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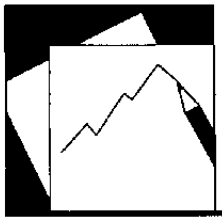

IMF Working Paper

The Economic Consequences of HIV/AIDS in Southern Africa

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The Economic Consequences of HIV/AIDS in Southern Africa

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Abstract

The paper provides an analysis of the impact of HIV/AIDS on the health sector, public education, the supply of labor and the returns to training in nine Southern African countries. Drawing on the preceding sections, it assesses the impact of HIV/AIDS on per capita income in a neoclassical growth framework. HIV/AIDS affects per capita income mainly through its impact of human capital, as measured by the supply of experienced workers. Other factors include the impact on capital accumulation, on education, and on total factor productivity.

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I. INTRODUCTION

HIV/AIDS is the leading cause of death in Southern Africa, causing major social and economic disruptions.[2] While HIV/AIDS is not primarily an economic issue, the epidemic has attained a scale that makes it a major (if not the major) factor affecting economic development in the region over the next decades. The present paper provides some tools for analyzing the economic consequences of HIV/AIDS, in particular, the fiscal implications and the effect on economic growth.

The Joint United Nations Programme on HIV/AIDS (UNAIDS) estimate that by end-1999, 19.1 percent of the adult population in Southern Africa were HIV-positive. Section II discusses the demographic impact of the epidemic. For example, life expectancy at birth is estimated to have dropped by more than 20 years for some of the countries covered, the population growth rate has dropped by between 0.6 and 1.5 percent, and AIDS-related mortality rates have increased to 1.2 to 2.9 percent of the adult population for the respective countries.[3]

Section III analyses the impact of HIV/AIDS on the public sector, focusing on the health sector, the education sector, personnel costs, social expenditure, and general government revenues. In the health sector, the demand for health services obviously increases, while health personnel is affected by the epidemic as well. This section also addresses the scope for improving access to highly active antiretroviral treatments (HAARTs). The analysis of the education sector focuses on the impact of HIV/AIDS on the quality of education, measured by pupil-teacher ratios.

Sections IV and V give an assessment of the impact of HIV/AIDS on the supply of labour and on the private sector. HIV/AIDS affects the size, as well as the age structure, of the working-age population. Owing to increased mortality rates, experienced employees become more scarce, and the returns to training decline. Sickness and deaths of employees cause

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[2] For the purpose of this study, Southern Africa comprises Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, and Zimbabwe.

[3] All numbers refer to the year 2000. See Tables 1 and 2 for details.

disruptions to the production process and result in declining productivity. In the formal sector, the costs of medical and death-related benefits rise.

Section VI, to some extent, draws on the previous sections, and addresses the impact of HIV/AIDS on economic growth and per-capita income. The analysis is based on a neoclassical growth framework, and focuses on variables such as productivity, savings, human capital (measured as workers' experience), and population growth. The key determinants of the impact of HIV/AIDS on per capita income are the decline in the rate of population growth, the decline in human capital, and the response of investors to a decline in the return to capital.

II. The Demographic Impact of HIV/AIDS in Southern Africa

Southern Africa is the region with the highest rates of HIV prevalence in the world. According to UNAIDS, the Joint United Nations Programme on HIV/AIDS, 9.4 million, out of a total population of 97 million, were HIV infected in 1999. For the region, the adult HIV prevalence rate averages 19.1 percent; it ranges from 13.2 percent in Mozambique to 35.8 percent in Botswana (see Table 1). This compares to an adult prevalence rate of 8.6 percent

Table 1. The demographic impact of HIV/AIDS in Southern Africa (I)

	Total population, 1999 (in thousands)	People living with HIV/AIDS, 1999 (in thousands)	Adult HIV prevalence rate, 1999 (in percent)	Estimated AIDS deaths, 1999	Life expectancy at birth, 1998 (in years)	Life exp. at birth, "no AIDS", 1998
Botswana	1,592	290	35.8	24,000	40.1	61.5
Lesotho	2,108	240	23.6	16,000	54.0	62.0
Malawi	10,674	800	16.0	70,000	36.6	51.1
Mozambique	19,222	1,200	13.2	98,000	...	...
Namibia	1,689	160	19.5	18,000	41.5	65.3
South Africa	39,796	4,200	19.9	250,000	55.7	65.4
Swaziland	981	130	25.3	7,100	38.5	58.1
Zambia	8,974	870	20.0	99,000	37.1	56.2
Zimbabwe	11,509	1,500	25.1	160,000	39.2	64.9
Southern Africa	96,545	9,390	19.1	742,100	...	...
Sub-Saharan Africa	596,272	24,500	8.6	2,200,000	...	...
Global total (excluding sub-Saharan Africa)	5,362,577	9,800	0.2	600,000	...	...

Data sources: UNAIDS (2000) for columns 1-4, and International Programs Center at the U.S. Bureau of the Census (1999) for columns 5-6.

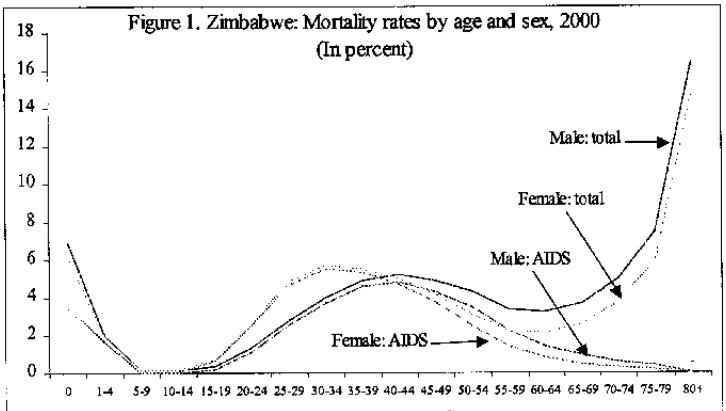
for the whole of sub-Saharan Africa, and of 0.2 percent for the world excluding sub-Saharan Africa.

As a consequence, life expectancy at birth has fallen dramatically (see Table 1). The International Programs Center (IPC) at the U.S Bureau of the Census estimate that, by 1998, life expectancy at birth had fallen by 20 years or more for most of the countries considered here, and that it had fallen to less than 40 years for four of these countries.[4]

According to the IPC, rates of population growth have already decreased by between 0.6 percent and 1.5 percent by 2000 (see Table 2). By 2010, rates of population growth are expected to decline by up to 3 percent for the worst affected countries, reflecting rising mortality, reduced fertility rates of HIV infected women, and declining birth rates.

HIV/AIDS especially affects mortality rates for the working age population, and, due to mother-to-child transmission, child mortality (ages 0-4). Figure 1 illustrates the impact of HIV/AIDS on mortality rates by age for Zimbabwe. As in other countries in the region, AIDS-related mortality affects women to a higher extent, and at an earlier age, than men due to earlier sexual activity and higher risk of male-to-female transmission of the virus. For women in the working-age population, mortality rates peak at 5.7 percent for the age 30-34 cohort (5.5 percent dying due to AIDS). For men, mortality rates for the working-age population peak at 5.2 percent for the age 40-44 cohort, with 4.8 percent dying due to AIDS.[5]

Figure 1. Zimbabwe: Mortality rates by age and sex, 2000
(In percent)



Source: International Programs Center, U.S. Bureau of the Census

[4] See U.S. Bureau of the Census (1999).

[5] These are rates that are only exceeded for the cohorts younger than age 1 and older than age 75.

For the age groups 15-49, Table 2 shows that, for the whole region, most deaths already are AIDS-related. By 2010, the IPC estimate that mortality rates will rise from between 0.2 and 0.4 percent in the absence of HIV/AIDS to between 2.4 and 5.0 percent by 2010.[6] This would mean that in this age group, AIDS would account for 65 percent or more of all deaths.

Table 2. The demographic impact of HIV/AIDS in Southern Africa (II)

	Population growth rate, 2000		Population growth rate, 2010		Mortality, ages 15-49, 2000		Mortality, ages 15-49, 2010		Dependency ratio, 2000		Dependency ratio, 2010		AIDS orphans, ages 0-15, 2010
	With AIDS	Without AIDS	With AIDS	Without AIDS	Total	Of which AIDS	Total	Of which AIDS	With AIDS	Without AIDS	With AIDS	Without AIDS	
	(In percent)		(In percent)		(In percent)		(In percent)		(In percent)		(In percent)		(Percent of population)
Botswana	0.9	2.6	-1.2	2.0	2.7	2.5	5.0	4.9	103.6	101.1	94.0	89.8	7.2
Lesotho	1.7	2.3	0.2	2.0	1.2	0.8	3.0	2.7	106.5	106.7	100.9	96.8	3.4
Malawi	1.7	2.7	0.8	2.2	2.0	1.5	2.4	2.0	116.5	115	95.0	95.8	3.7
Mozambique	1.6	2.5	0.2	2.0	2.0	1.3	3.3	2.8	110.1	108.9	99.3	97.4	4.4
Namibia	1.7	2.9	0.2	2.7	2.1	1.8	3.7	3.5	112.1	110.5	104.6	103.3	6.6
South Africa	0.6	1.2	-1.2	1.0	1.3	1.0	3.3	3.0	85.6	84.4	81.8	75.6	4.4
Swaziland	2.1	3.2	0.5	3.1	2.0	1.5	4.1	3.7	117.9	116.8	112.6	111.4	6.8
Zambia	2.0	3.2	1.7	2.9	2.4	1.9	2.4	2.1	121.5	120.8	106.7	108.4	4.6
Zimbabwe	0.3	2.2	-0.8	1.9	2.9	2.7	4.1	3.9	96.6	94.4	78.6	79.5	5.9

Data source: Data provided by the International Programs Center at the U.S. Bureau of the Census.

