The Macroeconomic Impact of AIDS in Sub-Saharan Africa

Mead Over
Population, Health and Nutrition
Population and Human Resources Department

The World Bank
Africa Technical Department
Population, Health and Nutrition Division
Technical Working Paper No. 3

June 1992

THE MACROECONOMIC IMPACT OF AIDS IN SUB-SAHARAN AFRICA*

by

Mead Over
Population and Human Resources Department
The World Bank

June, 1992

* Work on this paper was partially supported by a grant from the World Bank's research committee and by the Population, Health and Nutrition Division of the Bank's Africa Region. Earlier versions of this paper were presented at the American Economic Association meetings in Atlanta, December, 1989 and at the Vth Annual Conference on AIDS in Africa in Kinshasa, October, 1990. The author is grateful for discussions with Lawrence J. Lau, Dean T. Jamison, Rudolfo A. Bulatao, Peter Way and John Cuddington for the able research assistance of Joseph Kutzin, but is personally responsible for any errors. The statements in this paper are the personal views of the author and do not reflect the official views of the World Bank.

TABLE OF CONTENTS

ABSTRACT

This paper estimates the macroeconomic impact of AIDS on the Sub-Saharan economies by projecting the growth trajectories of 30 countries with and without the AIDS epidemic over the period 1990 - 2025. The paper defines the "impact" of the epidemic to be the difference between the trend growth rates with and without AIDS. If the only effect of the AIDS epidemic were to reduce the population growth rate, it would increase the growth rate of per capita income in any plausible economic model. The central question addressed by this paper is whether the specific characteristics of the AIDS epidemic would be sufficient to reverse this prediction, such that per capita income growth would be negative rather than positive. The characteristics examined here are the effect of the epidemic on savings and the distribution of the epidemic by productivity class of worker, which the paper calls the "socio-economic gradient" of the epidemic.

The paper shows that an AIDS epidemic can reduce the growth rate of per capita income in the average country even when it is evenly distributed across productivity classes of workers, provided at least 50% of treatment costs are extracted from savings. Either raising the percentage of treatment costs financed from savings or biasing the epidemic toward the more productive workers increases the negative impact on per capita growth and the two combined effects interact to produce an even larger impact - especially on the ten countries with the most advanced epidemics. For the most plausible assumptions, that 50% of the treatment costs are financed out of savings and that each education class of workers has double the risk of the one beneath it, the net effect of the AIDS epidemic on the growth of per capita GDP is a reduction of about a third of a percentage point in the ten countries with the most advanced epidemics. This is a substantial impact in countries that have been struggling to escape from a period of negative growth rates.

I. BACKGROUND AND OVERVIEW

Prior to the epidemic of the acquired immune deficiency syndrome (AIDS), the death rate among Sub-Saharan Africans aged 15 to 49 was already about five or six per thousand, which is approximately eight times higher than the death rate for this age group in developed countries and substantially higher than in other regions of the developing world. In several urban and some rural African populations, the AIDS epidemic is already quintupling or even sextupling this base mortality rate - leading to mortality rates for prime age adults as high as three percent per year or almost fifty times higher than mortality rates for this same age group in the U.S. and Europe. Furthermore, despite national and international efforts to control the disease, infection by the causative agent, the human immuno-deficiency virus (HIV) continues to spread in many Sub-Saharan African (SSA) countries.[1]

Since HIV infection leads inexorably to death from AIDS within two to twenty years, the future illnesses and deaths of the six million Africans thought to be currently infected will have a substantial impact on the economies of African countries for at least two decades - regardless of the effectiveness of the national and international programs now underway to prevent further infection. If prevention efforts are ineffective and a cure for HIV infection is as elusive as a cure for cancer has proved to be, the impact will extend indefinitely. Furthermore, as opposed to the other major fatal diseases in SSA, AIDS is disproportionately killing the most productive members of society: prime age urban adults with secondary school education or greater (Table IV). Thus an important aspect of AIDS policy is predicting the magnitude and character of the epidemic's future cost.

