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

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Abstract

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 macroeconomic prospects. Particular attention is paid to human capital accumulation. Taking demographic projections, human capital accumulation projections, and other inputs, a recursive computable general equilibrium approach is employed to quantify impacts on key macroeconomic variables and identify the major channels through which these impacts occur. Policy options for blunting the major negative impact channels are also considered.

Due to the long time lags between infection and onset of AIDS, the AIDS case projections to 2010 are, barring rapid advance in medical technologies, essentially programmed into the system since nearly all of the people projected to die in this decade, including the latter parts, are already HIV positive. The analysis indicates that these impending AIDS cases and deaths could have large economic impacts. 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 though the productivity effect is the strongest.

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) reactive 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 reactive policies, education policy was explicitly considered. AIDS poses a threat to educational attainment from both the supply and demand sides. AIDS deaths amongst teachers and administrators will worsen already severe supply side constraints. In addition, widespread orphaning is likely to reduce the demand for education. Both of these effects point to reduced school enrollments and human capital accumulation.

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 also justify large prevention expenditures (2.5% of GDP from 2002 to 2007) even if per capita GDP is the sole criteria 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.

In the final section, these and other relatively broad policy options are considered. 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, accelerating the general economic reform agenda, administrative and regulatory simplification, accelerated efforts to extend labor-saving agricultural technologies, and tightly targeted (to teachers for example) use of highly active anti-retroviral therapy (HAART). Widespread use of HAART does not appear to be feasible.

The challenge is in moving beyond general policy ideas (both reactive and preventive) to real policy initiatives. This will require careful thought particularly with respect to issues of implementation.

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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 substantial regional variation (see 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%. For at least the southern and central provinces, the projected demographic effects are stunning. For example, life expectancy in these provinces by 2010 is expected to decline to about 36 years as opposed to a projected 50 years in the absence of the pandemic (Ministry of Health et al., 2001).

Due to the magnitude of the HIV/AIDS pandemic, it has easily overrun the bounds of a pure health issue. Instead, it has become a top priority development issue in the southern Africa region, including Mozambique. The goal of this paper is to try to come to grips with the implications of the HIV/AIDS pandemic in its economic dimension. In this initial assessment, focus is on the implications for macroeconomic prospects. The idea is to attempt to quantify impacts on key macroeconomic variables and identify the major channels through which these impacts occur.[1] Having done this, one can then consider policy options for blunting the major negative impact channels.

The official demographic projections for Mozambique assume an average time lag of nine years between infection and death from AIDS. Consequently, the AIDS case projections though 2010 are, barring rapid advance in medical technologies, essentially programmed into the system since nearly all of the people projected to die in this decade, including the latter parts, are already HIV positive. Given the time lags inherent in the pandemic, policy actions can be divided into two categories: a) reactive 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. The period under consideration extends to the limits of the official demographic projections (2010) and thus pertains to the period where reactive policies are relevant. However, the basic results can also be used to consider the implications of preventive policies.

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 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 reactive and preventive policy implications.

[1] The paper focuses primarily on GDP and GDP per capita despite some well-known limitations of these variables. See Arndt and Lewis (2000 and 2001) for a discussion on the limitations of these variables as welfare indicators in the context of the AIDS pandemic.

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, and it is not adopted in this analysis. Even under the assumption of relatively constant medical technology, the demographic impacts of HIV/AIDS are quite uncertain as is made clear in the next section. 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.[2] Finally, the analysis bumps 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 about one 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 spread around the country including some in rural zones, are presented in Table 1. To illustrate some of the uncertainty associated with measures of HIV prevalence rates at the national level, rates implied by the earlier set of demographic projections (based on observations from only four health posts with none of those located in the northern provinces) are shown in the final column of Table 1. Earlier demographic projections appear to strongly overestimate prevalence rates in the North. Since the northern provinces account for about one third of the population, the new figures revise the national adult prevalence rate downwards from 16% to 12%. Average prevalence rates are also lower in the Center. However, this is essentially due to a lower prevalence rate in Zambezia province. Remaining central provinces essentially conform to the earlier projections. Prevalence rates in the South are actually slightly higher than previously forecast. Further comparisons of the two sets of projections are presented in Appendix B.

According to the most recent projections, population growth between 2000 and 2010 will be only about 1.6% per annum as opposed 2.5% in the absence of the pandemic. By 2010, the size of the population is expected to be about 90% of the hypothetical no AIDS level. Along with the overall size, the structure of the population also changes dramatically. 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,

[2] Mozambique has made large strides in developing credible data relevant for this analysis. Nevertheless, some 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. Throughout the paper, I try to point out data limitations and knowledge holes without harping on them.

during childbirth or through breastfeeding, is roughly 30%.[3] 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.[4] The remaining 18 to 19 infants are highly unlikely to contract HIV until they become sexually active.

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 one 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. These figures on orphaning are probably the grimmest figures from a very grim set.

While the figures on orphaning follow logically from the incidence of the epidemic, impacts on the dependency ratio (the non-working age population divided by the working age population) are less intuitive. If the pandemic mainly strikes young adults in their prime working years, then first thought indicates that the dependency ratio should rise since the most obvious effect is to reduce the denominator of the ratio. In fact, dependency ratios are projected to decline fairly significantly. Figure 2 shows four alternative measures of dependency ratios. All four measures are projected to decline by about 14% over the 2000 to 2010 period.[5]

Four facts underlie this somewhat counter-intuitive result. First, women are more likely to be HIV positive than men. In the projections for 2001, women represent about 57% of the total HIV positive population. The ratio of HIV positive females to HIV positive males is about 1.31. Furthermore, for the 15-24 age group, this ratio is 3.37. So, women are more likely to contract HIV, and they tend to contract it earlier in life. This has implications for fertility. Second, the population is very youthful. In 2001, about 45% of the population was under 15 years of age. Third, even considering MCT, this segment of the population has very low HIV prevalence rates. The HIV prevalence rate in 2001 for the group under 15 years of age was estimated at about 1.0% (compared to about 12% for adults). For the age range 5-14, the prevalence rate is estimated at about 0.2%. Finally, even in the absence of drug therapy, there are long time lags between becoming HIV positive, the onset of AIDS, and eventual death. As indicated earlier, the demographic model underlying the figures illustrated here assumed, for adults, eight years between infection and the initial onset of AIDS and a life expectancy of one year thereafter.

Since large numbers of women are projected to develop AIDS and die well before the end of their normal childbearing years, birth rates decline rather dramatically. In addition, over the span of a decade, many youths will transition to adulthood. Furthermore, even if

[3] This is the figure employed in the demographic projections.
[4] 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.
[5] Not all demographic models of countries strongly afflicted by HIV/AIDS produce this decline in the dependency ratio. For example, demographic models for South Africa project a relatively constant dependency ratio through time.

these youths become sexually active and HIV positive early in life, their life horizons still extend an additional nine years. This combination of a large group moving into adulthood and a reduced birth rate are the primary factors driving down the dependency ratio over the period 2000 to 2010. So, at a minimum, the massive orphaning and attendant social problems that are projected to occur due to the pandemic will be accompanied by an improvement, rather than a worsening, of the overall dependency ratio. This decline in the dependency ratio is about the only cheerful news in the entire constellation of facts surrounding the pandemic.

Barring a medical miracle, these basic facts also point to the earliest conceivable exit from the clutches of the pandemic. If the group currently under 15 can learn to avoid becoming HIV positive, the brunt of the pandemic will pass in the space of about a decade. The same basic facts, especially the long time lags between infection and onset of AIDS, also indicate that the AIDS cases projected over the rest of the decade are essentially programmed into the system. Potential macroeconomic impacts over the coming decade are the focus of the remainder of the paper.

3. The Economics of HIV/AIDS: Literature Review and Impact Channels

Efforts to comprehend the macroeconomic implications of the HIV/AIDS pandemic have been appearing in the economics 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.

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%.[6] 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. This more pessimistic tone has been adopted by many of the author's cited in the previous paragraph. For example, Bloom (2000) states: "the whole economy [in Africa] could unravel ... what is about to come is ten times worse."[7]

[6] Dixon, McDonald, and Roberts (2001) provide another recent examination of the relationship between AIDS and economic growth using a panel data approach. They are far from optimistic about potential macroeconomic impacts; however, in contrast with Bonnel, they find that the macroeconomic impact of the pandemic is unclear given available data.

[7] Wils et al. (2001) perform a dynamic analysis of the "Mozambique's Future" that cuts against this more pessimistic grain. They recognize the pandemic; however, their base case scenario is surprisingly sanguine.

Some of the channels of impact of HIV/AIDS are summarized in Box 1. Recent analysis also suggests that the relative importance of the channels indicated in Box 1 depends on economic structure in combination with the incidence of the pandemic. For example, in their examination of South Africa, Arndt and Lewis (2000) identify budget deficits driven by increased spending on health and social programs as a major contributor to the overall economic impact. In South Africa, unemployment amongst unskilled and skilled workers mutes the effect of a reduced rate of labor stock accumulation in those labor segments. Highly skilled labor (human capital) is fully employed and the stock is relatively large; however, the incidence of the epidemic is strongly biased towards the unskilled and skilled labor segments. As a result, labor accumulation and human capital effects are relatively small.

