshi food for education program is about USD 0.10 per beneficiary per day. So, assuming the same cost level, 200 days in school per year, and one to two million children targeted (from nearly half to nearly all children enrolled in primary school), the total cost would be about USD 20-40 million per year. To gain perspective on this cost, the total government allocation to education in 2000 amounted to about USD 125 million or about 3% of GDP. Obviously, increasing pay and benefits and improving working conditions for the roughly 50,000 teachers currently working would increase that amount. Finally, technical assistance is famously expensive with the total annual cost for volunteers (such as US Peace Corps or United Nations) and for experts at around \$50,000 and \$250,000 respectively (Arndt, 2000).

On the other hand, as discussed above, the benefits of maintaining or increasing enrollments and educational quality justify large costs assuming the programs are effective. In order to satisfy this last caveat, care will have to be taken to design programs that will function in the Mozambican context. The latter point is worth stressing because in general in cross-country comparisons, the link between public sector investments and educational outcomes is extremely weak. Such investments, then, should be undertaken with caution to ensure that their effectiveness, while at the same time improving the management of the overall education system.

A second major implication arises implicitly from the analysis. Implementation of policy reforms in general should be undertaken as soon as is feasible. The delays between infection and onset of AIDS provide a window of opportunity for implementing policies while AIDS deaths rates are relatively low. This message applies to general economic policy reform measures, not just those focused specifically at the AIDS pandemic. Bold policy reform entails adjustment costs, but if rapidly implemented, a large share of the adjustment costs are likely to be incurred prior to the years where large numbers of AIDS deaths are projected, and the benefit stream will help counter the negative impacts in these years. Also, due to AIDS deaths within government, capacity to implement policy change may decline, so that the best chance for effective implementation might be the near term rather than in the future.

8.2. Preventive policy responses

The human costs of the pandemic alone provide compelling reason to consider aggressive strategies to reduce HIV prevalence. The economic analysis presented above indicates that considerable economic benefit can be reaped from successful efforts to reduce HIV prevalence. As mentioned earlier, efforts to reduce HIV prevalence rates are long-term investments. Averting infection today implies one fewer AIDS case in approximately eight years.

While nobody claims to possess the ideal measure for assessing the “optimal” level of resource allocation to preventive policy, there is considerable debate over which of the highly imperfect but available measures to use. Hans Binswanger (2000) argues for use of loss of GDP. This would justify a massive preventive policy response since almost everyone believes that the total GDP costs HIV/AIDS are large and negative. Per capita GDP is another metric for gauging benefits and costs. Per capita GDP impacts of AIDS are considerably smaller than the overall GDP impact. Hence per capita GDP is by far the most conservative measure in terms of magnitude of preventive expenditure outlays.

Nevertheless, even the lower end estimate for per capita GDP impacts (a 0.3% growth differential) justifies an active AIDS prevention policy. As in the case of education, the benefits from an AIDS prevention policy will be realized primarily in the next decade. Consequently, some additional assumptions are required. In particular, an active AIDS prevention policy is assumed to be implemented in 2002. This policy is maintained at a cost amounting to a constant fraction of GDP through 2007 and then is phased out linearly over the next three years. Despite the preventive policies, GDP and population are assumed to be the same in 2010 due to the effect of time lags. From 2011 to 2020, GDP per capita grows at a 0.3% per annum increment for the case of an effective preventive policy, corresponding to the lower end of the range of estimated per capita GDP effects. Even under the restrictive assumption that only per capita GDP matters,

spending on prevention at a level of up to 2.5% of GDP from 2002 to 2007 with phased decreases through 2010 is still justified (see Appendix C for details).

This estimate implicitly assumes roughly constant medical technology, which is quite pessimistic. If, on the other hand, one is willing to optimistically assume that a cheap and effective vaccine will emerge by the end of this decade and that a major international effort will be launched to widely distribute this vaccine once developed, then the level of effort that should be allocated to preventive policy diminishes considerably since, for most of the infections averted, the vaccine would (by assumption) prevent the progression on to AIDS.