No one doubts the enormous toll that an adult AIDS death inflicts on surviving household members. But the nature of the long-run aggregate impact of the epidemic is uncertain. In both the labor-surplus and the neoclassical labor-constrained growth models, the marginal product of an average worker is less than the average product. Therefore, in either model removing average workers from an economy will raise per capita output and income unless an offsetting mechanism is sufficiently strong to counteract this effect. A dramatic example of the possibility that a reduction in population can increase average wages and incomes occurred in 14th century Europe as a result of the bubonic plague, which caused the populations of European countries to decrease by one-third within fifteen years, but resulted in substantially increased real wages.[2] Just as HIV infection is thought to be

---

[1] Of the two known strains of HIV, HIV-1 is more pathogenic, much more widespread in Sub-Saharan Africa and appears to be more easily transmitted during sexual intercourse than HIV-2. In this paper, HIV refers to HIV-1.

[2] Weir (1989, Table 1) estimates the elasticity of real wages with respect to population as -1.7 (t-statistic = -2.4) for France and -1.0 (t-statistic = -10.9) for England over the period 1300 to 1500. Also see Gottfried (1983), and McNeill (1976) for fuller histories of the social and economic impacts of the bubonic plague.

almost certainly fatal, the bubonic plague in early medieval Europe was also extremely virulent, with a case-fatality rate averaging 75%.[3] Also the mystery surrounding the mode of transmission of the plague was no greater than that enshrouding the cause of "slim disease" in Africa until the late 1980s.

Notwithstanding these points of similarity, the AIDS epidemic is decidedly not the bubonic plague. Being spread by the bite of fleas resident in households of all stations, the plague was much less selective in its spread through the population than is the HIV virus, which is spread to adults almost exclusively by sexual intercourse. While historical evidence suggests that the plague was easily transmitted, the probability of HIV infection on a single act of heterosexual intercourse between an infected and uninfected partner is estimated to be 0.01 or lower. In contrast to the rapid progress of a case of 14th century plague, which killed infected medieval Europeans in a matter of days or sometimes hours, HIV infection is extremely slow to kill, with half of all infected individuals surviving more than ten years. The consequence of these differences is that any aggregate effect of the AIDS epidemic on the size of national SSA populations will occur only slowly over decades, rather than in a matter of years as happened with the plague. The question is whether this slow impact will nevertheless be large enough to influence macroeconomic aggregates such as the gross domestic product (GDP) and the GDP per capita and whether the effect on the latter will be positive or negative.

AIDS in SSA has several features that might together offset the tendency for a reduction in population growth to increase the growth rate of per capita income. First, because SSA AIDS strikes prime-age urban adults and does not spare the elite, it arguably kills workers of much greater than average productivity. Second, medical treatment of AIDS cases is a sufficiently large addition to total health care expenditure to threaten aggregate savings and investment rates in these countries. Third, AIDS morbidity prior to death reduces the productivity of the existing work force. Fourth, the magnitude of the AIDS epidemic is so great in some SSA countries that observers fear a "disruption effect;" i.e the sickness and death of some workers will affect the productivity of other workers and even, potentially, the stability of the political and economic environment.

The purpose of the present paper is to estimate the impact of the AIDS epidemic on the growth of GDP and GDP per capita in 30 African countries over the period 1990 to 2025, taking into account the current resource base and AIDS epidemic in each country and explicitly modeling the disproportionate loss of more productive workers and the consequent loss of savings. Consideration of the morbidity and disruption effects is beyond the scope of this paper, but would clearly act in the direction of slowing per capita income growth.

---

[3] The features of HIV infection described below are fully exposited in Over and Piot (1991), which also estimates the costs and effects of alternative interventions. For epidemiological descriptions of the bubonic plague in medieval Europe, see the citations in footnote 2.

To be useful for investigating the importance of the disproportionate distribution of AIDS cases towards the more productive workers, the model used to project growth with and without AIDS must disaggregate production into a more productive and less productive sector and must disaggregate the labor force by productivity class. Section II of the paper first briefly reviews the existing literature on the economic impact of AIDS. Section III then proposes and estimates a two-sector model of African growth and uses it to project GDP and per capita GDP growth without AIDS. Section IV characterizes the AIDS epidemic in the sample countries. Under alternative assumptions about the epidemic's distribution and financing, Section V projects the impact of AIDS on the growth of GDP and of GDP per capita in the average Sub-Saharan African Economy for the period 1990 - 2025, where impact is defined as the difference in the annual growth rate between the AIDS and the no-AIDS scenarios. Section VI presents conclusions.