In Mozambique, by contrast, the impact channels are likely to be quite different. In most

Box 1: Potential Channels of HIV/AIDS Impact on the Economy

For firms:

disruption/absenteeism	⇒ affects overall productivity
worker experience down/morbidity	⇒ affects labor productivity
insurance/benefits up	⇒ affects costs, profits, savings
For government:	
AIDS spending up	⇒ crowds out other spending, deficit
economic structure shifts	⇒ affects tax revenue
AIDS and the civil service	⇒ affects quality of government services
For households:	
loss of income/orphans	⇒ reduced investment, poverty
caring for HIV/AIDS victims	⇒ greater stress on social systems
For the macro economy:	
lower physical & human investment	⇒ reduced growth trajectory
slower technical progress	⇒ reduced growth trajectory

nations in sub-Saharan Africa afflicted by the AIDS pandemic, the budget share of the Ministry of Health has changed little and few expect Mozambique to deviate from this norm. As a result, health spending is unlikely to drive up budget deficits. In addition, investment is primarily funded through foreign funds (e.g., aid and foreign investment). Consequently, switching from investment to consumption expenditure by local agents will have a muted effect on total investment.[8] These facts indicate that the effect on capital accumulation from expenditure switching may be less salient than it was in South Africa.

Also in contrast to South Africa, available time use studies indicate that adult Mozambicans are engaged in productive activities especially in the informal sector (Arndt and Tarp, 2000). The importance of the informal sector is reflected in the national accounts where, in 1997, the informal or family sector accounted for more than half of the total value of production in the economy. Since adults are generally engaged in productive activity, fewer adults implies fewer workers, which translates directly into reduced output. In South Africa, on the other hand, fewer unskilled workers might simply result in reduced unemployment. Also in contrast to South Africa, HIV prevalence rates in Mozambique are, at best, constant across skill classes. Highly skilled people may, in fact, exhibit higher prevalence rates.[9]

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 variables; such as technical progress, physical capital, and human capital; will cumulate over time with potentially substantial implications for the economy. Put another way, 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.

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 Education and Development

Evidence continues to mount for a strong positive association between education levels and productivity growth in both agricultural and non-agricultural sectors. An early review of 18 studies focused on agricultural productivity conducted by Lockheed, Jamison, and Lau (1980) concluded that education had a significant and positive impact on agricultural productivity. However, the authors qualified their results by stating that the effect of education was likely to be much stronger in "modernizing agricultural environments than

[8] Assuming credit constraints preclude massive dissavings.
[9] Gregson, Waddell, and Chandiwana (2001) provide a detailed review of the evidence on the relationship between education levels and HIV prevalence.

in traditional ones" (p. 61). More than two decades later, this qualification still excludes much of Africa and almost all of Mozambique.

However, a series of recent microeconomic analyses tends to find a strong association between education and agricultural productivity even in traditional African contexts. Positive 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. Put simply, the illiterate neighbors of more educated farmers, who tend to be more innovative, benefit by simply watching and copying.

In Mozambique, analysis from the 1997 household survey finds indirect 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). Since agriculture utterly dominates rural activities in Mozambique, increased consumption is fairly strong indirect evidence of increased agricultural productivity. The urban per capita consumption increases for households with at least one member who has completed primary school are consistent with a number of studies on returns to education (see, for example, Psacharopolous 1994 for a review of microeconomic studies and Bloom, Canning and Sevilla 2001 for a recent study using macroeconomic panel data).

Existing occupation and wage data for Mozambique also support the notion of strong returns to education. The wage for the roughly 60,000 Mozambicans with tertiary education exceeds the wage for unskilled agricultural labor, which is by far the largest labor category, by a factor of about 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, the scope for education to stimulate economic growth and poverty reduction is relatively high. 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 consumption by about 24% and reduces poverty 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 (PARPA 2001-2005). Unfortunately, the AIDS pandemic poses a threat to enhancing educational attainment from both the supply and demand sides.

4.2 Education and HIV/AIDS

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 of three households have access to a basic primary school (EP1) in their village.[10] Access to an upper primary school (through level EP2) is substantially more rare. Only 17% of rural households have an upper primary school in their village. This is of real concern since analyses of the 1997 household survey appear to indicate a threshold effect. As discussed in the previous sub-section, completion of EP2 by any household member raises per capita consumption of members of the household significantly. The effect on per capita consumption of completion of EP1 is positive but substantially less strong. Access to secondary schooling in rural areas is even more circumscribed with only 2% of rural households having a secondary school in the village (Handa, Omar, and Ibraimo 1998).[11]

With figures like these, expansion of supply becomes a fairly obvious goal. Handa and Simler (2000) assert that, at the moment, expansion of supply should take precedence over efforts to increase school quality (through, for example, lowering the student/teacher ratio) provided that the supply enhancements are targeted at villages that do not have a school and do not have a school nearby (56% of the total villages without schools). However, each school requires at least one teacher and teachers are in short supply.

AIDS will worsen the supply constraint. There is little reason to believe that HIV prevalence rates amongst teachers and other critical personnel in the education sector should be any lower than the prevalence rates in the adult population. Indeed, there is some reason to fear that the rate might be higher. As stated by Badcock-Walters and Whiteside (2000), "the comparatively high incomes, often remote postings and social mobility of …[educators]… has long suggested that they may be of far greater risk than the population they serve" (p. 2).[12] This fear is confirmed in Zambia where, in 1998, the AIDS death rate among educators was 70% higher than that of the 15-49 age group in the general population (Badcock-Walters and Whiteside 2000).

Concerns also exist on the demand side. For villages with schools, the main reason cited in 1997 (prior to the real onset of 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, the need for children to work will clearly become more pressing. In a review of the literature, UNAIDS (1999) lists taking children out of school as one of the four most common household responses to stresses induced by the AIDS pandemic.

[10] This level of access to basic primary school is no small achievement considering the devastation wreaked by the civil war (Arndt, Jensen, and Tarp, 2000).
[11] 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.
[12] Also see Gregson, Waddell, and Chandiwana (2001).

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. As the number of children living with friends and relatives increases, one would certainly not expect this effect to be reduced. More likely, the tendency to keep children of relatives and friends at home to work will become more pronounced.

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. It is possible that the education system could function reasonably well at this reduced rate. With reduced supply and reduced demand, supply might be adequate to cope with current demand. However, this is unlikely. Much more likely, demand constraints will bind in some areas and supply constraints in others leaving the system to operate well below potential capacity. Nimble management of the sector could help substantially; however, managerial capacity is already thin and not immune to AIDS. For example, Badcock-Walters and Whiteside (2000), while concerned about deaths amongst teachers, worry even more about a "catastrophic" erosion of the stock of education sector managers in the southern Africa region.

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.

$$
T=\begin{bmatrix}
T_{11} & T_{12} & & & & T_{16} & & & T_{19} \\
& T_{22} & T_{23} & & & T_{26} & & & T_{29} \\
& & T_{33} & T_{34} & & T_{36} & T_{37} & & T_{39} \\
& & & T_{44} & T_{45} & & T_{47} & & T_{49} \\
& & & & T_{55} & & T_{57} & T_{58} & T_{59} \\
& & & & & T_{66} & & & T_{69} \\
& & & & & & T_{77} & & T_{79} \\
& & & & & & & T_{88} & T_{89}
\end{bmatrix}
$$

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.[13]

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. Also, for simplicity, the assumption that immigration is zero has been maintained. Therefore, the population only grows 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 of the population and births surviving to age one from the 1996 census, and on the labor force from Ibraimo (2000) and national accounts. The estimation period was from 1996 to 1999. The census only supplies one year of data. Surviving births were assumed to be a constant share of the female population aged 15 to 49. Also, data on the labor force by skill category were only available for one year though estimates of the size of the overall labor force were available for each year in the estimation period from national accounts.

Given the data holes and short time series, a minimum cross entropy approach, following Golan, Judge, and Miller (1996), was employed. The approach relies upon information

[13] Note that the matrix assumes that, once an individual has entered the labor force in a particular labor category, that individual will stay in the same category until death or permanent retirement. There is no opportunity for skills upgrading (or downgrading). While inappropriate for other countries, this is probably a reasonable working assumption for Mozambique. It is certainly not a perfect description of current conditions—anecdotal evidence of skills upgrading exists—nor is it a fact of life. Encouraging skills upgrading is a potentially viable policy response to the AIDS pandemic and one that has not been considered here.

theory and is well-suited to problems where data series are short and/or incomplete. Estimates of the labor force by category were constrained to sum to the total labor force as estimated by national account. The minimum cross entropy approach also permits use of prior information on transition probabilities. Prior values for the transition probabilities were derived from education sector reports by Verde Azul (2000) and World Bank (2000) and from demographic data. The prior values employed and more details on the estimation procedure are presented in Appendix A.

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}).

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. In developing the base AIDS scenario, AIDS 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.

Specifically, projected AIDS mortality rates by age class were mapped to the various educational and occupational categories. These AIDS death rates were simply added to the estimated death or permanent retirement rates shown in the last column of Table 1. Recall that the row probabilities must sum to one. For the labor categories, the AIDS death rates were subtracted from the probability of remaining in the labor force thus maintaining row balance.

For educational categories other than tertiary, the increase in the death rate is next to zero since children enrolled at these levels are too old to be afflicted by MCT and too young to have developed AIDS from sexual contact.[14] However, due to the supply side constraints, massive orphaning and attendant social problems mentioned above, we expect the probability of remaining in school and the probability of transitioning to the next higher educational level to decline. These probabilities were reduced 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}- .02*(AIDS death rate in t/maximum AIDS death rate)].

[14] This is true even for children who become sexually active and HIV positive at very early ages due to the nine year lag between infection and death.

Instead of transitioning to a higher level of schooling, these individuals were assumed to transition to the lower labor skill level.