Prudence, however, dictates an active prevention program. As with education policy, the limiting factor is probably the ability to design and implement effective preventive policies rather than the overall budget. Nevertheless, a resource envelope large enough to contain costly initiatives appears to be justified as long as, of course, these initiatives are effective in controlling the spread of HIV.

Much has been written on prevention policy that does not bear repeating here. However, at least two themes can be identified (Ainsworth and Teokul, 2000). First, broad based AIDS awareness programs should focus on the young. This is a large group. The cohort under 20 (15) represents 55% (45%) of the population. Also, since they have not been sexually active for as long a period of time, young people are less likely to be HIV positive. This shows up clearly in the data. As indicated earlier, estimated prevalence rates for children ages 5-14 are nearly zero. For the age groups 15-19, 20-24, 25-29, and 30-34 in the year 2000, prevalence rates are estimated at 4.7, 10.9, 15.5, and 18.4 percent respectively. The rates thereafter decline with age.

In addition, young people are widely thought to be more malleable and thus more easily influenced by AIDS awareness programs because their behavior patterns are not as well established. Uganda is an example where delay of first sexual experience and other behavioral modifications are thought to have significantly reduced the spread of the pandemic (UNAIDS, 2001). Finally, the mounting evidence that educated people are taking steps to avoid infection indicates that the mitigating education policies outlined above might also serve as preventive policies.

Second, high-risk populations are another target group for behavior modification. For example, behavior modification in commercial sex, such as insistence on the use of a condom, has the potential to significantly slow the spread of the disease even in a generalized pandemic like in Mozambique. Safer commercial sex is widely credited for the success of Thailand in curbing the pandemic (Ainsworth and Teokul, 2000).

To conclude, the economic analysis and related policy implications provide strong support for adoption of both mitigating and preventive policies. While the pandemic cannot be avoided, much can be done to reduce its harshness and duration.

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Appendix A 1: Transition Matrix Estimation

Sets /set elements/:

te /1996*1999/	Time periods used in estimation
d /upper, middle, lower/	Discrete distribution points
i /births, notschool, ep1, ep2, esg1_2, tertiary, unskilled, skilled, hskilled, exit, lab_force/	Categories of population by activity
notest(i) /births, exit/	Categories for which values are not estimated
p(i) and pp(i) /notschool, ep1, ep2, esg1_2, tertiary, unskilled, skilled, hskilled, exit/	Categories associated with transition probabilities
pe(p) /notschool, ep1, ep2, esg1_2, tertiary, unskilled, skilled, hskilled/	All categories in set p but exit
k(i) / notschool, ep1, ep2, esg1_2, tertiary, lab_force/	Categories with values for data constraints
uk(i) /unskilled, skilled, hskilled/	Categories with unknown values for data constraints

Parameters:

$q_{p,pp}$	Prior probability values
val_{it}	Data for estimations
v_{dit}	Prior bounds on estimated values
$birth_{pt}$	Births in each period
$delta$	A very small number

Variables:

Z	Objective value
$r_{i,ip}$	Posterior probabilities for transition matrix
s_{dit}	Posterior probabilities for error terms
$estval_{it}$	Estimated values
$ehat_{it}$	Error term on known items

Equations:

Minimize Z subject to:	Description
$Z = \sum_p \sum_{pp} r_{p,pp} * \ln(r_{p,pp} / q_{p,pp} + delta) + \sum_d \sum_k \sum_{te} s_{d,k,te} * \ln(s_{d,k,te} + delta)$	Objective
$estval_{pe,te+1} = births_{pe,te} + \sum_{pp} estval_{pp,te} * r_{pp,pe}$	Transition Equation
$estval_{lab-force,te} = \sum_{uk} estval_{uk,te}$	Total labor force
$val_{k,te} = estval_{k,te} + ehat_{k,te}$	Defining the error 1
$ehat_{k,te} = \sum_d s_{d,k,te} * v_{d,k,te}$	Defining the error 2
$\sum_{pp} r_{pe,pp} = 1$	Moment zero r
$\sum_d s_{d,k,te} = 1$	Moment zero s

Table A 1: Prior probabilities employed in estimation of the transition matrix.