One important indicator for the effect of HIV/AIDS on per capita income is the dependency ratio, defined as defined as the ratio between the young (age 0-14) plus the old (age 50+) population and the working age population). Dependency ratios increase initially, as most deaths occur between ages 15 and 49. However, birth rates decline due to lower fertility of HIV infected women and as the result of increased prevention efforts. Thus, in the later stages of the epidemic, dependency ratios may fall (see Table 2).

Another important indicator for the social and economic consequences of HIV/AIDS is the number of orphans. Owing to high mortality rates among young adults, the numbers of orphans are increasing strongly. By the year 2010, between 4.1 percent (Lesotho) and 7.9 percent (Swaziland) of the total population, or between 12 and 20 percent of the relevant age group, will be underage orphans (ages 0-14). Of these, between 75 and 95 percent will be orphaned by AIDS.

[6] The low mortality rates in the no-AIDS scenario reflect that the age distribution within the age groups 15-49 is skewed towards the younger cohorts.

III. The Impact on the Public Sector

The HIV/AIDS epidemic affects all areas of the public sector through its adverse impact on public servants, on revenues, and on certain categories of expenditures. However, the data available are largely based on case studies, and insufficient for a comprehensive analysis. This section therefore covers only two areas, health and education, in more detail, and then summarizes the available information on personnel costs, social expenditure, and government revenues. As the focus of the paper is on analyzing the consequences of HIV/AIDS, rather than devising optimal strategies to combat the epidemic, this paper does not discuss the costs of prevention campaigns.

The health sector stands out as the HIV/AIDS epidemic results in an increased demand for health services, whereas the available personnel is also affected by the epidemic. For example, the share of hospital beds occupied by patients who are HIV positive exceeds 50 percent in most Southern African countries. In order just to maintain the numbers of doctors and nurses, training would have to increase by 25 to 40 percent. The paper also provides estimates of the aggregate costs of various types of care (including highly active antiretroviral treatments (HAARTs) based on estimated unit costs and assumptions about the coverage rates of these services.

For the education sector, this paper addresses the question whether it will be possible to maintain current standards of education, in spite of the large losses of teachers owing to AIDS. The analysis focuses on the numbers of teachers who would have to be trained in order to maintain given pupil-teacher ratios.

Increasing mortality rates result in disruptions in public service in all areas. Personnel costs may rise as death benefits and pensions to surviving dependents increase. For the social security system in general, the impact of the epidemic depends on the extent to which payout are financed by and related to prior contributions.

Government revenues will decline (at least relative to a no-AIDS scenario) as the tax base grows less rapidly, and tax collection rates may decline. In certain areas (especially health and social security), government expenditure is likely to increase. Thus, the fiscal balance is likely to deteriorate overall.

Health[7]

The HIV/AIDS epidemic has an immediate effect on the health sector, increasing the demand for public and private health services and, at the same time, taking its toll on health sector personnel.

Table 3 provides several indicators for the quality of health services in Southern Africa. Total health expenditure per capita ranges from US$ 9 (for Malawi) to US$ 203 (for South Africa, corresponding to between 0.2 percent and 4.1 percent of the per capita spending for the United States. If the purchasing power of the US dollar differs across countries (owing to lower prices for services and nontraded goods in lower-income countries), health spending in terms of US$ is not a good indicator for the quality of services. Therefore, Table 3 also gives health expenditure per capita in terms of US$ at purchasing power parity (PPP).[8] At PPP exchange rates, total health expenditure per capita ranges from US$ 45 (for Malawi) to US$ 552 (for South Africa), corresponding to between 0.9 and 11.1 percent of U.S. per capita health expenditure. The differences in spending on health services across countries mainly reflect differences in GDP per capita. As a percentage of GDP, health expenditure ranges from 3.4 percent (for Swaziland) to 7.5 percent (for Namibia).

The best trained health personnel, physicians[9], is extremely scarce for the poorest countries in the region. For Malawi and Mozambique, the countries with the lowest share of physicians in the population (about 3 physicians per 100,000 people), the availability is only about 1 percent of the level for the United States. As a consequence, if only 10 percent of those infected would seek the services of a physician, then the ratio of HIV-positive patients to physicians would range from 17 (for South Africa) to 250 (for Malawi).[10] In interpreting these numbers, however, it is important to bear in mind that in the poorer countries, a larger range of health services is provided by staff who are not formally qualified as physicians.

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[7] For a broader discussion, see Haacker (2001).

[8] While this has the advantage that it responds less to short-term fluctuations of the nominal exchange rate, it is important to bear in mind that PPP exchange rates are estimated based on the prices of a bundle of goods and services that is very different from goods and services relevant for the health sector, which means that this adjustment is rather crude.

[9] Defined as health personnel who have completed a degree of sufficient duration.

[10] See Haacker (2001).

Thus, the ratio of nurses to doctors may range from 10-20 in Southern Africa, whereas a ratio of 3-4 would be more common for industrialized countries.

Table 3. Indicators for the quality of health services in Southern Africa

	Total health expenditure per capita			Physicians	Nurses	Hospital Beds
	In U.S. Dollars,2000	In PPP U.S. Dollars, 2000	In percent of GDP, 1997	Per 100,000	Per 100,000	Per 1,000
Botswana	155.0	398.1	4.2	23.8	219.1	1.6
Lesotho	21.0	88.8	5.6	5.4	60.1	1.1
Malawi	8.9	44.8	5.8	3.0	n.a.	1.3
Mozambique	12.7	55.4	5.8	3.0	n.a.	0.9
Namibia	113.7	394.1	7.5	29.5	168.0	0.3
South Africa	203.0	552.3	7.1	56.3	471.8	0.8 1/
Swaziland	42.6	129.6	3.4	15.1	n.a.	0.7
Zambia	19.8	58.7	5.9	6.9	113.1	
Zimbabwe	33.2	127.0	6.2	13.9	128.7	0.5

Data sources: Cols. 1-2 are extrapolations for 2000, using 1997 WHO data on expenditure shares (col. 3). WHO Estimates of Health Personnel for cols. 4-5, most data refer to 1995 or 1996. For Malawi and Mozambique, the data on health personnel are from World Bank, *World Development Indicators*, 2001. World Bank, various sources and South African Ministry of Health for col. 6. World Bank, *World Development Indicators*, 2001, for col. 7. 1/ Public hospitals only.

An alternative indicator for the impact of HIV/AIDS on the demand for health services is the share of patients suffering from HIV-related diseases. A survey of various websites and news agencies suggests that the share of hospital beds occupied by AIDS patients ranges from 30 to 80 percent, and the World Bank estimates that the number of hospital beds needed for AIDS patients will exceed the total number of beds available now in Botswana by 2002, in Namibia by 2005, and in Swaziland by 2004.[11]

Available demographic projections indicate that the situation in the health sector is likely to deteriorate further. Following the dramatic increase in HIV prevalence rates in recent years in most of the countries covered here, the numbers of AIDS cases and of AIDS deaths is projected to rise substantially over the coming years (see Table 2). For South Africa, for example, mortality rates are expected to double between 2000 and 2010 (from 1.5 percent to 3.0 percent), reflecting an increase in AIDS-related mortality from 0.7 percent to 2.3

[11] See the relevant Worldbank country studies listed under references.

percent.[12] As a consequence, the demand for health facilities and trained health personnel will increase substantially over the coming years.

While the demand for health services expands, employees in the health sector are also affected by the disease. If the countries covered here were just to keep the numbers of doctors and nurses constant, and if HIV prevalence rates for health sector staff are similar to those of the general population, training of doctors and nurses would have to be expanded by about 25-40 percent over the 2000-10 period.[13]

As little data on actual costs of HIV-related health spending is available, most studies use estimates of the costs of treating individual patients, deriving aggregate costs by multiplying the costs per case with a coverage rate that seems realistic or desirable.[14] This approach has the advantage that the estimates of HIV-related costs are based on some common criteria and are comparable across countries. However, the scaling-up method is weak in identifying overhead and fixed costs. Also, there are few data on the numbers of HIV patients receiving various forms of treatments.

A recent study by the World Bank summarizes the available data on the costs of various forms of care to HIV patients, including highly active antiretroviral treatments (HAARTs).[15] Their estimates are summarized in Table 5. To reflect differences in the costs of health services across countries, Table 5 provides separate numbers for "higher-income countries" (Botswana, Namibia, South Africa, and Swaziland). By far the most expensive forms of treatment are highly active antiretroviral therapies (HAARTs). The costs of HAARTs do not only comprise the costs of the drugs, but also the required support services (e.g. lab testing).