A higher proportion of students enrolled in tertiary education are also expected to leave school due to stresses induced by the AIDS pandemic. In addition, some tertiary level students will develop AIDS and be forced to drop out of school. 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 and by the same function shown in the previous paragraph (maximum drop of 2 percentage points as a function of the adult AIDS death rate). To maintain row balance, the AIDS death rate was added to the "Exit" column and the functional drop of up to 2% was added to the probability of transitioning to the skilled labor force.

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 lowers the probability of remaining in category (T_{ii}); however, 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 3, 4, 5, and 6. The figures illustrate that, under the estimated transition probabilities and without AIDS, the labor force is projected to skills upgrade rather 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. Rates of growth slow very considerably but are still positive for the two skilled labor categories in the Base AIDS scenario. Given the difference in productivity between the skilled labor categories and unskilled labor, this slow down in skilled and highly skilled labor stock accumulation is significant economically.

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.[15]

[15] This analysis glosses over important factors like worker experience. In the economic model presented in the next section, worker experience is rather crudely addressed through productivity effects. However, the experience profile of the workforce should be addressed in later work.

The evolution of primary school enrollment and the evolution of the unskilled labor force are essentially dual to one another. 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, 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 6. 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.

As indicated above, these alternative labor stock accumulation scenarios will have economic impacts. The method for assessing these impacts is presented in the following section.

5. Economy-wide Modeling Approach

5.1 Model Structure

The impact of the HIV/AIDS pandemic is simulated using an economywide 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" with which we can examine how different factors and channels of impact 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. Aggregate macro models would miss (a) the sectoral interactions which have been shown to be important in previous work, (b) the implications of rural-urban migration, (c) the (large) differences in HIV prevalence among regions of Mozambique, and (d) the differences in HIV prevalence by skill and educational category.[16] The disaggregation

[16] Disaggregation of macroeconomic models, such as in Cuddington, Hancock and Rogers (1994), is possible and enables the models to capture important compositional effects. Distinctions between the

present in CGE models permit them to capture compositional effects, a feature that has proved valuable in earlier analyses. For example, in an analysis of South Africa, Arndt and Lewis (2001) found that lackluster growth in investment sectors was a key reason for a counter-intuitive rise in the unemployment rate despite the concentration of AIDS deaths in labor classes with high unemployment rates.

Experience with this class of models also highlights some disadvantages. An economy-wide approach is not well suited for the analysis of all issues. In striving to develop a comprehensive picture of the entire economy, some detail is necessarily suppressed. If detail highly relevant to the analytical question at hand has been suppressed, the approach is obviously poorly suited. At the opposite extreme, some issues can be adequately addressed with economic frameworks that are less detailed allowing the analyst to spend more time on analysis and less time on data issues and modeling, and aggregated macroeconomic models have been employed for the analysis of the macroeconomic implications of HIV/AIDS.[17] Nevertheless, the cross-cutting nature and real economy impacts of HIV/AIDS indicate that compositional effects are likely to be important (as they were in South Africa. As a result, the CGE approach was adopted.

CGE models, such as the Mozambique model, are frequently applied to issues of trade strategy, income distribution, and structural change in developing countries.[18] Economic decision-making is the outcome of decentralized optimizing by producers and consumers. A variety of substitution mechanisms are specified in these models, with substitution among labor types, between capital and labor, between imports and domestic goods, and between exports and domestic sales all occurring in response to variations in relative prices. Institutional rigidities and imperfect markets can be captured by the exogenous imposition of features such as immobile sectoral capital stocks, labor market segmentation, and a fixed exchange rate, which together limit a neoclassical interpretation of the models but permit their more realistic application to developing countries.

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.[19] 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.

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models then begin to fade. McKibbin and Wilcoxen (1999) present a fully merged CGE and macro modeling framework.

[17] Critics of CGE models would no doubt add to this list of disadvantages.

[18] The Mozambique model is a modified version of the IFPRI standard model (Löfgren et al., 2001). A thorough exposition of the properties of this class of models can be found in Dervis, de Melo, and Robinson (1982). See Robinson (1989) for a review of CGE model applications to developing countries.

[19] 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.

On the supply side, sectoral production occurs according to a translog production function that determines how capital and labor inputs are combined together in generating value added. The value added aggregate is then combined with intermediate (material) inputs to produce output according to a fixed coefficients technology. Profit-maximization by producers is assumed, implying that each factor is demanded so that marginal revenue product equals marginal cost.

On the demand side, the Mozambique model maintains the standard CGE assumption that domestic goods are imperfect substitutes for traded goods (both exports and imports). Sectoral exports are assumed different from output sold domestically, and are combined using a constant elasticity of transformation (CET) function to form domestic output. This treatment captures explicit differences between exports and domestic goods (such as quality), as well as other barriers preventing costless reallocation of output between the export and domestic markets (such as market penetration costs). Hence, the price of the good on domestic markets need not equal the domestic price of exports, which is determined by the world price, the exchange rate, and exogenous export subsidies. Producers maximize revenue from selling to the two markets, so that the ratio of exports to domestic sales is a function of the price ratio.

As with exports, sectoral imports and domestically produced goods are imperfect substitutes in both intermediate and final uses. Demanders of imports minimize the cost of acquiring a "composite" good, defined as a CES aggregation of imports and domestic demand.[20] Substitution elasticities can vary by sector, with lower elasticities reflecting greater differences between the domestic and imported good. Retaining the small country assumption, the supply of imports is assumed infinitely elastic at a price fixed by world market conditions. The domestic price of the imported good is determined by the world price times the exchange rate, plus any tariffs. The assumption of cost minimizing behavior by demanders implies that the sectoral desired ratio of imports to domestic goods is a function of their price ratio.

Two household categories (rural and urban) are distinguished in the model, along with government and enterprise accounts. Each group receives income from rental of endowments (labor and capital) and has explicit behavioral rules governing savings and expenditure behavior. Specifically, factor income from endowments is distributed to the households using fixed shares, as are enterprise dividends. Households are taxed at a fixed rate, and may also receive transfers from the government; they save a fixed fraction of their income (which adds to the pool of domestic savings), with the remaining income spent on consumption.

Firms receive the returns to capital, pay enterprise taxes, and receive transfers. The remainder is divided between enterprise savings and household dividends. The government receives tax revenue from import tariffs, indirect (excise) taxes, value added taxes, and income taxes on enterprises and households. The government also receives significant

[20] This characterization of imperfect substitutability was developed by Armington (1969). It has since become a standard feature in numerous applied models; see, for example, Dervis, de Melo, and Robinson (1982) and Devarajan, Lewis, and Robinson (1990).

revenue in foreign aid. The government spends money on transfers (to households and firms), health, education, public administration and defense as well as government investment. The remaining surplus or deficit is added to the available supply of savings in the economy.

Sectoral private consumption is determined through fixed expenditure shares under the assumption that households have a Cobb-Douglas utility function. Government consumption is also allocated using fixed expenditure shares. Final demand for intermediate goods is the sum of the intermediate demands generated in each producing sector. Investment is allocated using dynamic updating rules discussed in more detail below.

Several other features affect simulations with the CGE model. 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. The government deficit is fixed in nominal terms. Government spending thus varies with tax revenue. Net foreign savings 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 our model, the aggregate producer 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 expectations approaches (or even perfect foresight). 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 very 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.

Having established expectations formation, a series of dynamic equations are also required to "update" various parameters and variables from one year to the next. For the most part, the 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 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.

Using these simple relationships to update key variables, we can generate a series of growth scenarios, based on different assumptions about demographics, transition probabilities, and other parameters. It is important to note that, at present, we are primarily interested in the *differential* impact across scenarios. From this vantage point, what matters most is whether our benchmark Base AIDS and No AIDS scenarios are more or less reasonable. It is not a forecast of economic outcomes. Instead, it is a base from which the differential impact of alternative options can be assessed.

5.2 Key Assumptions

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:

- an increased level of 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 key government services,
- a much younger, more inexperienced labor force with significantly less opportunity for mentoring/training on the job,
- a generalized decline in the health status 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,
- greater uncertainty associated with the formation of long-term contracting arrangements, and

- the need to cope with the ramifications of the pandemic outside of the workplace, such as attending funerals and arranging for appropriate care for orphans and AIDS sufferers, that inevitably will detract from process improvement in the workplace.

Papers documenting these expected 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 in order to HIV prevalence among employees, production outsourcing, and increasing the capital intensity of production-- among large formal sector companies in Africa. That large firms are reacting indicates that AIDS has the attention of large company managers and that these managers believe that the costs of remaining in current business modes are unacceptable. The ability of firms, particularly large formal sector companies, to insulate themselves from the negative effects of the pandemic remains an open question. Generally, the most consistent numbers related to AIDS and firm productivity emerge from effects that are relatively easy to observe and document. These include absenteeism, health and life insurance rates, and AIDS deaths.

Another effect that is relatively easily 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. These are disturbing numbers if, as the microeconomic evidence suggests, worker experience and mentoring are important determinants of the level and rate of growth of productivity.[21]

At the aggregate level, health (using life expectancy as a proxy) has been found to be a significant contributor to growth in a number of studies. However, in these analyses, it is unclear whether the life expectancy variable is associated uniquely with health or with other determinants of growth (Barro and Sala-i-Martin 1995). Recent analyses by Bloom,

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

Canning and Sevilla (2001) and Mayer (2001) have sought to isolate more rigorously the impact of health. Bloom, Canning, and Sevilla use cross-country panel data from 1960 to 1990 (one observation on each country in the sample per decade) and stay with 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 growth. Reversing the logic to declining health, these studies suggest that the negative productivity effects of HIV/AIDS might be quite large.[22]

While a number of indicators point to a potentially significant impact on productivity growth, the evidence remains indirect. Empirically well-grounded studies of the impacts of AIDS on rates of productivity growth do not yet exist. There are two primary reasons for this. First, measuring productivity growth by itself is strewn with pitfalls. Separating out the myriad direct and indirect effects of AIDS adds further complications. Second, even though the pandemic is now 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.[23] 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.[24] 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 (but not reported) by Arndt, Robinson, and Tarp (forthcoming).