II. PREVIOUS ESTIMATES OF THE ECONOMIC IMPACT OF AIDS

One approach to estimating the cost of an illness was pioneered by Rice (1966), who proposed a dichotomization of the costs of a disease into the "direct" and "indirect" costs. In application, the "direct" cost is the cost of medical treatment and the "indirect" cost is the foregone production of the affected individual. Rice estimated the average direct and indirect cost per case for most North American diseases and then multiplied by the number of cases of each to arrive at an estimate of the total annual cost of illness in the United States. While she and subsequent authors have applied this methodology several times with increasing refinements to U.S. data,[4] the first attempt to systematically review the cost of illness in developing countries from this perspective is only now appearing in a forthcoming World Bank study of disease priorities (Jamison and Mosley, forthcoming).[5]

The AIDS epidemic has pushed work on the cost of AIDS in developing countries ahead of costing work on other diseases long endemic there.[6] Using the Rice approach, Over et al. (1988) computed low and high estimates of both the medical treatment and the foregone earnings caused by a case of HIV infection in two Sub-Saharan African countries, which are summarized in Table I. The low and high estimates differed primarily by the social class of the affected individual, with the rural, primary-educated AIDS patient assumed to consume fewer medical resources and to withdraw from a less productive

[4] Subsequent authors who have applied Rice's (1966) approach, with extensions and refinements, to U.S. data include Scitovsky (1967) Scitovsky and McCall (1976) and Cooper and Rice (1976). Also see Weisbrod (1961), Klarman (1965) and Shepard (1991) for studies of specific diseases.

[5] Less complete efforts for developing countries are contained in Walsh and Warren (1980, 1986), Walsh (1988) and Institute of Medicine (1986).

[6] Foster and Lucas (1991) review the literature on the economic impact of AIDS in developing countries and Over et al. (1991) review the literature on the consequences of ill health in developing countries. Also see the recent application of the Rice approach to malaria in Shepard (1991).

Table I Direct and Indirect Cost Per Case of HIV Infection in Tanzania and Zaire Discounted at 6% to the Time of Infection

	Zaire		Tanzania	
	Low	High	Low	High
Direct Cost (Cost of Health Care)				
Undiscounted	132	1,585	104	631
Discounted at 6% to the date of infection	47	560	37	223
Indirect Cost (Foregone Earnings)	890	2,669	2,425	5,093
Total Cost (Indirect plus Discounted Direct Cost)	937	3,229	2,462	5,316
Ratios				
Indirect Cost/ Direct Cost	19.1	4.8	65.9	22.8
Direct Cost/ Per Capita GNP	0.8	9.3	0.4	2.2
Total Cost/ Per Capita GNP	5.5	19.0	8.5	18.3

Note: All figures in 1985 US Dollars.

Source: From Over, Bertozzi and Chin (1989).

occupation than would an urban, secondary-educated patient. The greater range of estimates in Zaire than in Tanzania reflects the availability of more expensive medical treatment options and higher wages in the modern sector of the former country in 1985 than in the latter.

While useful for comparing the costs of different diseases to one another with a stationary distribution of disease, the Rice approach has several drawbacks for estimating the aggregate economic cost of AIDS in Sub-Saharan Africa (SSA). First, because it focuses on average rather than marginal costs, the Rice approach will misrepresent the increased medical treatment or lost production costs if the marginal cost of either differs from the average. In fact, the massive increase in African deaths due to AIDS is increasing the scarcity of medical resources and of certain classes of workers, thereby increasing the average "direct" and "indirect" costs as the epidemic progresses. Second, as demonstrated by Barlow (1967) and Barlow and Davies (1974) in their simulation of the impact of malaria eradication on Sri Lanka, the impact on well-being of a radical change in epidemiology may appear much different in the short run than it does in the long run after taking into account the feedback effects on the entire economy and on per capita consumption. In fact, Barlow's model is noted for plausibly arguing that, whatever its effect on well-being, malaria eradication might reduce per capita income in the long run.