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[12] The estimates for mortality rates refer to all ages (unlike Table 2, which refers to the working-age population) are based on projections from the U.S. Bureau of the Census. See Haacker (2001) for details.

[13] Compare the discussion of training and learning on the job, further below.

[14] THis approach is commonly referred to as "scaling up". See Bonnel (2001) for a broad discussion.

[15] See Bonnel, *Costs of Scaling HIV Program Activities*, 2001. Martin (1996) summarizing earlier studies, puts the lifetime costs of treating one AIDS patient (as a percentage of GNP per capita) at 276 for Kenya, 117 for Malawi, 115 for Rwanda, between 72 and 460 for South Africa (the latter number including antiretrovirals), 264 for Tanzania, 106 for Zambia and 144 for Zimbabwe. Worldbank (1999) estimates that, on average, the lifetime costs of treatment amounted to 270 percent of GDP per capita.

Table 4. The costs of treating HIV patients

	Costs per patient per year	
	Low-Income Countries	Higher-Income Countries
Palliative care	$ 25.80	$ 25.80
Prevention of opportunistic infections	$ 36	$ 79
Clinical treatment of opportunistic infections	$ 359	$ 698
Costs of HAARTs (drugs only)	$ 1,400	$ 1,400
Costs of HAARTs (support)	$ 600	$ 1,000

Data sources: Bonnel, *Costs of Scaling HIV program activities*, 2001. For palliative care, prevention of opportunistic infections, and treatment of opportunistic infections, table 4 reports data from a medium cost scenario. For highly active antiretroviral therapy, it reports low cost estimates. Botswana, Namibia, South Africa, and Swaziland are classified as higher-income countries.

The estimates of the costs of providing health services to HIV patients, which are provided in Table 5, are largely based on the unit costs shown in Table 4. However, many countries have negotiated prices for HAARTs that are substantially lower than the prices in industrialized countries, and the estimates by the Worldbank already reflect this. However, the estimates below are based on an estimated total cost of $ 1,100 per patient per year (including the costs of the drugs, as well as the required medical support) for the lower-income countries, which is somewhat lower than the Worldbank estimates quoted in Table 4, and corresponds to the costs suggested by Members of the Faculty of Harvard University, 2001.[16] For the higher-income countries, the assumed total cost is $ 1,500.

The estimates of the costs of HIV/AIDS –related health services in Table 5 are based on the assumption that the coverage rate for palliative care and prevention of opportunistic diseases is 30 percent, the coverage rate for clinical treatment of opportunistic diseases is 20 percent, and the coverage rate for HAARTs is 10 percent.[17] These coverage rates reflect that access to health services is limited. The estimates of the costs of health services, using common coverage rates, then give an indicator of the impact of HIV/AIDS on the health sector that is consistent across countries, and that can be compared to actual health expenditure.

[16] The classification of lower and higher income countries follows Bonnel (2001). See Table 5.

[17] For a definition of the groups of HIV infected requiring various forms of treatment (to which the coverage rates refer) see Haacker 2001.

Table 5. The impact of HIV/AIDS on HIV-related health services

(In percent of GDP)

	Palliative care and prevention of opportunistic infections		Clinical treatment of opportunistic infections		Costs of highly active antiretroviral therapies (HAARTs)		Total HIV-related health services, for assumed rates of coverage		Total health expenditure, 1997	Public health expenditure, 1997
	2000	2010	2000	2010	2000	2010	2000	2010		
Botswana	0.1	0.1	0.2	0.3	0.2	0.5	0.5	0.9	4.2	2.6
Lesotho	0.1	0.3	0.5	1.0	0.7	2.0	1.3	3.2	5.6	4.1
Malawi	0.4	0.5	1.5	2.0	2.4	4.0	4.3	6.5	5.8	3.4
Mozambique	0.3	0.5	1.1	1.8	1.7	3.6	3.0	5.9	5.8	4.1
Namibia	0.1	0.1	0.4	0.6	0.4	0.9	0.9	1.7	7.5	3.9
South Africa	0.0	0.1	0.2	0.3	0.2	0.5	0.3	0.9	7.1	3.3
Swaziland	0.1	0.2	0.4	0.8	0.5	1.1	1.0	2.1	3.4	2.5
Zambia	0.2	0.2	0.8	0.9	1.3	1.7	2.3	2.8	5.9	2.3
Zimbabwe	0.2	0.3	0.8	1.1	1.1	2.2	2.1	3.5	6.2	2.7

Source: Haacker (2001). The estimates are based on coverage rates of 30 percent for palliative care and prevention of opportunistic diseases, 20 percent for clinical treatment of opportunistic infections, and 10 percent for HAARTs. The assumed coverage rates are not intended as statements on desirable or feasible coverage rates in the respective countries. Rather, they provide a common indicator to compare the impact of HIV on the demand for health services across countries.

Table 5 shows that the required expenditure for palliative care, prevention of opportunistic diseases, and clinical treatment is substantial. While some of the countries, notably Botswana and South Africa, would be able to and presumably do achieve higher coverage rates than the ones assumed here, the demand for HIV-related health services accounts for about a third of total health expenditure for two of the poorer countries by 2010. However, many of those who need treatment are not able to pay for it, and would have to rely on public health services. Even at the low coverage rates assumed, the costs of treating HIV patients will exceed one half of total public health expenditure for some countries, and will exceed total public health expenditure in one case (Uganda).

At a coverage rate of 10 percent, the costs of providing triple therapy would initially range from 0.2 percent of GDP for Botswana and South Africa to 2.4 percent of GDP for Malawi. By 2010, the costs will rise to between 0.5 percent of GDP (Botswana, South Africa) to 4.0 percent of GDP (for Malawi), for two reasons. (1) The numbers of AIDS patients will increase in the near future, following the increase in new infection in recent years. (2) The number of those receiving triple therapy increases, as triple therapy extends the lives of patients.

The estimated costs, based on an assumed coverage rate of 10 percent, show that owing to substantial reductions in the prices of HAARTs, several countries (notably Botswana and

South Africa) will be able to provide these medications for a significant proportion of AIDS patients. However, for other countries, the scope for introducing HAARTs is very limited. Even for the low coverage rates assumed, HIV-related health expenditure would exceed current public health expenditure for several countries. Thus, it is very doubtful whether the governments of these countries will allocate significant public resources to improve access to HAARTs.[18]

Education

The HIV/AIDS epidemic affects the education sector in various ways: While the number of teachers falls owing to increased mortality, the number of pupils declines owing to declining birth rates and increased child mortality. Also, there is a risk that access to education will deteriorate. A increasing proportion of school-age children will be orphans, and might not be able to afford to continue education.[19] Especially in rural areas with relatively small schools, deaths of teachers may result in disruptions of schooling, if these teachers cannot be replaced speedily.

With increased mortality of teachers on one hand, but declining numbers of pupils on the other hand, will it be possible to maintain the quality of education? One useful indicator for the quality of education are pupil-teacher ratios. Table 6 uses the latest available data on pupil-teacher ratios (about 1996, as reported in the UNESCO's World Education Report 2000) as a reference point, and estimates how many teachers need to be trained to maintain these latest available pupil-teacher ratios.

The projected numbers of pupils (Table 6, cols. 3-4) mirror the demographic projections for the relevant age group from the database of the International Programs Center at the U.S. Bureau of Census, assuming that gross enrolment rates would stay the same.[20] Mortality rates for teachers are assumed to be the same as for the general population (age 20-60). Teachers

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[18] A possible exception are temporary treatments to reduce the rate of mother-to-child transmission.

[19] See also Table 2. The International Programs Center at the U.S. Bureau of Census estimate that by 2010, between 12 and 20 percent of the population of ages 0-14 will be orphans.

[20] Given the high numbers of orphans, keeping enrolment rates constant would already be an achievement. For example, the World Bank (1999, pp. 226-229) report data suggesting that enrolment rates for orphaned children decline, especially for households with relatively few assets.

are assumed to retire at age 60 (a typical value for this retirement rate would be 0.8 percent) or quit (at an assumed rate of 2 percent per year).[21]

For the years 2000 and 2010, the required number of new teachers who need to be trained is shown on Table 6, columns 5 and 6. Of these, a certain number replace teachers who have owing to AIDS, this is shown as absolute numbers (cols. 7-8), and as a proportion of total teacher training (col. 9-10).

Table 6. The impact of HIV/AIDS on the education sector

	Pupil-teacher ratios (1996)		Total number of pupils (000s)		Required teacher training (total)		Training to replace AIDS victims		AIDS deaths, % of total training	
	primary	secondary	2000	2010	2000	2010	2000	2010	2000	2010
Botswana	25	17	452	437	1,380	1,569	543	1,231	39.4	78.5
Lesotho	47	24	471	502	646	802	92	371	14.2	46.2
Malawi	59	45	3,295	3,398	3,729	3,376	1,013	1,523	27.2	45.1
Mozambique	58	33	1,769	1,901	2,287	2,466	447	1,218	19.5	49.4
Namibia 1/	32	21	509	522	1,398	1,298	618	800	44.2	61.6
South Africa	36	29	11,421	9,160	17,337	13,118	9,045	10,273	52.2	78.3
Swaziland	34	19	290	333	767	975	149	527	19.4	54.0
Zambia 2/	39	n.a.	1,643	1,911	3,078	3,359	1,017	1,272	33.0	37.9
Zimbabwe	39	27	3,269	2,669	5,448	4,368	2,960	3,610	54.3	82.6

Data sources: IMF staff projections and calculations, based on demographic projections from the U.S. Bureau of Census and historical data on the numbers of pupils and teachers in primary and secondary education from the UNESCO's World Education Report 2000. 1/ Pupil-teacher ratios for Namibia are taken from the UNESCO's World Education Indicators database and refer to 1992. 2/ Projections for Zambia refer to primary education only.