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[22] HIV/AIDS probably ruins life expectancy as a reasonable proxy variable for health. For example, in Mozambique, life expectancy in 2010 is expected to be about 14 years lower than it would have been in the absence of the pandemic. Few would expect output to be lower by 56% (56=4*14) *based on the health effect alone*.

[23] 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.

[24] These rates of growth maintain relative factor returns in acceptable ranges.

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.[25] For agricultural labor, the sum of the central and northern populations is considered. For non-agricultural labor and capital, the southern population is considered. So, if one percent of the adult population in the South has AIDS in year t, TFP growth rates between year t and year t+1 are adjusted downward by one percentage point for all classes of non-agricultural labor and capital.

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. Consistent with available demographic information, a low rate of migration from rural to urban zones is implicitly assumed at prevailing wage differentials.

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 soft 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 very significant in the next decade. Unless specifically noted, mega-project investment is assumed to occur regardless of HIV/AIDS in all scenarios. Finally, recall that in all scenarios 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.[26]

[25] 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.

[26] 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).

A further word on the mega-projects is necessary. Forecasts of mega-project activity and structure were obtained from Andersson (2001). Andersson 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 very large investment capital inflows. These flows are shown in Table 2.

Mega-projects are modeled by including a single mega-projects activity in the model. Investment capital comes entirely from foreign direct investment. Consistent with Mozal, imported capital goods comprise 96% of this investment expenditure. The technology employed by the mega-projects activity is also modeled on observations of Mozal. This technology is highly capital intensive with returns to capital comprising about 96% of total value added (Andersson, 2001). Labor value added accrues primarily to highly skilled and skilled labor. Intermediate input use is dominated by imported intermediates. The mega-projects activity produces entirely for the export market. Returns to capital are assumed to be repatriated. An activity tax equal to 1% of sales is imposed with the revenue accruing to government.[27]

Purchase of drug therapies represents another major potential flow of foreign exchange. The potential volume of this flow is easily illustrated. The HIV positive population in Mozambique is estimated at about 1.2 million in 2001. Drug therapy is available at a cost of about $500 per person per year. The cost of treating the entire HIV positive population in terms of drugs alone would thus be about $600 million per year. There is no way that Mozambique can afford this sum and little evidence that the international community is prepared to deliver *additional* aid at that level. Providing drug therapies only to individuals with AIDS (as opposed to simply HIV positive) would considerably shrink the pool of people eligible for drug therapies and commensurately reduce the costs, at least in the near term.

Nevertheless, drug costs are not the only barrier to widespread use of drug therapies. Even if large volumes of drugs appeared tomorrow for free, the means for effectively distributing the drugs are, at the moment, practically non-existent. 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. In light of these realities, drug therapies are ignored in the Base AIDS scenario. However, careful consideration of targeted drug treatment options is an important topic for future research.[28]

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[27] The use of a single mega-project activity based on Mozal has the advantage of simplicity but fails to capture some relevant aspects of mega-project investment. In particular, the natural resource based mega-projects offer the promise of significant revenue to government (well beyond 1% of sales) and hence a more significant impact on national income. However, since the mega-projects do not contribute to differentials across scenarios (except when the mega-projects are removed at which point the issue of taxation is dealt with explicitly), this simple approach was adopted.

[28] Some additional comments on drug therapies are worthwhile. The drug therapy issue presents brutal choices for the government of Mozambique. Since it cannot provide drug therapy to all who are in need, it must either provide no therapies or draw a line somewhere between those who receive and those who do not. The current policy is to make drug therapies available at cost at central hospitals. Once operational, the

5.3 Scenarios

Four AIDS scenarios are presented labeled: Base AIDS, LessEffect, Education, and NoMega.[29]

- *Base AIDS.* This scenario adopts the standard assumptions described above.
- *LessEffect*. This scenario provides some sensitivity analysis on some of the key assumptions that drive results in the Base AIDS scenario. In particular, the AIDS induced effects on productivity and transition probabilities in education and skills acquisition are halved. Also, in the LessEffect scenario, 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.[30]
- *Education.* This scenario takes nearly all inputs as in Base AIDS except the labor stock evolution, which is taken from the transition matrix Education scenario. In addition, to reflect the greater emphasis on education, donors are assumed to provide additional funding for education and the government of Mozambique is assumed to spend it for that purpose. 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. Rules on domestic government resource allocation remain unchanged so the external funding for education is a pure increment (e.g., though the funds may be fungible, the government of Mozambique does not reallocate them).
- *NoMega*. This scenario is the same as Base AIDS except that no mega-project investment is assumed to occur.

In addition to the four 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. For the reasons indicated earlier, a massive effort to deliver highly active anti-retroviral therapy (HAART) is considered impractical and is not modeled explicitly.

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policy will effectively make drugs available to the very small minority of Mozambicans who can afford them. In economic terms, this is likely to reduce death rates for workers with human capital. However, the analysis in section 4 indicates that the overwhelming determinant of the future stock of human capital is the growth rate, which the current policy is unlikely to influence. Targeted use of drug therapies might be a way to maintain supply and quality in the education system as assumed in the Education scenario.

[29] A scenario labeled TaxMega is also run with results presented in a footnote. TaxMega is the same as the base except that output taxes on the mega-project activity are increased from 1% to 5% of sales from the year 2000 onwards.

[30] In the LessEffect scenario, productivity growth effects are half as strong [no AIDS rate – (target adult population with AIDS)/(total target population)/2]. In addition, the probability of transitioning to the next higher educational level was reduced by a maximum of one percentage point (as opposed to two in the base AIDS scenario) 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}- .01*(AIDS death rate in t/maximum AIDS death rate)]. 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

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 7. 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, is projected to occur in 2002 as shown in Table 2. This investment is assumed to "come online" (add to the available capital stock and hence productive capacity) in 2003. As a result of the additional mega-project production in 2003, the growth of GDP between 2002 and 2003 is very rapid.[31]

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.

Sectors that provide investment goods, such as construction and other manufactures, are particularly hard hit. But, 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 3 and 5). 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

[31] The actual timing of mega-project investment and the timing of productive capacity "coming online" is highly unlikely to unfold as projected. For a number of purposes, these timing issues are crucial. However, since we are primarily interested in the differential effects of HIV/AIDS across scenarios, the nuances of mega-project timing are not particularly important.

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.[32] Indeed, if the assumption of Hick-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 only 2.5%.

The differences in growth rates shown in Figure 7 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.

The major impacts on GDP can be roughly decomposed into their component parts. This is done for the Base AIDS scenario and is shown in Figure 8. All of the effects are important. The most important, according to the decomposition, is the productivity effect. At least three caveats apply to the decomposition. The first is technical. Since these effects interact, the order of simulation matters in determining the magnitude of each effect. Sensitivity analysis on the ordering of simulations reveals differences in magnitudes but a qualitatively similar story. The second caveat also relates to interactions. Since educated people will be the primary generators and adaptors of improved technology, the decomposition of human capital and technology effects, though possible in the model as currently specified, is somewhat artificial.

The final caveat applies to implications beyond 2010 (e.g., beyond the simulation period). As illustrated in Figure 6, 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 a viable and 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 9, the Education and Base AIDS scenarios are nearly indistinguishable in terms of GDP. However, they are quite different

[32] It should be noted that a single sector macroeconomic model with multiple factors of production, biased technical change, and differential rates of accumulation of factors could also be expected to capture the interactions between biased technical change and differential rates of factor accumulation. However, the elasticities of substitution between factors for the aggregate production function in the model would be forced to do a considerable amount of work. They would have to capture the apparent substitution effect from shifts in the composition of output along with the underlying flexibility of production technologies (presumably an average on a value added share basis of the sectoral elasticity values). Compositional shifts in the structure of output can have significant effects on the apparent aggregate substitution elasticity. See, for example, Hertel, Stiegert, and Vroomen (1996).

in terms of output per worker. As can be deduced from Figures 3, 4, and 5, 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).

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 exiting school early and joining the labor force are likely to be at least 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 10. 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.

Turning to the mega-projects, the results indicate, as expected, that the mega-projects will have an important impact on GDP (as well as a host of other macroeconomic variables). Over the period 2000 to 2010, realization of all of the mega projects listed in Table 2 increases annual average GDP growth by about 1.3%. By 2010, the level of real GDP is 16% higher compared with the NoMega scenario. Unfortunately, the mega-projects contain very few links to the domestic economy. Despite the large differences in GDP, the impact on national income and national welfare is very small when tax rates on mega-projects are low. For example, the sum of real household consumption and recurrent government spending is less than 1% larger in the Base AIDS scenario compared with the NoMega scenario. Consequently, unless the tax take from mega-projects increases dramatically, they provide almost no counter-balance to the economic impacts of HIV/AIDS. [33]

[33] Given the current understanding of the likely production structure of the mega-projects, the only real link to the domestic economy is through taxation and/or royalties. Real opportunities exist here that should be capitalized upon. For example, assuming all additional government revenue is spent, a five percent output tax on the mega-projects allows the level of real government expenditure to expand to 21% above the level of the Base AIDS scenario by 2010 (recall that the Base AIDS scenario assumes an output tax of 1%).