The macroeconomic links between AIDS and growth have recently been analyzed by Rowley, Anderson and Ng (1990), Cuddington (1991), Cuddington and Hancock (1992) and Kambou, Devarajan and Over (1991).[7] Rowley and her co-authors focus their attention primarily on the epidemic's effect on national health expenditures due to AIDS treatment

[7] Also see Way and Over (1992) which combines the economic model estimated here with the demographic and epidemiologic estimates of the Interagency Working Group's model in a single "typical" African country.

costs and conclude that such costs would not be "affordable" or "sustainable" under a variety of alternative epidemiologic/demographic scenarios. However, because her production function assumes that national output is proportional to labor in each year by an exogenously growing factor of proportionality, her model cannot address the issue of the long-run impact of AIDS on GDP or on GDP per capita.

Cuddington (1991) and Cuddington and Hancock (1992) use a Solow-style one-sector, two factor growth model to predict economic growth paths in Tanzania and Malawi under alternative assumptions about the share of AIDS treatment costs financed from savings, and the loss in productivity of an AIDS case after the onset of symptoms and prior to death.[8] The two studies begin with World Bank projections of the demographic impact of AIDS, which predict that in the worst case scenarios Tanzania's population growth would slow by 0.7 percentage points and Malawi's by 1.2 points as a result of AIDS. When they assume that AIDS treatment costs have no impact on national saving and that living AIDS cases retain their full productivity, they find that, although GDP growth is reduced by 0.6 percentage points in Tanzania and by 1.1 points in Malawi, the epidemic slightly increases the growth of per capita GDP by 0.1 percentage points in each country. Under the assumptions they consider most plausible, that AIDS treatment costs are 100% financed from savings and each worker sick with AIDS is half as productive as he or she would ordinarily be, the rate of growth of GDP is reduced by 0.8 percentage points in Tanzania and by 1.5 percentage points in Malawi. With these larger impacts on GDP, the AIDS epidemic would reduce per capita GDP growth in Tanzania by 0.1 percentage points and in Malawi by 0.3 points.

Kambou, Devarajan and Over (1992) apply the eleven-sector computable general equilibrium model previously developed by Benjamin and Devarajan for Cameroon (1985) to the analysis of the impact of AIDS over five years in a single African economy, modeled as a one-time reduction in the labor-force of 10,000 workers. Like Cuddington and Hancock, these authors use calibrated rather than estimated behavioral equations. This model demonstrates the potential positive impact of the reduction of labor supply due to AIDS on the real wages of the remaining workers and predicts that the reduction of output caused by the loss of urban skilled workers is greater in all sectors than the reduction caused by the loss of an equal number of rural workers. Even in the cash crops sector, the loss of 10,000 urban workers has a seven times greater negative impact on than would the loss of 10,000 rural workers. However, in the capital goods, the construction and the services sectors, the negative impact is 100 times larger when the lost workers are skilled and urban.

---

[8] The model also incorporates, but finds little effect of, the reduction in average worker experience caused by AIDS deaths.

III. PROJECTING MACROECONOMIC GROWTH WITHOUT AIDS

A. AFRICAN GROWTH IN HISTORICAL PERSPECTIVE

The growth experience of the Sub-Saharan countries since 1960 is summarized in Table II and Figure 1. In the 1960's, the first decade after independence for many of these countries, the real value of gross domestic product grew relatively well at average rates close to 5% per year. However, population also grew rapidly during this period at a constant 3% per year, so that the net growth of per capita GDP remained less than 2%.[9]

Table II Average Growth Performance of Sub-Saharan African Countries

	GDP+	Population	GDP per Capita
1960-1965	4.7	2.9	1.8
1965-1970	4.6	2.9	1.7
1970-1975	4.3	3.1	1.2
1975-1980	3.3	3.1	0.2
1980-1985	0.8	3.0	-2.2
1960-1985	3.2	3.0	0.2

Averages are weighted by population. Growth rates are between first and last year of period.