Table 6 shows that in 2000, between 14 and 54 percent (average: 44) of the teachers that need to be trained in the respective countries would replace AIDS victims. This indicates that for countries like Botswana, Namibia, South Africa, and Zimbabwe, the required number of new teachers has increased by between 65 and 119 percent by 2000.[22]

By 2010, the rate of newly trained teachers replacing AIDS victims would rise to between 38 and 83 percent (average: 66). At the same time, the number of pupils is affected by declining birth rates (partly due to AIDS, see Table 2). For 8 of the nine countries covered, the number of pupils grows only modestly (by less than 1 percent per year) or declines. As a consequence, the total required number of teachers may increase only

[21] For simplicity, it is assumed that exits of teachers do not affect the age structure of teachers relative to the general population.

[22] These estimates are derived from the rates of newly trained teachers replacing AIDS victims (say, x), as $1/(1-x)$, taking into account that for 2000, the impact of AIDS on hte total number of pupils is relatively small.

modestly, and would even decline for some countries between 2000 and 2010. However, the number of additional teachers required by 2000 is so large that even taking into account the slowdown (or decline) in the numbers of pupils, and thus in the demand for teachers, between 2000 and 2010, the numbers of newly-trained teachers needs to expand substantially to avoid any (further) deterioration in pupil-teacher ratios.

An alternative indicator of the impact of HIV/AIDS on the education sector, which is less affected by demographic shifts, is the share of a cohort leaving school who would need to become teachers in order to maintain a constant pupil-teacher ratio (see Table 7). Using the number of required teachers for 1996-2000 *not* replacing AIDS victims as a benchmark, Table 7 shows that, for most countries, the share of a cohort entering the labour market deciding to become teachers would have to increase substantially to avoid a decline in the quality of education.

Table 7. Required number of teachers, in percent of cohort leaving school

	1996-2000, excluding AIDS ("benchmark")	1996-2000, including AIDS	2001-2005, including AIDS	2006-2010, including AIDS	1996-2010, increase relative to benchmark (In percent)
Botswana	2.5	3.6	4.0	4.0	52.1
Lesotho	1.2	1.3	1.4	1.5	14.8
Malawi	1.5	1.9	1.3	1.2	-2.8
Mozambique	0.4	0.5	0.5	0.5	16.4
Namibia	1.8	2.9	3.1	2.7	62.2
South Africa	1.1	1.8	1.8	1.6	60.4
Swaziland	2.4	2.8	3.3	3.0	27.2
Zambia	0.9	1.3	1.3	1.2	38.6
Zimbabwe	1.1	2.0	1.4	1.4	40.7

Data sources: IMF staff estimates.

Whether in terms of the total numbers of teachers required, or as a percentage of cohorts leaving school, our estimates indicate that the numbers of newly trained teachers already needs to increase substantially in order to avoid a deterioration in pupil-teacher ratios. In spite of rising mortality rates, declining birth rates slow down the increase in the numbers of teachers required towards 2010. However, the required numbers of newly trained teachers would still be considerably higher than before the onset of the HIV/AIDS epidemic.

It is important to note that our analysis is based on the assumption that enrolment rates would stay constant. This provides a useful reference point; however, given the increasing numbers of orphans, maintaining enrolment rates would already be an achievement and

would require additional funding. While a decline in enrolment rates would ease the burden of the epidemic on the education sector, it would also mean a deterioration in the access to education and, as orphans dropping out of education would typically come from poorer households, an increase in inequality.

Personnel Costs

The HIV/AIDS epidemic will cause disruptions to all areas public services, through increased mortality of employees. If mortality rates among public sector employees are similar to those in the total population, 1 of 40 employees or more have died of AIDS in the contries considered here in 1999 alone; this ratio may fall to 1 of 20 per year as mortality rates keeps rising.[23] While this applies to the private sector as well, the impact of increased mortality on personnel costs is likely to be larger for the public sector, for two reasons: (1) Most countries covered here have a special public sector pension scheme (which would also cover benefits to surviving spouses and dependents).[24] (2) While companies might reduce AIDS-related expenditures by scaling down services and shifting them to the public sector, this would be less feasible for government institutions.

There is very little data available on medical and death-related benefits to public sector employees. However, the two examples below indicate the potential scale of the impact.

In Lesotho, gratuity payments to spouses or dependents of employees who have died of AIDS would average at about 50 percent of a deceased's last annual salary.[25] If the number of AIDS cases rises to 3.2 percent of the public sector workforce by 2010, payouts to surviving dependents of AIDS victims would amout to 1.6 percent of the total wage bill. However, death-related benefits are proportional to tenure, so that the net effect on the pension fund should be small.

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[23] See Table 2.

[24] According to Barbone and Sanchez (1999) all countries in the region, apart from Zimbabwe, run a separate public sector pension system. For Botswana and Malawi, a national pension scheme exists only for the public sector (see Barbone and Sanchez, 1999).

[25] Source: "Lesotho – The Development Impact of HIV/AIDS. Selected Issues and Options", Worldbank, 2000.

The Ministry of Education of Swaziland, in a detailed study of the impact of HIV/AIDS on the Education Sector, report average cost of sick leave and death-related benefits of 85,600 emalangeni per case.[26] This can be split up in cost of sick leave of about 22,000 emalangeni (75 percent of annual salary), and death-related benefits of 63,600 emalangeni (216 percent of annual salary).[27] Thus, if these ratios carry over to the public sector workforce as a whole, and if the number of AIDS cases rises to 4.8 percent of public sector employees by 2010, the cost of sick leave and death-related benefits would increase to 14 percent of the public sector wage bill (about 1.7 percent of GDP).[28]

Social Expenditure

More generally, the HIV/AIDS epidemic affects the entire social security system. In this regard, it is necessary to distinguish three different types of programs:

(1) Provident funds, which, at death or retirement, pay out the accumulated contributions, plus interest. Generally, the HIV/AIDS epidemic would have a minor effect on the the balance of such a fund, as long as the interest paid on contribution reflects market interest rates. According to Barbone and Sanchez (1999), Swaziland and Zambia run such a program.

(2) A social insurance program in which benefits are proportional to the duration of contributions. Generally, the formula applied to calculate the benefits would not directly reflect interest rates, so that the HIV/AIDS epidemic would have an effect on the balance of the social security system. For example, the government might subsidise (relatively low) benefits to dependents of those dying early. Also, AIDS victims are likely to leave under-age orphans, who might be entitled to benefits.

(3) A social security program in which benefits do not depend on contributions, or which is financed directly out of the government budget. In Botswana, for example, orphans are entitled to a fixed monthly allowance. This type of social security system would be most

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[26] See Swaziland Ministry of Education, 1999.

[27] IMF staff estimate.

[28] It is important to note that these payouts are gross. A full assessment of how this affects the pension fund and/or the fiscal balance, though, would require an analysis of the link between benefits paid out and contributions paid in.

vulnerable to the HIV/AIDS epidemic, as claims would increase proportionally with mortality rates, while revenues, if the system is financed from contributions rather than the government budget, stay constant.

Fiscal Balance

HIV/AIDS affects government revenues primarily through its adverse impact on the tax base. As the rate of population growth declines, so do components of the tax base such as personal income, company profits, imports, or consumption.[29] Also, company profits are negatively affected by HIV/AIDS-related costs, and losses of public servants could result in a decline in tax collection rates. More difficult to quantify are losses associated with disruptions in the tax administration due to increased mortality.

At the same time, certain categories of expenditure (e.g. health and social expenditure, and overall personnel costs) will increase. For the health sector, our analysis shows that the expected costs, even at limited rates of coverage, will be substantial. However, so far there is little evidence as to what extent the increased demand for health services is met by increased expenditure, or by rationing. Additionally, increased mortality rates will affect the availability of skilled and educated personnel. As shown above for the education sector, training of new staff would have to expand substantially to avoid a deterioration of the quality of services.

Overall, the fiscal position is likely to deteriorate substantially. Even excluding highly active antiretroviral therapies, the costs of treating HIV patients (for the assumed rates of coverage) would rise to between 1.0 and 2.5 percent of GDP for six of the nine countries covered here. While external assistance could alleviate some of the burden of the required fiscal adjustment, especially concerning the funding of health and prevention projects, this appears less likely for the broader fiscal repercussions.

[29] The impact of HIV/AIDS on economic growth and per-capita income is discussed further below.

IV. THE IMPACT ON THE SUPPLY OF LABOUR

The HIV/AIDS epidemic affects the supply of labour in various ways. The overall size of the labour force declines, the age structure shifts due to changes in mortality and birth rates, the skill composition of the supply of labour changes, and labour turnover rates increase.