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.

- 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.

- 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.

Given the extractive nature of most planned mega-projects, the government can probably claim a much larger share of revenues. Overall, the results indicate that the GDP contribution of the mega-projects is an extremely misleading indicator of impact on national welfare. The real indicator is tax take, which should be negotiated aggressively especially in extractive industries. Then, the mega-projects offer potential to contribute to economic development and the fight against AIDS.

- 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) reactive 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. The period under consideration pertains to the period where reactive policies are relevant. However, the basic results can also be used to consider the implications of preventive policies. 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.

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 relatively constant medical technology was adopted. Nevertheless, over time, the likelihood increases that a vaccine (or similar technology in terms of outcome) will emerge. Unfortunately, the answer to the crucial question of <u>when</u> a useable vaccine might emerge is not known. As of this writing, a number of potential technologies are at various stages of development. While available tests indicate promise and some technologies are proceeding to human trials (a fairly advanced stage of testing), an AIDS vaccine is not currently available and one may not come available for a considerable period of time (see, for example, www.iavi.org).

Under these circumstances, the prudent operational assumption, at least looking out over the remainder of the decade, is the one that has been maintained so far—medical technologies will not thwart the pandemic prior to 2010. So, the prospect of medical advances should not influence consideration of reactive policies designed to blunt the negative impacts of the pandemic over the coming decade. This is particularly true in light of the general consistency between the most promising reactive policies and overall development objectives as will be made clear below.

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 is quite likely to eventually bring down HIV/AIDS prevalence rates to relatively 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.[34] Once the brunt of the pandemic has passed, the policies can then, in principle, be discontinued.

8.1 Reactive policy responses

Under the broad category of reactive 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 school and of transitioning to higher grade levels. In the Education scenario, (donor 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 "back of the envelope" calculations permit one to assess the benefits of a 0.6% increment to growth beyond 2010. Some additional assumptions are necessary. In particular, the Education and Base scenarios are assumed to lead to the same level of GDP in 2010 (essentially consistent with the model result), but the Education scenario yields a GDP growth rate of 4.6% over the period 2010 to 2020 compared with 4.0% in the base. These growth rates are consistent with the results obtained in the modeling for the year 2010. The growth rate increment of 0.6% in the Education scenario reflects differentials in the stocks of economically active human capital (workers) and the growth rate of that stock (which depends primarily upon the number of students enrolled in school).[35] From 2021 to 2040 (the terminal year), growth rates are constant at 4.0% between the two scenarios. But, since the Education scenario has a higher level of GDP

[34] 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.

[35] This increment to growth is thus primarily dependent on the success of education policies in the current decade and largely independent of the success of prevention programs or medical technologies in reducing AIDS deaths in the next decade.

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. Reducing the perceived costs of sending children to school, by waiving textbook fees for example, is one fairly obvious (but potentially effective) avenue for attempting to blunt the demand side effect. 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).

More imaginatively, opportunity costs of sending children to school could also be addressed. For example, 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. Eliminating impediments to hiring teachers from abroad could help ease supply constraints. However, tapping international labor markets for teachers is likely to be a more viable strategy for English-speaking countries like Zambia than for Mozambique.[36] A more aggressive option would be to target teachers as recipients of anti-retroviral drug therapy at reduced prices.[37]

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. Regarding drug treatment for teachers, there are about 50,000 teachers. If about 10,000 of them (20%) are HIV positive and drugs (purchase plus distribution) cost USD 750 per person per year, the cost of the

[36] For critical administrative positions on the other hand, tapping international labor markets (including technical assistance) is likely to be a viable choice.
[37] As indicated earlier, drug therapies present difficult policy choices.

program would be about USD 7.5 million per year assuming all HIV positive teachers are treated and 100% of drug and delivery costs are borne by the state.[38]

These costs add up to about the 1% of GDP (actual cost depends on the implementation strategy) assumed in the Education scenario. To gain further perspective on cost, the total government allocation to education in 2000 amounted to about USD 125 million or about 3% of GDP. On the other hand, the benefits of maintaining or increasing enrollments and educational quality dwarf even these costs assuming the programs are effective. In order to satisfy this last caveat, considerable care will have to be taken to design programs that will function in the Mozambican context.

A second major implication arises implicitly from the analysis. The time to implement policy reforms is now. 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.

There are two primary reasons for moving to rapid as opposed to gradual implementation of policy reform measures. First, major policy reform measures typically impose adjustment costs. Minimization of these adjustment costs is the primary rationale for a gradual implementation strategy. However, since adjustment costs generally cannot be eliminated, a gradual approach implies bearing adjustment costs with a worsening pandemic as well as a delay in reaping the benefits of the reform. Conversely, if policy reform is implemented rapidly, 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.

In addition, the primary counter argument to a gradual policy implementation strategy is sharpened in the context of AIDS. In particular, a gradual policy implementation strategy too often leads to failure to fully implement the envisioned policy change. In the context of AIDS, the risks of implementation failure are heightened as policy attention is highly likely to focus increasingly on the direct effects of the pandemic distracting attention from implementation of general economic policy measures that could help to offset the economic impacts of the pandemic.

Second, due to AIDS deaths within government, capacity to implement policy change is likely to be affected. The presumption of increased administrative capacity over time might have to be scaled back or reconsidered entirely over the next decade or so. The best chance for effective implementation might be the near term rather than in the future. Along these same lines, AIDS strongly reinforces arguments for simplified administrative and regulatory structures, which marshal scarce government capacity in core functions.

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[38] Less costly options are obviously available. Fewer children could be targeted in the food for education program, and drugs could be distributed only to teachers who have exhibited symptoms of AIDS and recipients could be asked to contribute to the cost of treatment.

More generally, the preceding 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. The two major policy implications highlighted above-- provide additional resources to education and move quickly to implement the existing policy reform agenda-- arise primarily from a re-weighting of priorities in light of the pandemic. At the same time, the two basic policy thrusts discussed above 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.

Another example might help to make the point. More aggressive extension of labor-saving agricultural technology potentially constitutes a third thrust that counters implications of the pandemic and addresses major development constraints. On the latter, evidence is abundant that labor availability and low labor productivity limit agricultural output (Arndt and Tarp, forthcoming). The AIDS pandemic will not help. In light of AIDS, technologies that are labor saving, such as animal traction and herbicide, become even more attractive. Nevertheless, the desirability of efforts to more aggressively push labor saving technologies should be considered within the broader context of limited resources and administrative capacity.

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.[39] Since economic costs essentially begin with the onset of AIDS, the economic benefits of an averted infection begin nearly a decade later.

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. If population is the same in the policy intervention and base scenarios (as presumed in the previous analysis of education policy), then the per capita and total GDP measures boil down to the same thing. This is

[39] The exact delay continues to be debated. A shorter period between infection and death increases the economic benefits of preventive policies since the benefits are realized earlier. In addition, the duration of the period between infection and death varies across individuals implying that effective prevention would impact AIDS deaths earlier than the averages imply.

obviously not the case with respect to policies designed to limit the spread of HIV. Since, essentially by definition, successful preventive policies increase population, the economic gains are spread across more individuals. As indicated in the analysis, per capita GDP impacts of AIDS are considerably smaller than the overall GDP impact. Per capita GDP is thus 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. Like 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. The discount rate is 10% as before. 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).[40]

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.[41]

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

[40] As in the evaluation of the Education scenario, this calculation assumes no tendency for convergence in GDP. Assuming convergence over the 2020 to 2040 period reduces the maximum justified preventive expenditure level to about 1.9% of GDP, which leaves qualitative conclusions intact.

[41] The average length and the variance of the period between infection and death is a particularly critical parameter here. The shorter the average period and the higher the variance (assuming the distribution is symmetric) the more people who will become infected and die prior to a vaccine coming available and, concomitantly, the stronger the rationale for a prevention program.

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 reduce their probability of becoming infected indicates that the reactive 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 growth of the pandemic (Ainsworth and Teokul, 2000).

To wrap up, the economic analysis and related policy implications provide strong support for adoption of both reactive and preventive policies. While the pandemic cannot be avoided, much can be done to reduce its harshness and duration. Some relatively broad policy options were also presented; however, as usual, the devils are in the details. Moving beyond these general policy ideas (both reactive and preventive) to real policy initiatives will require careful thought particularly with respect to issues of implementation.

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Table 1: Estimated prevalence rates (adult population).

Region	Province	Estimated Prevalence Rates (2000)		
		Updated Provincial	Updated Regional	Demographic Model
South	Maputo City	13.0%	13.2%	12.0%
	Maputo Province	14.3%		
	Gaza	16.0%		
	Inhambane	9.6%		
Center	Sofala	18.7%	16.5%	20.7%
	Manica	21.1%		
	Tete	19.8%		
	Zambézia	12.7%		
North	Nampula	5.2%	5.7%	13.6%
	Niassa	6.8%		
	Cabo Delgado	6.4%		
Mozambique National			12.2%	16.0%

Sources: Ministry of Health (2002) and Ministry of Health et al. (2001).

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									

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).

Table 4: Economic structure and relative performance by sector.

	Base/ No AIDS VA Ratio (2010)	Factor Contribution to VA (1997)				Share of VA in GDPfc (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 *GDPfc* refers to GDP at factor cost.

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.