Then in 1973 and 1978 the oil price shocks disrupted the growth of these countries. In Table II and Figure 1, the effects of these shocks and of globally high interest rates are first visible in the 1975-1980 growth period, when GDP growth dropped a full percentage point. Since population growth remained constant, the net growth of per capita GDP dropped to 0.2% or one-sixth of its former value. The situation was exacerbated during the 1980-1985 period by a substantial worsening of the terms-of-trade for Sub-Saharan Africa so that the average growth of GDP fell to only 0.8% and for the first time average per capita income in the continent declined at the rate of 2.2% per year, faster than it had ever risen. This is during

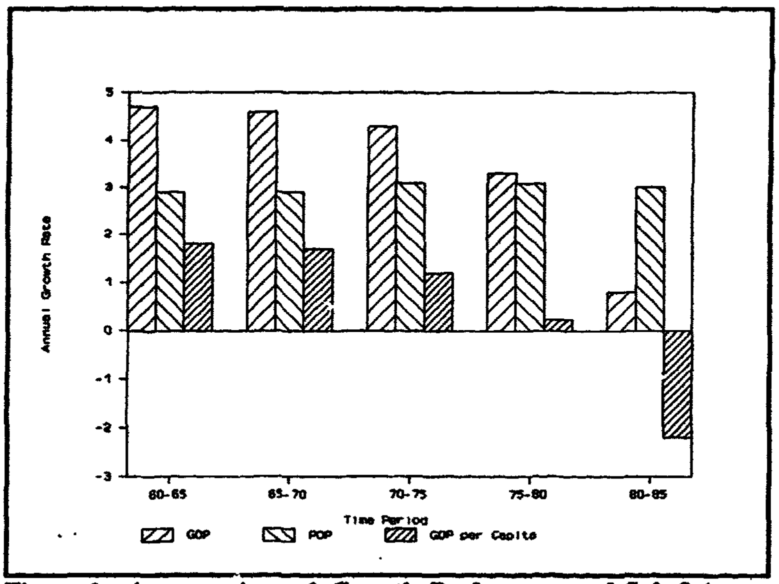

Figure 1 Average Annual Growth Performance of Sub-Saharan African Countries

[9] All economic data is from the World Bank's Economic and Social Database (BESD).

a period when per capita GDP in East Asia was rising at 6.7% and in South Asia at 3.2%, though Latin America has also been struggling with low or negative per capita growth rates.

Thus the AIDS epidemic strikes a continent already severely burdened by economic difficulties and excess population growth. To confront these difficulties, many SSA countries have adopted adjustment programs designed to reduce the level of protection of domestic private and parastatal enterprises and to increase the responsiveness of the economy to incentives. The result should be to increase the utilization of scarce human as well as physical resources and thereby to accelerate growth. The irony is that the AIDS epidemic is striking just at the moment when these resources are to be unleashed.

B. MODELLING THE LINK BETWEEN GROWTH AND THE LABOR FORCE

Table III Average Annual Growth Rates of Urban and Rural Output and Share of Rural Output by Five-Year Period, 1960 - 1985

	Urban Output	Agric. Output	Total Output	Share of Agric.+
1960-1965	9.7	2.9	4.7	51.7%
1965-1970	7.4	2.3	4.6	44.7%
1970-1975	6.6	1.5	4.3	40.0%
1975-1980	4.4	1.8	3.3	37.2%
1980-1985	1.4	0.4	0.8	36.2%
Overall Average	4.9	1.5	3.2	40.6%

* Averages are weighted by population. Growth rates are between first and last year of period.
\+ Agricultural share is for last year of period.

Source: World Bank Economic and Social Database.

In Sub-Saharan Africa the prevalence rate of HIV infection has typically been five to ten times higher in urban than in rural areas (Bongaarts and Way, 1989). To allow this pattern to influence the economic impact of AIDS, this paper models the growth process using two neoclassical production functions, one for the urban and one for the rural sectors. The use of a generalized Cobb-Douglas functional form for these production functions captures the assumption that the marginal cost of each additional lost worker is higher than that of the last. To operationalize the distinction between rural and urban production using the available data, we assume that all agricultural production is rural and all industrial and service sector production is urban.