The changes in the size of the supply of labour closely match the changes in the demographic structure of the population, which is discussed above (Section II). The age structure of the supply of labour is affected by changes in mortality rates and changes in the growth rate of the labour force. The average age of the labour force, for instance, can formally be described by:

$$\text{Age}(t) = \frac{\int_{t-(b-a)}^{t} (i-t+b) L_{i,t}\, di}{\int_{i=t-(b-a)}^{t} L_{i,t}\, di} = \frac{\int_{t-(b-a)}^{t} (i-t+b) \cdot e^{-\int_{i}^{t} g(j)\, dj} \cdot e^{-\int_{i}^{t} m_i(j)\, dj}\, di}{\int_{t-(b-a)}^{t} e^{-\int_{i}^{t} g(j)\, dj} \cdot e^{-\int_{i}^{t} m_i(j)\, dj}\, di}$$

Here, $L_{i,t}$ stands for the size of the cohort entering the labour market at time i at time t, and surviving till time t. Agents enter the labour force at age a, and may stay active until age b; the rate of growth of new cohorts entering the labour market at time j is denoted $g(i)$, and $m_i(t)$ stands for mortality rates for $L_{i,t}$.

As the HIV epidemic evolves, mortality rates ($m_i(t)$) increase, the share of members of the cohort entering the labour market at time i surviving till time t, $e^{-\int_{i}^{t} m_i(j)\, dj}$, declines, which brings down the average age of the workforce. Eventually, the decline in birth rates caused by HIV/AIDS results in a decline in the rate of growth of new cohorts entering the labour market ($g(i)$). Thus, the size of older cohort relative to the size of the youngest cohort, $e^{-\int_{i}^{t} g(j)\, dj}$, increases, and the average age of the workforce rebounds to some extent.

As the average age of workers declines, so does work experience. Thus, the supply of certain skills that are acquired on the job, or through training intended to complement working experience, will decline.[30]

As HIV prevalence rates differ across sub-groups of the population, the composition of the supply of labour may change. Generally, HIV prevalence rates for women are higher, and start rising at an earlier age, than for men. Other determinants of infection rates that have been proposed include location (mainly urban vs. rural), mobility (higher prevalence rates for migrants and staff working away from their families), income, and education. While data on HIV prevalence by region suggest that HIV prevalence rates tend to be higher in urban areas (including most of the formally skilled population) initially, this gap tends to close while the epidemic evolves.

V. THE IMPACT ON COMPANIES

This section focuses on two aspects: (1) The direct costs of HIV/AIDS to companies, which arise through disruptions of the production process due to sickness or death and from medical and death-related benefits, and (2) the changes in the cost of or returns to training. Other issues relevant to private enterprises are discussed in the sections on the supply of labour and on economic growth and per-capita income.

Direct Costs

HIV/AIDS affects companies' costs through a variety of channels. The most important ones are absenteeism, sick leave and disability pensions, medical care, pensions to surviving dependents, loss of productivity, and funeral cost and attendance. As case studies (some of which are summarised below) conducted in various companies show, these costs vary considerably across countries and sectors.

One study, focusing on the National Railways of Zimbabwe, projects that AIDS related cost will rise from Z$ 39 million in 1996 to Z$ 108 million in 2005, for a total workforce of

[30] Below, the impact on returns to training and on productivity will be discussed.

11,500. Of this, health expenditure accounts for 56 percent, absenteeism for 24 percent, and cost of training for 17 percent.[31]

A detailed study on three companies in Côte d'Ivoire (Aventin and Huard, 2000) suggest that for an HIV prevalence of 10 percent among the companies' workforce, HIV related cost would amount to between 6.8 and 10.0 percent of the workforce. Only one of the companies provides medical benefits and invalidity pensions to employees, for this company, each amounts to about one quarter of total costs. Sick leave accounts for a significant share of the costs (between 9 and 31 percent), as do losses of productivity (between 13 and 25 percent).

For Botswana, UNAIDS (1998c, quoting a study by the Botswana task force on AIDS) report that companies were anticipating that AIDS related cost would increase to 5 percent of the wage bill by 2004. As estimated HIV prevalence rates for Botswana have risen since, total cost may rise to 7-8 percent of the wage bill.

For South Africa, a recent study on a sugar mill puts the cost per worker per year at R 9,500. Of this, costs of replacement workers, lost producticity, and absenteeism account for about one quarter each.[32]

Frequently, companies in the formal sector provide medical benefits and pensions or lump-sum benefits to surviving dependents. For Zimbabwe, UNAIDS (1998c) report that life insurance premiums quadrupled due to HIV/AIDS. As early as 1995, AIDS-related deaths claims for Individual and Group life Assurance amounted to 48 percent and 38 percent of claims. Similarly, a study by Metropolitan Life for the manufacturing sector in South Africa estimates that the costs of risk benefits will rise from 7 percent of the wage bill in 1997 to 14.6 percent in 2007, largely due to HIV/AIDS.[33]

For countries for which data on death-related benefits are not available, mortality rates for the working-age population give an indicator for the impact of HIV/AIDS on companies' costs. The above case studies suggest that for a company with 1 percent of AIDS cases among the employees, direct costs may increase by 1-2 percent of the company's wage bill.

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[31] Quoted from Bollinger and Stover, 1999.

[32] See Cheevers and Morris, 2000.

[33] Quoted from Abt Associates, 2000.

If the company bears the costs of risk benefits (disability, death), this would mean additional costs of between 0.5 and 4 percent of the wage bill, depending on the extent of coverage. Current estimates of HIV/AIDS-related mortality rates range from 0.8 to 2.7 percent of the adult population and are projected to rise to between 2.1 and 4.9 percent (see Table 2), suggesting that the costs of HIV/AIDS to companies would rise to more than 10 percent of their personnel costs in many countries or regions.

There are several strategies for companies to contain the costs resulting from HIV/AIDS: (1) Supporting and funding of prevention efforts; (2) screening of prospective employees; and (3) reducing the scale of benefits and/or shifting certain costs to the private sector.

The available literature suggests that *prevention* campaigns on the company level can yield positive results and, financially, high rates of return.[34] However, such programs can be problematic for the companies if they are not fully accepted socially. Also, companies would typically lack the know-how to implement such strategies. For both reasons, it is important that such activities on the company level are supported by the respective governments, in terms of support services and of public endorsement.

Data on *screening* of prospective employees (by hiring employees from lower-risk groups, differentiating by social background or age) are not available. While the practice is illegal in some countries (e.g. South Africa), casual evidence suggests that it is not uncommon.

There are various options for *reducing the costs of benefits*. A company may reduce the scale of medical benefits, thus shifting the costs and risks to the public sector and their employees. For risk benefits, companies may shift from lump-sum benefits towards a provident fund or link benefits more clearly to tenure. This strategy would reduce payouts to AIDS victims dying early in their working life and their dependents.

Training and learning on the job

Rising mortality rates due to HIV/AIDS affect personnel costs directly, they also reduce the incentives to companies to invest in training of their employees. The returns from

[34] See, for example, Rosen et al., 2000.

investments in human capital to companies can be measured by the time an employee can be expected to stay with the company, discounted by an appropriate interest rate.

For example, a company may observe that their employees quit with a probability of 10 percent per year, and apply a discount rate of 5 percent. In this case, if mortality rates among employees rise from 0.25 percent to 3 percent, returns to training employees would fall by 15.3 percent.[35] If mortality rates rise to 5 percent, returns to training fall by 23.8 percent.

Table 8. HIV/AIDS, the returns to training, and working experience

Mortality rates (in percent)	Change in returns to training	Change in cost of maintaining fixed number of skilled employees (In percent)	Average duration of tenure (In years)
0.25	0.0	0.0	9.3
1.0	-4.7	6.6	8.6
3.0	-15.3	24.2	7.2
5.0	-23.8	41.8	6.2

Data source: Own estimates.

Alternatively, the company may have to maintain a constant number, say 100, of employees with some required skills. As mortality rates rise from 0.25 percent to 3 (or 5) percent, the average number of employees who need to be trained per year then rises from 10.2 to 12.7 (or 14.5), and the annual training budget would have to rise by 24.2 (or 41.8) percent.

Alternatively, skills are acquired as employees accumulate experience while working for the company, getting promoted to more complex and demanding tasks. As an indicator for company-specific skills, "experience" is defined as the number of years an employee can be expected to stay with the company. If 10 percent of employees quit the company each year, and mortality rates are 0.25 percent, a young employee can be expected to stay in the

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[35] The returns to training are calculated as $(s+m+\delta)\int_{\alpha}^{\omega}(i-\alpha)e^{-(s+m+\delta)*(i-\alpha)}di+(\omega-\alpha)e^{-(s+m+\delta)*(\omega-\alpha)}$, where s is the job separation rate, m is the mortality rate, δ is the discount rate, α is the employee's age, and γ is the age at which the employer retires from the labour force. In the above example, α equals 15, and ω equals 60. For simplicity, it is assumed that quit rates and mortality rates do not differ across workers. The assumed leaving rate of 10 percent is within the range of 6.8-18.3 percent (excluding workers leaving due to sickness or death), reported by the World Bank, 1999.

company for an average of 9.3 years.[36] If mortality rates rise to 3 (or 5) percent, this expected period with the company falls to 7.2 (or 6.2) years, that is, job-specific experience falls by 22 (or 33) percent. The proportion of employees who stay for more than 10 years falls from 34 percent (for a mortality rate of 0.25 percent) to 25 percent or 20 percent (for mortality rates of 3 or 5 percent, respectively).