[1]This is not an exhaustive list of potential policy responses.
[2]More detail can be found in the main body text and in the policy implications section.
[3]HAART: highly active anti-retroviral therapy.

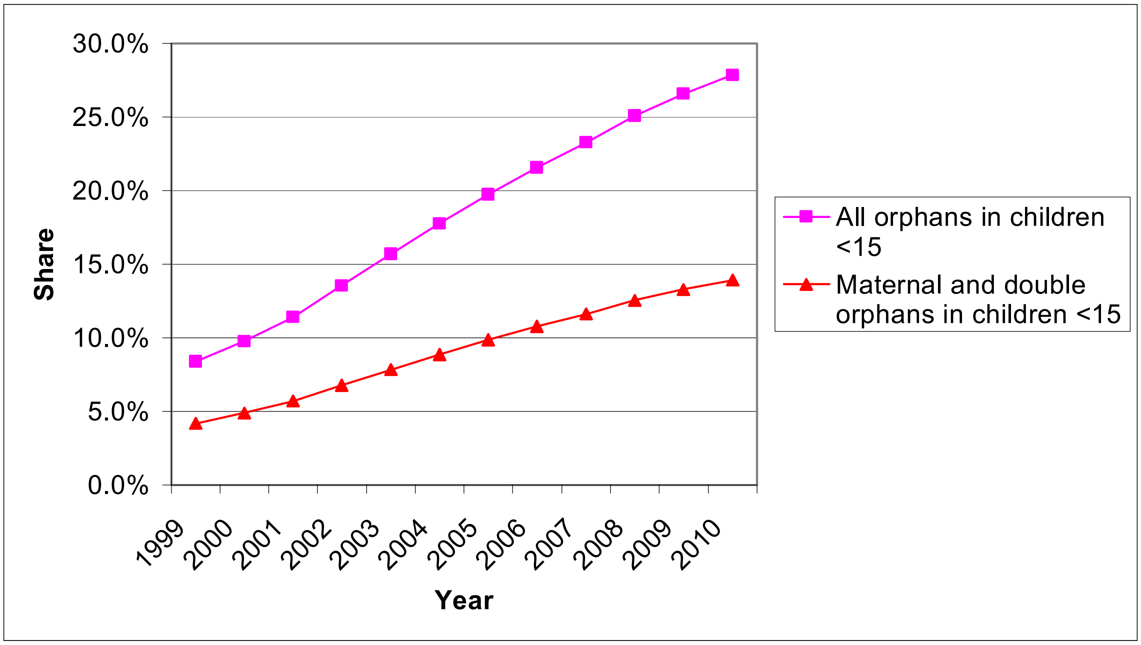

Figure 1: Children who have lost at least one parent from all causes—relevant shares.

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).

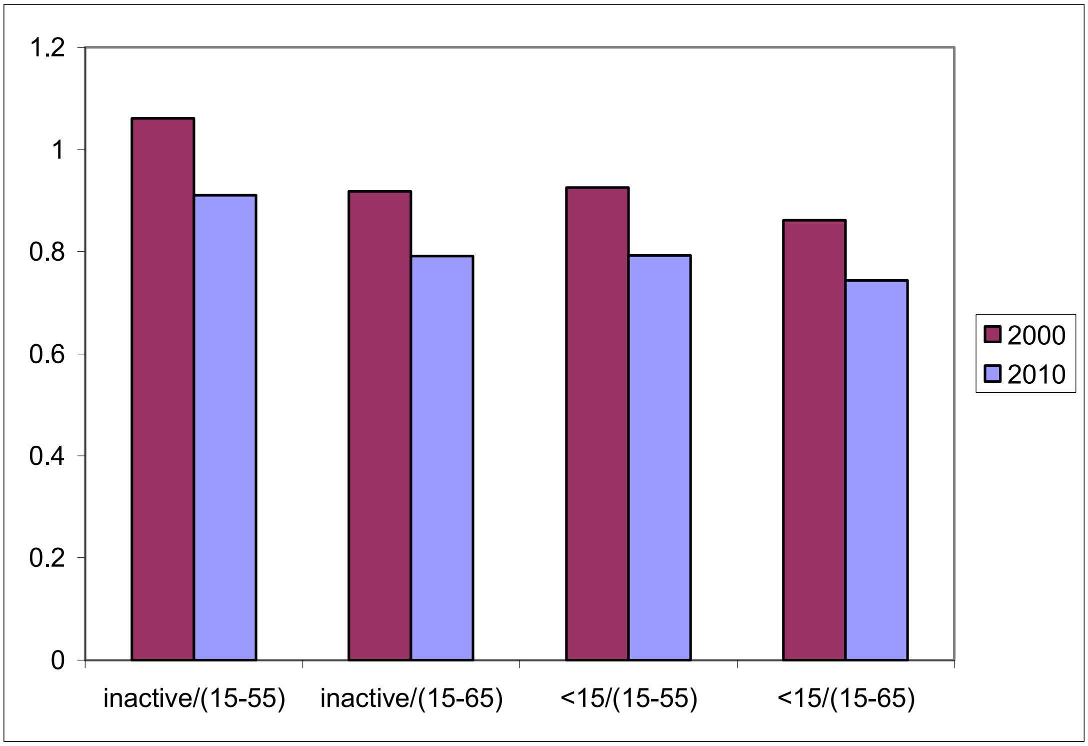

Figure 2: Estimated dependency ratios.

Source: Ministry of Health et al. (2002) and author's calculations.

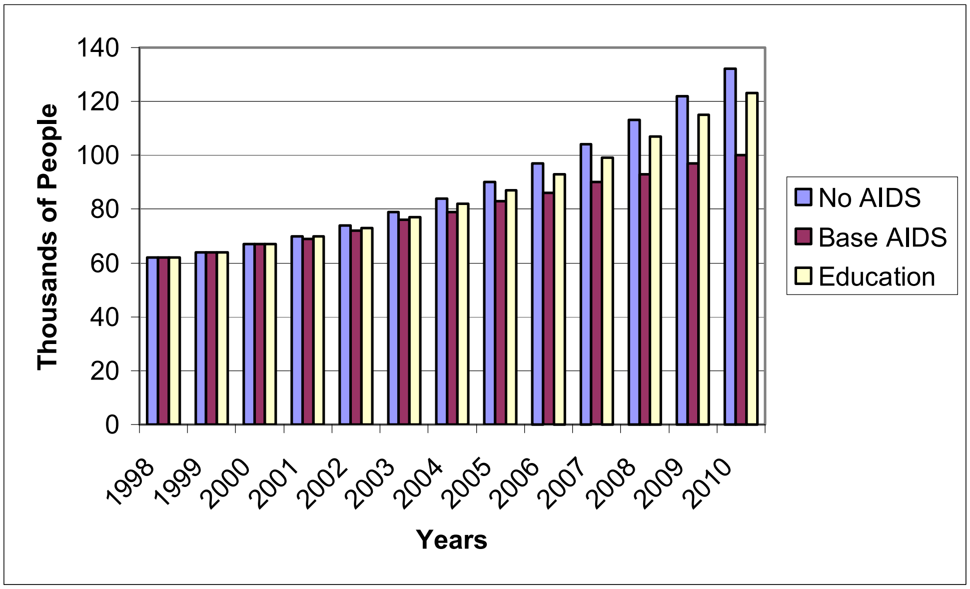

Figure 3: Estimates of the evolution of the highly skilled labor force.

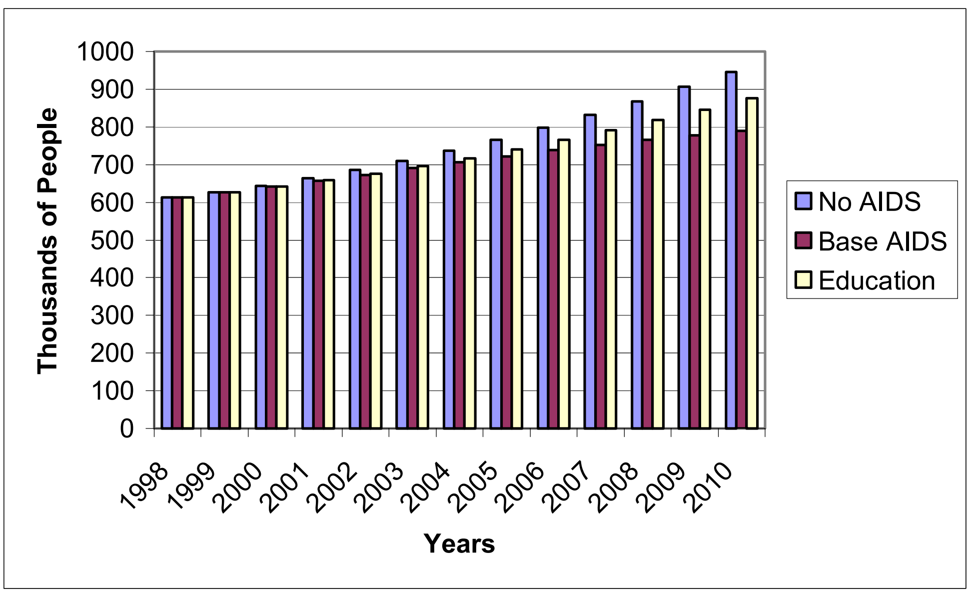

Figure 4: Estimates of the evolution of the skilled labor force.