Using these definitions, Table III presents the average growth rates of urban and rural production in the Sub-Saharan African countries together with the growth rate of total output repeated from Table II above. The last column of Table III gives the share of total output contributed by agriculture in each period. Note that urban sector output grew substantially faster than rural output in every period, but that the growth of both sectors declined markedly between 1960 and 1985. The result of a faster growth rate of the urban

Table IV The Relationship Between HIV Infection and Socio-Economic Status

Country (Date)	Type of Sample (Size)	Indicator of S.E.S.	Level of Socio-economic Status			
			Lower	**Middle**	**Higher**	
Zaire (1987)	Employees of urban textile factory (5951)	Job Category	**Worker** 2.8%	**Foreman** 4.6%	**Executive** 5.3%	
Rwanda (1987)	Urban wives in national sample (1255)	Education of Husband	**0-4 Years** 18%	**5-7 Years** 32%	**8+ Years** 34%	
		Monthly Income of Husband	**None** 22%	**< 10,000*** 25%	**> 10,000*** 35%	
		Job of Husband	**Farmer** 9%	**Soldier** 22%	**Private** 32%	**Gov't** 38%
Zambia (1985)	Patients, blood donors and staff of a hospital (1078)	Years of Education	**0-4 Years** 8.0%	**5-9 Years** 14.7%	**10-14 Years** 24.1%	**14+ Years** 33.3%

Sources: Allen et al. (1991), Melbye et al. (1986), Ndilu (1988).

sector has been its increasing share of national output, as demonstrated by the last column of Table III.

The principal factor inputs at this aggregated level are capital, arable land and labor. Disaggregating capital and land by the sector to which they contribute in each country is impossible with the available data. Therefore, the analysis uses the assumption that all capital contributes to urban (i.e. industrial and service sector) production and all arable land contributes to rural (i.e. agricultural) production. Labor can be disaggregated using data on the percentage of the labor force in agriculture and the percentage of the population that is urban.

The limited evidence available on the relation of infection rates to socio-economic status suggests a strong positive correlation between current levels of infection and economic productivity. First, by striking the urban work force more heavily than the rural one, the

AIDS epidemic is undermining the sector that Table III reveals to be the growth pole of African economies. Second, even within the urban area there is a pronounced "socio-economic gradient" of the epidemic.

Table V Average Annual Percentage Growth Rates of Factor Inputs in Sub-Saharan Africa: 1960-1985*

Factor of Production	SECTOR	
	Rural	Urban
Arable Land	1.1 (175/197)*	-
Capital+	-	0.3 (91/93)
Labor Force		
All Workers	1.58 (170/204)	5.61 (170/204)
Workers with no schooling	0.5 (162/197)	-0.9 (12/29)
Workers with some primary	18.1 (120/197)	2.4 (162/197)
Workers with some secondary	- (0/3)	16.9 (170/204)

* The two figures in parentheses are, respectively, the number of five-year growth rates in the average and the number of non-zero values of the underlying variable.

+ Capital is estimated for 1975, 1980, 1985.

Source: Bank Economic and Social Database.

Table IV presents the published univariate analyses of large national samples from Zaire, Rwanda and Zambia. Note that the three variables identified as positively correlated with infection in the Rwanda sample are also obviously correlated with one another. A multivariate analysis of the Rwandan data sorts out this multicollinearity to reveal that the most powerful single determinant of the wife's infection status, as measured by the size of the t-statistic, is the monthly income of the husband (Allen, et al., 1991). The odds of a woman being infected are twice as high if her husband has a higher income than if he has a lower one, after controlling for the woman's own sexual behavior and her past history of sexually transmitted diseases, among other variables. While it is plausible that the more highly educated, higher income men have changed their behavior at least as much as other social groups, there is not yet any evidence to confirm this hypothesis. In any event, such a behavior change would require five or ten years before it substantially affects the distribution of infection by socioeconomic status.