However, companies can replace employees who quit or die by hiring new workers. To the extent that skills are not specific to a particular job, the aggregate supply of experienced workers, rather than the tenure of workers at a specific company, becomes relevant. If mortality rates rise from 0.25 percent to 3 (or 5) percent, the average level of working experience declines from 18.8 to 14.7 (or 12.3) years.[37]

VI. Economic Growth and Per-Capita Income

HIV/AIDS may affect economic growth and income per capita through various channels. Disruptions to the production process caused by sickness and death of employees have an adverse impact on productivity, and the decline in the rate of growth of the labour force results in a fall in the rate of growth of GDP. Also, HIV/AIDS affects the supply of human capital (relative to the size of the labour force) if the average level of experience in the workforce declines, if HIV prevalence rates differ across segments of the population, and if the quality of education deteriorates.

The impact of HIV/AIDS on the accumulation of physical capital is more complex. In the context of a neoclassical growth model (a version of which is used below), a decline in the rate of growth of the labour force is associated with an increase in the steady-state capital-labour ratio and thus output per head. However, public and private domestic savings fall as

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[36] The time an employee is expected to stay with a company can be calculated as $(s+m)\int_{\alpha}^{\omega}(i-\alpha)e^{-(s+m)*(i-\alpha)}di+(\omega-\alpha)e^{-(s+m)*(\omega-\alpha)}$. The example is based on the same parameters as used for the returns to training, above.

[37] The average level of work experience is calculated as: $E=\frac{1}{b+m}-45\cdot\frac{e^{-(b+m)\cdot 45}}{1-e^{-(b+m)\cdot 45}}$, where b stands for the population growth rate (equal to 2 percent in the above example), m denotes mortality rates, and 45 (years) is the duration of a full working life. See below, section VI, for more details.

AIDS-related expenditures rise and, for private households, families have to cushion off the income loss that occurs if a breadwinner falls sick and dies. Also, the rate of return to capital is likely to decline, owing to a fall in productivity, increasing personnel expenditure, and a possible increase in the capital-labour ratio. This would discourage investment, and, consequently, inward foreign direct investment is likely to fall, and capital outflows to increase.

Several studies addressed the link between HIV/AIDS and economic growth in the early 1990s[38] As these papers typically conclude that the impact of HIV/AIDS on per-capita income is rather small, and as the full scale of the epidemic had not been recognized at the time, there has been little research on these issues over the following years. However, as the full demographic, social, and economic impact of HIV/AIDS in Southern Africa has become evident, several new studies have provided assessments of the broad macroeconomic impact of the epidemic.[39]

While output per capita is an important indicator for the impact of HIV/AIDS on living standards, it is by no means sufficient. In particular, HIV/AIDS results in a significant decline in life expectancy, and an increase in risk. Also, private and public expenditure needs to be shifted in response to the epidemic. For example, Arndt and Lewis (2000) estimate that about 5 percent of GDP will be AIDS-related in South Africa by 2010, crowding out other expenditure.

Of the earlier papers, Over (1992) uses a two-sector framework (urban/rural) with Cobb-Douglas production functions. Rural production draws on land, unschooled labour, and primary school educated labour; urban production draws on capital and primary and secondary school educated labour. Key determinants of the impact of the epidemic are the effect on savings and the distribution of infection rate across skill classes. If, for example, AIDS cases are distributed evenly across skill classes and 50 percent of the cost of treatment are financed from savings, annual GDP growth will decline by about 1 percent for the ten countries with the most advanced epidemics (with prevalence rates assumed to rise to around

[38] For example, Over (1992), Cuddington (1993 (a), 1993 (b)), Cuddington and Hancock (1995).

[39] See, for example, Arndt and Lewis (2000), Bonnel (2000), Botswana Institute for Development Policy Analysis (2000), or ING Barings, South African Research (2000).

20 percent) between 1990 and 2025, and the growth rate of GDP per capita will decline by 0.13 percent.

Cuddington and Hancock (1995), in a study on Malawi, analyse the impact of HIV/AIDS in a dualistic economy. Thus, workers in the formal sector who died from AIDS could be replaced by under-employed workers from the informal sector. Human capital takes the form of work experience. As the age distribution of workers shifts towards the younger workers, productivity declines. The productivity of workers with AIDS is reduced by one half. For a scenario with AIDS prevalence rising to 1.1 percent by 2010 (corresponding to a HIV prevalence rate of about 11 percent) and 50 percent of AIDS cost met by reduced savings, the growth rate of GDP would fall by 0.2 percentage points, and the level of GDP per capita would fall by about 1 percent by 2010.

Arndt and Lewis (2000, 2001) report projections of the impact of HIV/AIDS in South Africa based on a 14-sector CGE model. HIV/AIDS affects labour productivity and total factor productivity, household spending patterns and government spending. This study predicts that the level of GDP per capita will fall by 8 percent until 2010, and that non-AIDS related absorption per capita will fall by 13 percent (relative to a scenario with no AIDS). Of the change in the level of GDP (8 percent), about 2.7 percent are attributed to a decline in total factor productivity, and about 3.6 to a decline in national savings.

In Bonnel (2000), HIV/AIDS affects GDP indirectly through the erosion of social capital, which is approximated by the World Bank's ratings of macroeconomic performance of developing countries. Bonnel estimates that, due to HIV/AIDS, the rate of growth of GDP per capita in Southern Africa has fallen by about 1.2 percent between 1990 and 1997, which would imply that the level of GDP per head has fallen by 8.1 percent over this period.[40]

A study by ING Barings (2000), however, predicts an increase in GDP per capita of 7.5 percent by 2010, relative to a no-AIDS scenario.[41] This result stems from the model's emphasis on the demand side of the economy., whereby AIDS-related expenditure would

[40] These estimates are based on an HIV prevalence rate of 20 percent.

[41] ING Barings (2000) predict that while the labour force will decline by 12.8 percent by 2020, GDP will fall by 4.7 percent only.

stimulate demand and raise GDP.[42] In a similar study, the Bureau for Economic Research (South Africa) estimate that between 2002 and 2015, real GDP growth for South Africa will rise by 0.7 to 1.0 percent, reflecting a decline in GDP growth of between 0.3 and 0.6 percent, while the rate of population growth is projected to decline by 1.3 percent.[43] However, the modest decline in GDP growth corresponds to an increase in capacity utilization, and shift of about 5 percent of the labour force into the formal sector. Thus, potential GDP growth declines by between 1.4 and 1.8 percent, and the projected gains in GDP per capita would eventually be reversed.

A Theoretical Framework

In view of the relatively large number of countries under consideration, and due to the limited availability of relevant data, the analysis below is based on a relatively simple neoclassical growth framework.

The model allows for two different forms of human capital, education and experience. Total labour supply, in terms of efficiency units, is equal to

$$Z = \sum_{i=1}^{n} [L_i B_i f(E_i)], \qquad (1)$$

where L_i is the number of agents for the respective skill or education category i, B_i is a productivity parameter, and $f(E_i)$ is a function of the average level of experience in this category.

The economy is characterised by a Cobb-Douglas production function, in which output depends on total factor productivity (A_0), physical capital (K), and the effective labour supply, which means that

$$Y = A_0 K^{\alpha} Z^{1-\alpha} \qquad (2)$$

Consistent data on the impact of HIV/AIDS by skill category across countries are not available. While groups with lower skills are reported to have higher infection levels in South

[42] ING Barings make use of the WEFA macreconometric model of the South African economy.

[43] See Bureau for Economic Research (2001).

Africa, this appears not to be a uniform pattern across countries.[44] In light of the limited availability of data on HIV prevalence rates by socio-economic group, and because HIV affects human capital primarily through its impact on the overall age profile of the labour supply, rather than the composition of the labour supply by skill category, the analysis below assumes that HIV prevalence rates and mortality rates (and thus the level of experience, E_i) are the same across skill categories.

Assuming that $f(E_i) = E_i^{\gamma} = E^{\gamma}$, and defining $B = \sum_{i=1}^{n} s_i B_i$, with $s_i = \frac{L_i}{L}$ and $L = \sum_{i=1}^{n} L_i$, the effective supply of labour can then be written as

$$Z = E^{\gamma} B L . \tag{3}$$

Thus, aggregate output is given by

$$Y = A E^{\gamma(1-\alpha)} K^{\alpha} L^{1-\alpha}, \quad \text{with} \quad A = A_0 B^{1-\alpha}, \tag{4}$$

and the capital stock evolves according to

$$\dot{K} = \iota Y - \delta K, \tag{5}$$

where ι is the economy's investment rate, δ is the rate of depreciation of the capital stock, and a dot above a variable indicates a rate of change. In per capita terms, the economy can be described as

$$y = A E^{\gamma(1-\alpha)} k^{\alpha}, \text{ with } \dot{k} = \iota y - (\delta + n) k, \tag{6}$$

where $y = Y/L$, $k = K/L$, and n stands for the rate of growth of the labour supply.