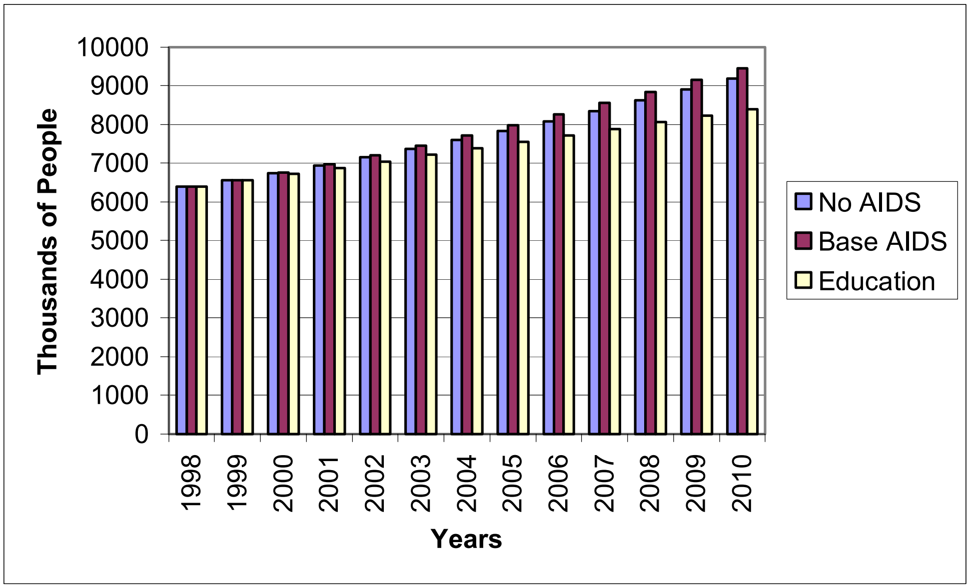

Figure 5: Estimates of the evolution of the unskilled labor force.

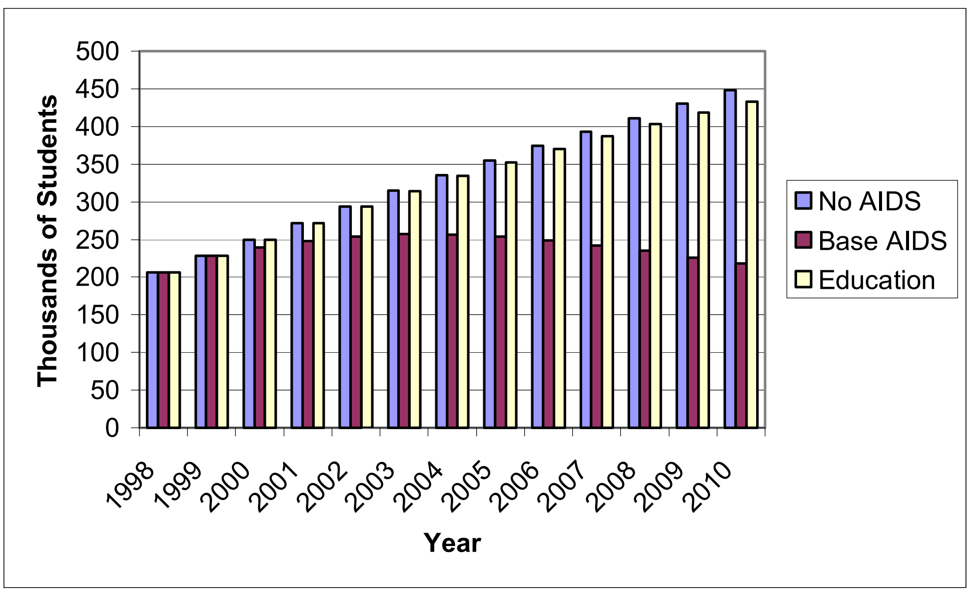

Figure 6: Estimates of enrollment in EP2.

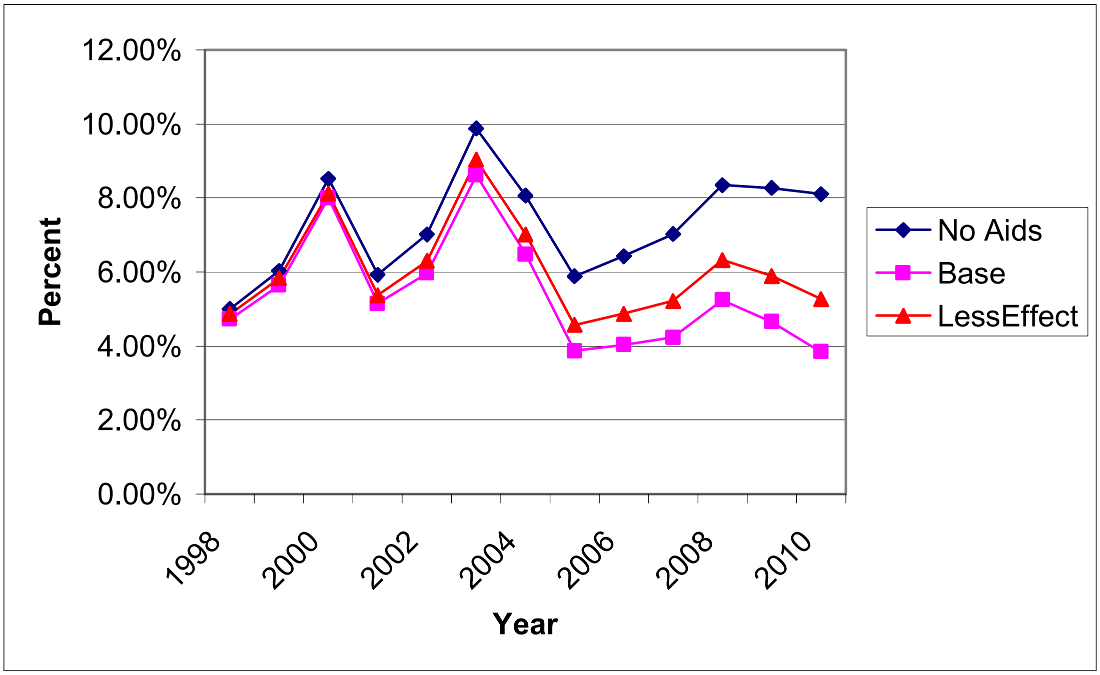

Figure 7: HIV/AIDS and Real GDP growth.

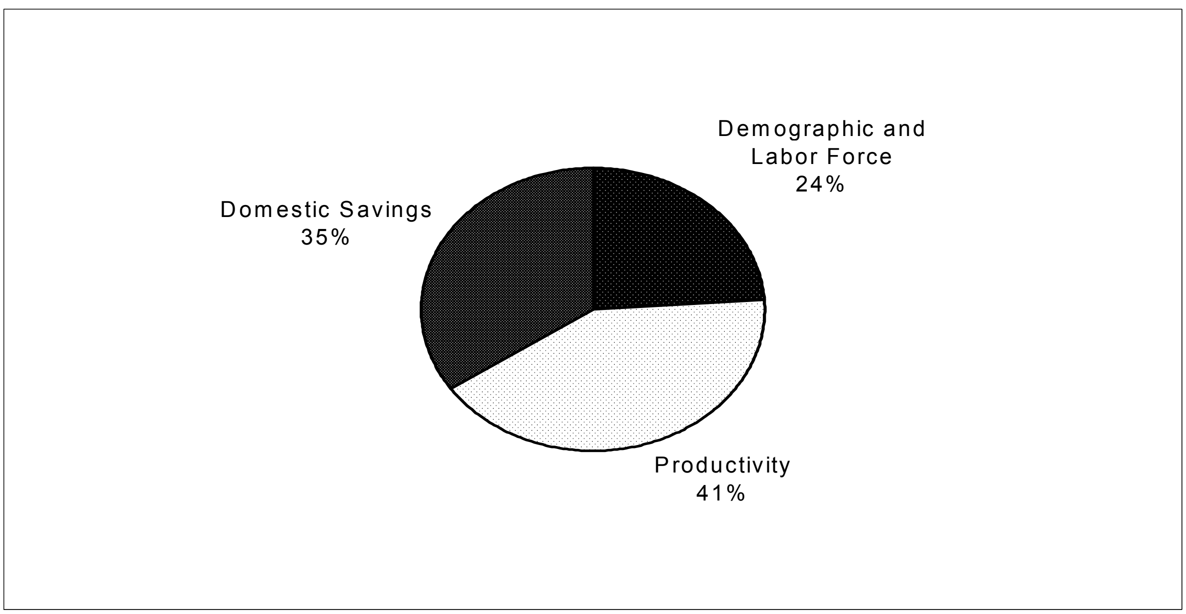

Figure 8: A decomposition of HIV/AIDS impacts for the Base AIDS scenario.