	Notschool	EP1	EP2	ESG1_2	Tertiary	Unskilled	Skilled	HSkilled	Exit
Notschool	80.0%	17.5%				1.0%			1.5%
EP1		78.3%	6.0%			14.7%			1.0%
EP2			50.0%	10.0%		55.0%	8.0%		1.0%
ESG1_2				85.0%	5.0%		9.0%		1.0%
Tertiary					72.0%		2.0%	25.0%	1.0%
Unskilled						99.0%			1.0%
Skilled							99.0%		1.0%
HSkilled								99.0%	1.0%
Exit									

Appendix B 1: An Overview of Static CGE Models

This appendix reviews the basic characteristics of a standard static CGE model. The specific features of the Mozambique model, including the addition of dynamic elements, are highlighted in the main text.

CGE models can be thought of as containing four basic elements:

- a) behavioral specification,
- b) accounting constraints,
- c) treatment of imports and exports, and
- d) market closure.

These elements are treated in turn.

Behavioral Specification

In any economic model, the behavior of the agents must be specified. For example, firms are often assumed to maximize profits subject to available technology and taking prices for inputs and outputs as given. Likewise, households are often assumed to maximize utility subject to a budget constraint. These are also the most common assumptions applied to CGE models. In addition, other agents are usually represented in a CGE model. For example, government receives revenue (through taxes and other sources) and purchases goods and services. Enterprises earn financial profits (returns to capital) and either distribute dividends or retain the earnings for investment purposes. Investors, through the purchase of commodities in order to form capital, determine the commodity composition of investment. Just as for firms and households, expenditure allocation rules must be specified for these additional agents. The rules can be simple or complex. For a simple example, all agents could allocate available funds across uses in constant budget shares. More complex rules that account for items such as risk, imperfect competition, or returns to scale can also be applied.

Accounting Constraints

The behavioral specifications within CGE models rarely set them apart from other economic models. The accounting equations, on the other hand, are a major distinguishing feature from partial equilibrium models. CGE models contain a number of identities that enforce consistency. For example,

- a) households must respect their budget constraint,
- b) the domestic price of imports equals the CIF price multiplied by the exchange rate and the prevailing tariff rate plus any marketing margins or additional domestic sales taxes,
- c) the value of imports cannot exceed the availability of foreign exchange,
- d) supply of commodities must equal demand for commodities (with inventory accumulation counted as demand),

- e) firms cannot use more of any factor than the total availability in the economy,
- f) investment must be financed via foreign or domestic savings, and
- g) government consumption must be financed through tax revenue, foreign grants (aid), or borrowing on domestic or foreign markets.

These propositions are essentially a matter of accounting; however, they serve to circumscribe the range of possible outcomes, sometimes surprisingly tightly. For example, skilled labor is often fully employed. This implies that, for a given stock of skilled labor, if an industry expands output and uses more skilled labor in the process, other industries must use less skilled labor. To achieve equilibrium in the various factor and product markets, prices adjust to simultaneously satisfy the decision rules and the accounting constraints.

Exports and Imports

As in most models with foreign trade, exports and imports receive special treatment. While the ideal special treatment remains a matter of considerable debate, it is clearly incorrect to assume that a domestic commodity and the same commodity being imported or exported are homogeneous (with the possible exception of trade in bulk commodities such as white maize between similar countries). For the vast majority of traded commodities, the empirical evidence is overwhelming that imports, exports, and domestic goods are differentiated products. The exact form of differentiation and the degree of differentiation remains contentious.

The most common practice in CGE modeling is to adopt the “Armington assumption” whereby products are distinguished by country of origin (Armington 1969). Other assumptions are possible. For example, goods might be differentiated by firm. So, Honda automobiles might be considered the same wherever they are produced but they differ from Ford automobiles. In a single country CGE model employing the Armington assumption, there are three goods associated with each commodity: imports, exports, and domestically produced goods for domestic consumption.