For a given ι, A, E, δ and n, the economy moves towards a steady state, which is characterized by

$$k^* = \left[\frac{\iota A E^{\gamma(1-\alpha)}}{\delta + n} \right]^{\frac{1}{1-\alpha}} \quad \text{and} \quad y^* = A E^{\gamma(1-\alpha)} (k^*)^{\alpha}. \tag{7}$$

Equivalently,

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[44] See, for instance, Bureau for Economic Research (2001).

$$y^* = A^{\frac{1}{1-\alpha}} E^{\gamma} \left[\frac{\iota}{\delta + n} \right]^{\frac{\alpha}{1-\alpha}}. \tag{8}$$

Thus, the HIV/AIDS epidemic affects per capita income through its effect on productivity (A), human capital/experience (E), the investment rate (ι), and the rate of growth of the labour supply. Formally,

$$\frac{\Delta k^*}{k^*} = \frac{1}{1-\alpha}\frac{\Delta A}{A} + \gamma \frac{\Delta E}{E} + \frac{1}{1-\alpha}\left[\frac{\Delta \iota}{\iota} - \frac{\Delta(\delta + n)}{\delta + n} \right] \tag{9}$$

and thus

$$\frac{\Delta y^*}{y^*} = \frac{1}{1-\alpha}\frac{\Delta A}{A} + \gamma \frac{\Delta E}{E} + \frac{\alpha}{1-\alpha}\left[\frac{\Delta \iota}{\iota} - \frac{\Delta(\delta + n)}{\delta + n} \right]. \tag{10}$$

A framework similar to the one summarized in Eq. (9) is used in most of the studies referred to above, and it will be referred to below as the "closed-economy model". However, an anlysis of the impact of the HIV/AIDS epidemic typically finds a significant increase in the capital-labour ratio, and a corresponding decline in the rate of return to capital.[45] This, in turn, would have an impact on investment, i.e., inward foreign direct investment will decline, and/or capital outflows will rise. In the longer run, the rate of return to capital would adjust to the world interest rate, adjusted for a risk premium, i.e.

$$\frac{\partial y}{\partial k} - \delta = \alpha A E^{\gamma(1-\alpha)} k^{\alpha - 1} - \delta = r_{RoW} + RP. \tag{11}$$

Provided that the world interest rate (r_{RoW}) and the risk premium (RP) stay unchanged, the change in the steady-state capital-labour ratio will then be equal to

$$\frac{\Delta k^*}{k^*} = \frac{1}{1-\alpha}\frac{\Delta A}{A} + \gamma \frac{\Delta E}{E}, \tag{12}$$

and the change in the steady-state level of output per capita is

$$\frac{\Delta y^*}{y^*} = \frac{\Delta A}{A} + \gamma(1-\alpha)\frac{\Delta E}{E} + \alpha\left[\frac{1}{1-\alpha}\frac{\Delta A}{A} + \gamma \frac{\Delta E}{E} \right] = \frac{1}{1-\alpha}\frac{\Delta A}{A} + \gamma \frac{\Delta E}{E}. \tag{13}$$

[45] The rate of return to capital is also negatively affected by the decline in productivity and human capital.

Below, the model described by Eq. (13) will be referred to as the "open-economy model".

The Impact of HIV/AIDS on Key Parameters

The macroeconomic framework described above can be used either for a steady-state analysis or for a dynamic analysis, combining the model with projections of the demographic impact of HIV/AIDS over time. The analysis below focuses on the steady-state impact, as this approach provides clearer insights of the economic mechanisms at work. One drawback of this approach is that the required assumptions regarding the demographic impact of HIV/AIDS are relatively crude.

Some of the countries are in demographic transition, and would experience declining population growth rates even in the absence of HIV/AIDS. The steady-state population growth rate in the absence of HIV/AIDS is therefore approximated by the growth rate for the young cohorts (age 0-14), rather than the total population, for the year 2001 in the "no-AIDS" scenario from the database of the International Programs Center (IPC) at the U.S. Bureau of Census. Mortality rates for the working age population (age 15-59) in the absence of HIV/AIDS are taken from the same database, for the year 2001. Dependency ratios are assumed to stay unchanged, so that the size of the labour force is proportional to the size of the total population.[46]

HIV prevalence are assumed to stay constant at the end-1999 levels, as estimated by UNAIDS (see Table 1), and the number of AIDS deaths is set as a constant proportion of 10 percent of the HIV infected. An adult HIV prevalence rate of 10 percent is assumed to slow down population growth by 0.9 percent, which is in line with the projections by the U.S. Bureau of the Census.

The estimate of the impact of HIV/AIDS on total factor productivity is based on company-level data of HIV-related cost, mainly due to absenteeism (see the discussion of the impact of HIV/AIDS on private enterprises, above). Thus, an AIDS incidence rate among the workforce of 1 percent is assumed to reduce total factor productivity by 0.5 percent.

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[46] Compare Table 2, which shows that the impact of HIV/AIDS on dependency ratios is relatively small.

Regarding the role of physical capital, we distinguish between a "closed-economy model" and an "open-economy model", and estimates of the impact of HIV/AIDS are reported separately for each setting below. The elasticity of output with respect ot capital, α, is set equal to 0.3, and the rate of depreciation is set at 8 percent.

For the "closed-economy model", the base values for investment rates and savings rates are the averages of these variables through the 1990s.[47] Increases in health expenditure are assumed to equal 115 percent of per capita income per AIDS case, and the resulting decline in private savings is equal to the increase in health expenditure, multiplied by the savings rate.

Additionally, it is assumed that households affected by AIDS do not save. The proportion of affected households is set equal to the proportion of AIDS cases in the adult population.[48] Government investment and foreign direct investment are assumed to stay constant as a proportion of GDP, so that the change in investment rates is equal to

$$\Delta\iota = \left[-1.15 * \frac{\text{AIDS cases}}{\text{Population}} - 1 * \left[\frac{\text{AIDS cases}}{\text{Adults}} \right] \right] * s .^{49}$$

As an aggregate measure of experience, we adopt the average age of economically active agents. Assuming, for simplicity, that mortality rates m are constant across the working-age population (here: age 15-60), and that the number of agents entering the labour force grows at a constant rate b, experience is then given by

$$E = \frac{(b+m)\int_{15}^{60} i \cdot e^{-b\cdot(i-15)} \cdot e^{-m\cdot(i-15)} di}{(b+m)\int_{15}^{60} e^{-b\cdot(i-15)} \cdot e^{-m\cdot(i-15)} di} = 15 + \frac{1}{b+m} - 45 \cdot \frac{e^{-(b+m)\cdot 45}}{1 - e^{-(b+m)\cdot 45}},$$

[47] For some of the countries in the sample, private savings are negative through the 1990s. In this case, it is assumed that the marginal private savings rate is equal to 5 percent.

[48] This is a conservative assumption, for two reasons. (1) The share of households affected by AIDS is certainly larger than the AIDS incidence rate among the adult population. (2) Households affected by HIV/AIDS may not only not save, but dissave.

[49] There is some double-counting here to the extent that an increase in health expenditure is financed by reduced savings.

where $(i - 15)$ stands for the years of work experience of an agent at age *i*, $e^{-b\cdot(i-15)}$ is the relative size of the cohort entering the labour market *i* years ago, and $e^{-m\cdot(i-15)}$ is the proportion of those entering the labour market *i* years ago who are still alive. The growth rate of the labour force, *b*, has a negative effect on aggrgate experience because for a high rate of growth of the labour force, older (and more experienced) cohorts are smaller relative to younger ones.

For the analysis of the impact of HIV/AIDS on "experience" it is important to distinguish the "medium term" and the "long term". In the medium term (10 – 15 years), HIV/AIDS affects the composition of the labour force mainly through increased mortality rates. The growth rate of new entrants to the labour force does not change significantly as long as the cohorts were born before the onset or escalation of the HIV/AIDS epidemic. In the long term, the age structure of the work force is also affected by declining birth rates, and the effect of increasing mortality rates on experience is mitigated. However, the decline in birth rates would take 45 years (until about 2050) to take full effect, so that the medium term effects are currently much more relevant.

Finally, the parameter γ, which measures the elasticity of a agent's efficiency with respect to years of experience, is set equal to 0.5, which would imply that a worker becomes 1.5 percent more efficient per year on average (with higher rates of efficiency gains of about 3 percent for younger workers). This is in line with similar specifications, e.g. in Cuddington and Hancock (1995), or with estimated wage equations for sub-Saharan Africa, such as in Bigsten et al. (2000).

The "Closed-Economy Model"

Tables 9 and 10 show the estimates of the impact of HIV/AIDS on steady-state output per capita in the "closed-economy model". In this model, the savings rate (and thus investment) changes only as resources are reallocated to the health sector, or as households affected by HIV/AIDS reduce their savings. The decline in total factor productivity ranges from 0.7 to 1.8 percent, reflecting AIDS incidence rates of up to 3.6 percent (for Botswana).