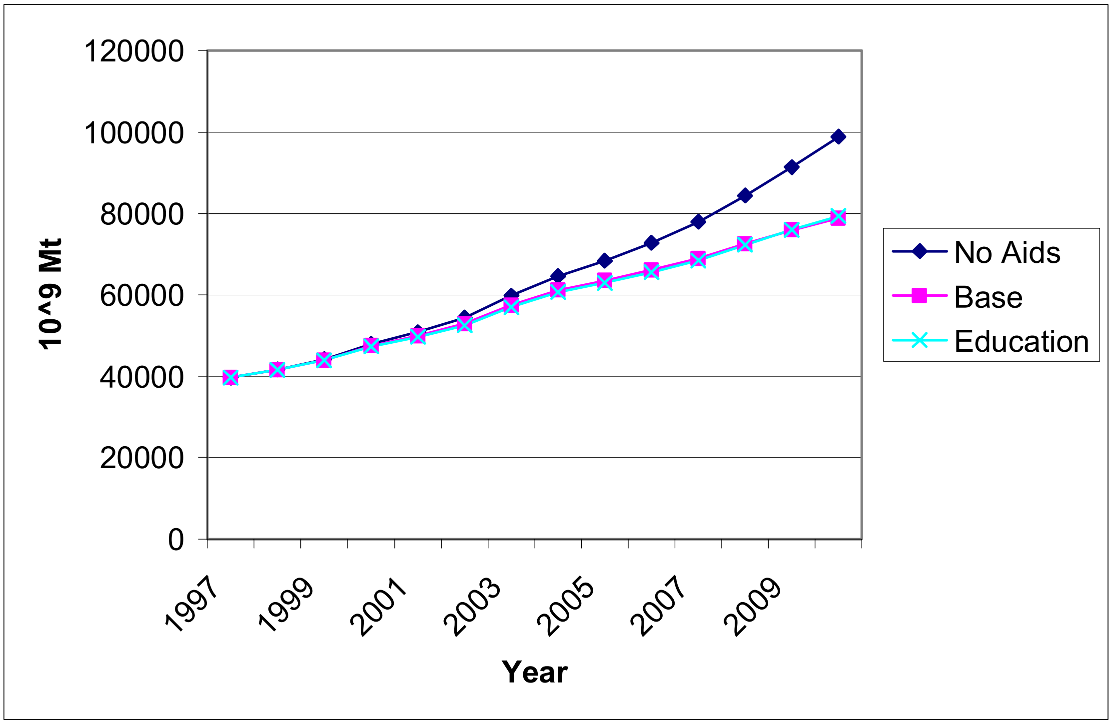

Figure 9: Comparing GDP impacts between Education and Base AIDS scenarios.

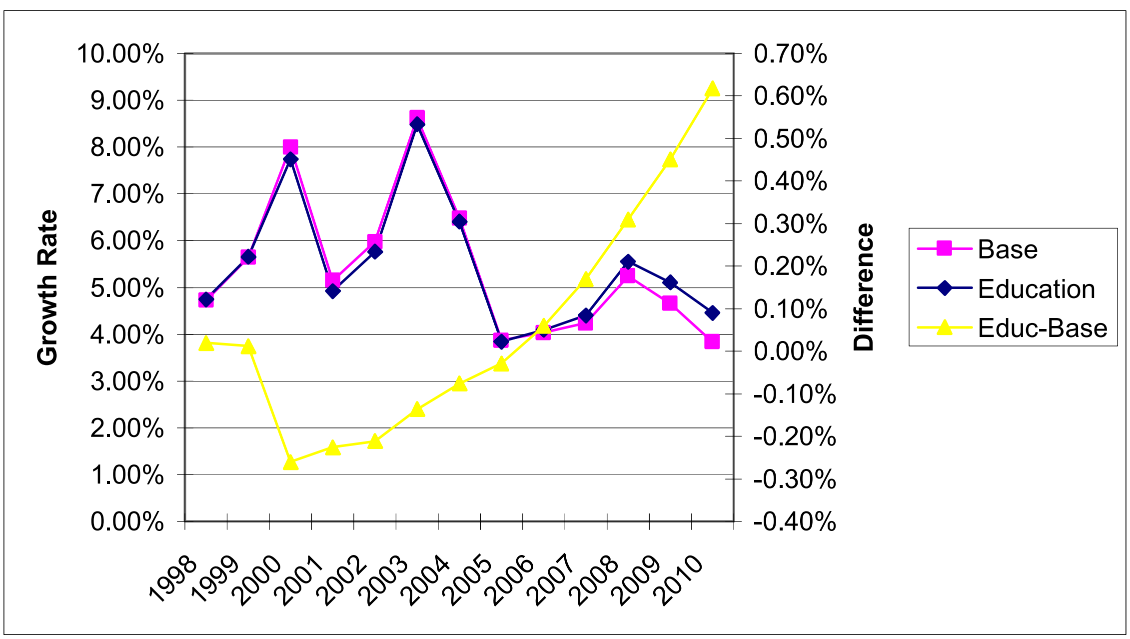

Figure 10: Comparing GDP growth rates between Education and Base AIDS scenario.

APPENDIX A

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
$esval_{it}$	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 A1: 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

IMPLICATIONS OF REVISED HIV PREVALENCE RATE ESTIMATES

As indicated in the Introduction and as shown in Table 1, updated information on HIV prevalence rates was obtained for 2000. Estimated prevalence rates were revised significantly downwards in all Northern provinces, stayed roughly constant in most Central provinces (Zambezia excepted), and rose slightly in most Southern provinces. At the national level, the adult HIV prevalence rate was revised downwards from 16% to 12.2%. These revised prevalence rate estimates form the basis for the revised set of demographic projections that serve as an exogenous input into the economic models employed here.

Since the old set of projections generated considerable interest, it is worth examining the differences in demographic outcomes between the two sets and exploring how those differences might translate into changes in economic impact. The differences, in 2010, between the old and the revised set of demographic projections are illustrated in Tables C1-C6. These differences are less striking than the differences for the year 2000 depicted in Table 1. At the national level, the adult HIV prevalence rate in 2010 is projected to be only slightly lower (less than one percentage point versus nearly four percentage points in 2000) than the earlier set of projections indicated (see Table B5).

The reduction in the divergence between the two sets of projections by 2010 stems from a fairly rapid growth in prevalence rates in the North and a significant increase in the severity of the pandemic in the South. In the North, the revised projections foresee adult HIV prevalence rates more than doubling over the 2000 to 2010 period (as opposed to staying relatively constant in the older set). However, due to the time lags between infection and the onset of AIDS, the AIDS case rate, which drives economic impacts, in the North lags the growth in prevalence rates (see Table B-6). In the South, AIDS related indicators (the adult AIDS case rate as a share of the adult population and the adult HIV prevalence rate) worsen by about 20% by 2010 compared with the older set of projections. Essentially, the revised demographic projections indicate a less severe but rapidly worsening situation in the North and a more severe pandemic in the South. Projections for the central provinces are somewhat milder overall but this effect is due almost exclusively to Zambezia where the pandemic appears to be unfolding in a manner similar to the northern provinces.

In terms of economic impact, the shifts in the regional distribution of the pandemic are worth highlighting. While the northern provinces contained about one third of the population in 1997, they only accounted for about 20% of gross domestic product (GDP) (Sulemane, 2000). On the other hand, the southern provinces, while containing only about 26% of the population, accounted for about 50% of GDP in 1997.

In the CGE model, these changes in the regional distribution of the pandemic are captured rather crudely through the technology parameters. As indicated earlier, growth in technology for agricultural sectors is driven by AIDS death rates in the Central and

Northern provinces. AIDS deaths in the Southern provinces drive technological progress in non-agricultural sectors. So, if the two sets of projections are entered into the model and compared, the differences in terms of economic impact will be less profound than the national numbers indicate due to the disproportionate economic weight of the South.

Table B7 compares major economic results for the two sets of demographic projections for the Base AIDS scenario. Under the old set of projections, the size of the overall economy is smaller due to a more severe AIDS pandemic at the national level. However, the regional impacts discussed above mitigate the difference. In addition, these regional effects make for a slightly stronger negative impact on per capita GDP in the revised demographic scenario.

Table B1: Population in 2010 by demographic projection set.

	Old	Revised	% Difference
Country	19,356,778	20,116,505	3.9%
Men	9,414,815	9,776,871	3.8%
Women	9,941,966	10,339,635	4.0%
North	6,458,003	6,866,171	6.3%
Central	7,711,780	8,108,664	5.1%
South	5,186,995	5,141,670	-0.9%

Table B2: Adult population (ages 15+) in 2010 by demographic projection set.

	Old	Revised	% Difference
Country	11,371,783	11,770,073	3.5%
Men	5,424,437	5,605,580	3.3%
Women	5,947,342	6,164,493	3.7%
North	3,786,348	4,001,829	5.7%
Central	4,407,482	4,615,211	4.7%
South	3,177,953	3,153,033	-0.8%

Table B3: HIV positive population in 2010 by demographic projection set.

	Old	Revised	% Difference
Country	1,960,414	1,926,543	-1.7%
Men	878,248	859,099	-2.2%
Women	1,082,167	1,067,443	-1.4%
North	550,259	516,154	-6.2%
Central	964,758	876,133	-9.2%
South	445,397	534,256	20.0%

Table B4: AIDS cases in 2010 by demographic projection set.

	Old	Revised	% Difference
Country	176,312	169,732	-3.7%
Men	78,933	75,420	-4.5%
Women	97,378	94,312	-3.1%
North	48,928	42,901	-12.3%
Central	87,229	78,450	-10.1%
South	40,155	48,381	20.5%

Table B5: Adult HIV prevalence rate in 2010.

	Old	Revised	% Difference
Country	16.0%	15.2%	-5.0%
Men	14.9%	14.1%	-5.4%
Women	17.1%	16.3%	-4.7%
North	13.5%	12.1%	-10.9%
Central	20.3%	17.6%	-13.4%
South	13.1%	15.9%	20.8%

Table B6: Share of adult AIDS cases in the adult population in 2010.

	Old	Revised	% Difference
Country	1.3%	1.2%	-6.8%
Men	1.2%	1.1%	-7.4%
Women	1.4%	1.3%	-6.3%
North	1.1%	0.9%	-16.9%
Central	1.7%	1.4%	-14.1%
South	1.1%	1.3%	21.6%

APPENDIX C

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 C1: 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

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

[2]For 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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