Closure

The final issue, closure, pertains to the macroeconomic characteristics of the economy in question. Is a fixed or flexible exchange rate regime pursued? Do taxes adjust to maintain an arbitrary alignment between government revenue and expenditures or does the government deficit adjust? Are factors of production fully employed and are they mobile across productive activities? Is investment driven by the available savings pool or do savings adjust somehow to accommodate an exogenous investment level? These questions are addressed through the choice of macroeconomic closure.

Results from CGE models are often sensitive to the choice of closure. This characteristic is sometimes cited as a weakness of CGE models. It could also be described as a strength. Economic outcomes do vary substantially depending upon macroeconomic conditions and policies. For example, if the defense buildup pursued by the United States under President Ronald Reagan had been tax financed rather than deficit financed, the economic structure of the

United States towards the end of the 1980s would arguably have been very different. Alternative closures permit CGE models to capture these alternative outcomes.

In summary, CGE models combine behavioral specifications for a large number of agents in the economy with accounting constraints and a view of the macroeconomic policy regime and the nature of product differentiation in international trade. Löfgren *et al.* (2001) provide a complete review of the basic CGE model that was adapted for this analysis.

Appendix C 1: Net Present Value Calculations

Table C1 illustrates the calculations employed to determine the economically justifiable levels of investment in preventive policy. The calculations were quite similar for education policy. For preventive policy, the perspective taken is that of one person whose income in 2010 is normalized to 100. The per capita income of this person evolves for the period 2002 to 2010 as in the Base AIDS scenario. The person is assumed not to be HIV positive and is assumed to have no chance of becoming HIV positive. Furthermore, this person does not care about any of the social or human costs of the AIDS pandemic. Nevertheless, roughly consistent with model results, the worker reaps income benefits from effective prevention policy in the period 2011 to 2020 in the form of a 0.3% increment to the growth rate of income.

Under these restrictive assumptions, this person is willing to invest 2.5% of income for the period 2002 to 2007 and a linearly declining share of income from 2008 to 2010 in order to obtain the increment to income growth during the period 2011 to 2020. Multiplication by population yields the same investment level as a share of GDP. Obviously, consideration of additional costs, such as the likelihood of contracting HIV and the social costs of the pandemic, would yield a higher investment figure

Table C 1: Net present value calculation on a per capita basis

	Per Capita Income ¹		Assumed Growth		Net ²
	Prevention	Base	Prevention	Base	
2002	75.8	75.8			-1.9
2003	80.9	80.9			-2.0
2004	84.8	84.8			-2.1
2005	86.7	86.7			-2.2
2006	88.8	88.8			-2.2
2007	91.2	91.2			-2.3
2008	94.6	94.6			-1.8
2009	97.7	97.7			-1.2
2010	100.0	100.0	0.028	0.025	-0.6
2011	102.8	102.5	0.028	0.025	0.3
2012	105.7	105.1	0.028	0.025	0.6
2013	108.6	107.7	0.028	0.025	0.9
2014	111.7	110.4	0.028	0.025	1.3
2015	114.8	113.1	0.028	0.025	1.7
2016	118.0	116.0	0.028	0.025	2.1
2017	121.3	118.9	0.028	0.025	2.5
2018	124.7	121.8	0.028	0.025	2.9
2019	128.2	124.9	0.028	0.025	3.3
2020	131.8	128.0	0.028	0.028	3.8
2021	135.5	131.6	0.028	0.028	3.9
2022	139.3	135.3	0.028	0.028	4.0
2023	143.2	139.1	0.028	0.028	4.1
~	~	~	~	~	~
2038	216.7	210.4	0.028	0.028	6.2
2039	222.7	216.3	0.028	0.028	6.4
2040	229.0	222.4	0.028	0.028	6.6

¹Per capita income is normalized to 100 in year 2010 in both scenarios.

²For 2002 to 2010, the net column illustrates the investment from base income, as a constant share of income from 2002 to 2007 and declining linearly from 2008 to 2010, that one would be willing to pay in order to obtain the increased income flow shown in the net column from 2011 to 2040. The net present value of the net column is zero and the share of income invested from 2002 to 2007 is 2.5%.

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