In the "medium term" (Table 9), experience declines by between 6 and 15 percent, resulting in a additional decline in productivity of between 2.0 and 5.2 percent. However, the

capital-labour ratio increases. While savings rates decline, the steady-state capital stock rises owing to the projected decline in the rate of population growth.

Table 9. The impact of the HIV/AIDS epidemic on steady-state output per capita, "closed economy", medium term

	Change in per capita output (In percent)	Due to change in TFP (In percent)	Due to change in capital/labour ratio (In percent)	Due to change in "experience" (In percent)
Botswana	2.6	-1.8	9.7	-5.4
Lesotho	2.7	-1.2	7.6	-3.7
Malawi	1.5	-0.8	4.8	-2.5
Mozambique	1.2	-0.7	3.9	-2.1
Namibia	0.3	-1.0	4.3	-3.1
South Africa	3.1	-1.0	7.1	-3.1
Swaziland	1.2	-1.3	6.2	-3.8
Zambia	0.9	-1.0	4.9	-3.1
Zimbabwe	4.2	-1.3	9.3	-3.9

Data sources: Own estimates.

In the longer term, some of the decline in experience is reversed, as the cohorts entering the labour market grow at a lower rate, and the average age of the working-age population increases. Thus, GDP per capita would increase even further, as shown in Table 10.

Table 10. The impact of the HIV/AIDS epidemic on steady-state output per capita, "closed economy", long term

	Change in GDP per capita	Due to change in TFP	Due to change in capital/labour ratio	Due to change in "experience"		
				Total	Of which: increased mortality	Of which: reduced growth of new entrants to labour force
	(In percent)	(In percent)	(In percent)	(In percent)	(In percent)	(In percent)
Botswana	9.6	-1.8	11.8	-0.5	-5.4	4.9
Lesotho	7.5	-1.2	9.0	-0.3	-3.7	3.4
Malawi	4.8	-0.8	5.8	-0.2	-2.5	2.3
Mozambique	3.9	-0.7	4.8	-0.2	-2.1	1.9
Namibia	4.3	-1.0	5.5	-0.3	-3.1	2.8
South Africa	7.1	-1.0	8.4	-0.2	-3.1	2.8
Swaziland	6.1	-1.3	7.7	-0.3	-3.8	3.4
Zambia	4.9	-1.0	6.1	-0.3	-3.1	2.8
Zimbabwe	9.2	-1.3	10.8	-0.3	-3.9	3.5

Data sources: Own estimates.

However, the estimates of the impact of HIV/AIDS are problematic. They rely on assumptions regarding the saving behaviour of economic agents which are difficult to quantify. Most importantly, they imply an increase in the capital-labour ratio of between 16 and 40 percent, due to a decline in the growth rate of the labour force. This would result in a

decline in the (gross) returns to capital of about 10 to 20 percent (not percentage points). If, for example, the depreciation rate is 8 percent, and the gross returns are 15 percent annually (and net returns equal to 7 percent), gross returns would decline to between 12 and 13.5 percent, and net returns fall to between 4 and 5.5 percent.

The "Open-Economy Model"

The open-economy model addresses the shortcomings of the closed-economy model by linking the rate of return on domestic assets to world interest rates (possibly adjusted for a risk premium). As investment opportunities in the economies under consideration deteriorate (as indicated by the falling rate of return to capital), one would expect a decline in foreign direct investment and/or a capital outflow to take advantage of more profitable investment opportunities abroad.

Tables 11 and 12 show estimates of the impact of HIV/AIDS on per-capita income for the medium and long term, respectively. In the "medium term", the negative impact of the decline in productivity and in experience on the rate of return to capital are offset by reduced investment rates (reflecting capital outflows or a decline in foreign direct investment). The resulting decline in the capital-labour ratio (falling by between 4 and 10 percent, accounting for a decline in output of 1.2 to 3.1 percent) then reinforces the decline in productivity and experience, and output per capita falls by 4.0 to 10.2 percent.

As in the analysis of the "closed-economy model", the decline in experience will be partly reversed as the weight of the younger cohorts in the working-age population declines, reflecting lower birth rates. The partial rebound in experience will also mitigate the decline in the capital-labour ratio required to keep the rates of return to capital in line with world interest rates. Thus, in the long term, output per capita falls by between1.2 and 3.2 percent.

Table 11. The impact of HIV/AIDS on per capita income, open economy, "medium term"

	Change in output per capita (In percent)	Due to change in TFP (In percent)	Due to change in capital/labour ratio (In percent)	Due to change in "experience" (In percent)
Botswana	-10.2	-1.8	-3.1	-5.4
Lesotho	-6.9	-1.2	-2.1	-3.7
Malawi	-4.8	-0.8	-1.4	-2.5
Mozambique	-4.0	-0.7	-1.2	-2.1
Namibia	-5.8	-1.0	-1.7	-3.1
South Africa	-5.8	-1.0	-1.8	-3.1
Swaziland	-7.2	-1.3	-2.2	-3.8
Zambia	-5.8	-1.0	-1.7	-3.1
Zimbabwe	-7.3	-1.3	-2.2	-3.9

Data sources: Own estimates.

Table 12. The impact of the HIV/AIDS epidemic on per capita GDP, closed economy, long run

	Change in GDP per capita	Due to change in TFP	Due to change in capital/labour ratio	Due to change in "experience"		
				Total	Of which: increased mortality	Of which: reduced growth of new entrants to labour force
	(In percent)	(In percent)	(In percent)	(In percent)	(In percent)	(In percent)
Botswana	-3.2	-1.8	-1.0	-0.5	-5.2	4.8
Lesotho	-2.1	-1.2	-0.6	-0.3	-3.6	3.3
Malawi	-1.4	-0.8	-0.4	-0.2	-2.5	2.3
Mozambique	-1.2	-0.7	-0.4	-0.2	-2.1	1.9
Namibia	-1.8	-1.0	-0.5	-0.3	-3.0	2.8
South Africa	-1.8	-1.0	-0.5	-0.3	-3.2	2.9
Swaziland	-2.3	-1.3	-0.7	-0.3	-3.7	3.4
Zambia	-1.8	-1.0	-0.5	-0.3	-3.0	2.8
Zimbabwe	-2.3	-1.3	-0.7	-0.3	-3.9	3.5

Data sources: Own estimates

While an explicit analysis of the impact of HIV/AIDS on annual growth rates, using annual projections of the demographic impact, is beyond the scope of the paper, it is possible to make some inferences regarding the impact on output growth. Most of the decline in experience due to increased mortality rates takes place within 15 years after the HIV/AIDS epidemic has escalated, whereas the rate of growth of new entrants to the labour force is barely affected during this period. While the evolution of HIV prevalence rates and hence HIV/AIDS-related mortality rates differ across countries, this suggests that the rate of per capita output growth will be between 0.3 and 0.7 percentage points lower than otherwise

through 2000-2010. In the long term, experience (and the capital-labour ratio) will recover to some extent, reflecting a lower growth rate of new entrants to the labour force. However, it will take 45 years from the time the cohorts born during the HIV/AIDS epidemic enter the labour market for this to take full effect. Thus, per capita output will recover slowly until about 2050, with output growth rates about 0.06 to 0.15 percentage points higher than otherwise.

VII. CONCLUSIONS

The present study aims at providing an assessment of the economic consequences of HIV/AIDS on the public sector, on the (formal) private sector, and, to some extent drawing on and summarising the analysis in the preceding sections, an analysis of the impact on per capita income.

Regarding the public sector, the impact on the *health sector* stands out. The HIV/AIDS epidemic increases the demand for health services; at the same time, health sector staff is affected by the epidemic. Available indicators suggest that health services already are overwhelmed by the epidemic. At the same time, the number of AIDS patients is expected to double over the next years for some of the countries considered here.

The demand for *education* will fall due to a declining population and reduced fertility rates. Although numbers of pupils will fall significantly, countries will find it hard to maintain pupil-teacher ratios at constant levels. Between 2000 and 2010, the proportion of newly trained teachers who replace teachers who have died of AIDS will rise from 45 percent to 67 percent.

A preliminary analysis of *public sector pension funds* suggests that death-related benefits may rise considerably. The institutional arrangements, however, and thus the fiscal implications, differ widely across countries.

For the private sector, the case studies available suggest that *personnel costs* do rise significantly, e.g. owing to medical and death-related benefits and AIDS-related absenteeism. The quantitative impact of HIV/AIDS on productivity, e.g. through disruptions of the production process or losses in human capital, is much less clear.

Regarding the impact of HIV/AIDS on *per capita income*, the above analysis distinguishes the effects of HIV/AIDS on total factor productivity, on capital accumulation, and human capital. HIV/AIDS affects human capital mainly through its effect on *experience*. The average level of experience declines due to increasing mortality rates. In the long term, however, the average level of experience recovers to some extent, as declining birth rates imply that the relative size of younger cohorts in the working-age population declines. As the rate of capital accumulation responds to changes in the rate of return to capital, the negative impact of the decline in productivity and human capital on per capita output is reinforced. In the long run, output per capita recovers partly, reflecting changes in the demographic composition of the work force.

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