If infection is correlated with economic productivity such that the epidemic disproportionately kills the more productive, average productivity may fall rather than rise as the labor force growth is slowed, exacerbating the economic impact of the epidemic. To capture this effect in a macro-economic model requires a further disaggregation of the labor force by productivity within the urban and rural sectors. Using information on the enrollment rates of the appropriate age groups in primary and secondary school, the total labor force for each country in each year is disaggregated into six groups according to their schooling and the sector to which they contribute.[10] Table V presents the average annual growth rates for all eight of these factors of production. Note the relatively rapid growth rates of two categories of workers, those with some primary but no secondary working in the rural area and those with at least some secondary education working in the urban area. The rapid growth of urban areas is also absorbing some growth of the primary schooled workers.

Given this data it is possible to estimate the contribution of each of these factors of production to the African growth process over the period 1960-1985. Table VI presents the results from the urban and rural production function estimates respectively. Because there are so few observations on which substantial numbers of uneducated workers contribute to urban production, or on which secondary schooled workers contribute to rural production, these two labor force categories are dropped from the production functions. The functional form specified is a generalization of the Cobb-Douglas function, where the two labor inputs are transformed by the Box-Cox transformation to allow production with zero quantities of either. Table VI reports the likelihood maximizing value of lambda, the Box-Cox parameter, for each sector and the other statistical results are conditional on this value of lambda. The rural production function is estimated with ordinary least squares on data from the six quinquennial years between 1960 and 1985. Because of the simultaneous determination of current capital stock urban and output, the capital stock variable is instrumented in the urban production function. The constant terms and coefficients of the fixed regional effect dummies are suppressed, but the F-statistic testing the hypothesis that all regional dummies are zero is presented. Conditional on the value of lambda, all coefficients of factor inputs and the coefficient of the time trend are statistically significant at the five percent confidence level.[11]

[10] Defining L0, L1 and L2 as the portions of the labor force having no, some primary and some secondary schooling, we estimate the six labor force categories from the secondary enrollment rate lagged five years (SERL) and from the primary enrollment rate lagged ten years (PERL) as follows:

$$L2 = SERL * LF ,$$
$$L1 = PERL * LF - L2 ,$$
$$L0 = \max\{0, LF - L2 - L1\} .$$

Then the urban and rural labor force variables are created from the available data on the agricultural labor force AGLF as follows:

$$URLF = LF - AGLF$$

$URL2 = \min\{L2, URLF\}$	$AGL2 = \max\{0, L2\text{-}URLF, AGLF\}$
$URL1 = \max\{0, \min\{URLF\text{-}URL2, L1\}, L1\}$	$AGL1 = \max\{0, L1\text{-}URL1, AGLF\}$
$URL0 = \max\{0, URLF\text{-}URL2\text{-}URL1\}$	$AGL0 = \max\{0, AGLF\text{-}AGL2\text{-}AGL1\}$

See Lau, Jamison and Louat (1991) for an alternative approach to estimating the annual flow of services from human capital which does not distinguish the urban and rural sectors.

[11] A dummy variable was also included in the regression equal to one for those observations in years 1975-85 for which it was impossible to construct a capital stock estimate. Its use permits the inclusion of an additional 8 observations in estimating the urban production function, which improve the precision but do not change the character of the results. Region-specific fixed effects are preferred to country-specific fixed effects in order to retain international variation as a source of output differences within regions. The six African

Some features of these estimates are worthy of note. The high output elasticity of capital of .75 is partly due to the maintained assumption that its contribution is only to urban production. Secondary school educated labor also has a high output elasticity of 0.41, while the urban output elasticity of primary school educated labor is only 0.13, both evaluated at the sample

Table VI Estimated Rural and Urban Production Function For Sub-Saharan African Countries, 1960-1985

Independent Variables	Coefficients (t-Statistics)		Output Elasticities	
	Rural	Urban	Rural	Urban
Arable Land	0.33 (5.2)		0.33	
Capital+		0.75 (8.0)		0.75
Labor				
Unschooled	0.0014 (8.3)		0.23	
Primary School	0.0013 (8.1)	0.0082 (2.6)	0.43	0.13
Scndry School		0.0274 (4.3)		0.41
Time Trend	not significant	-.0328 (-2.8)		-0.66
F on Regions	9.0 df=(5,152)	5.0 df=(5,87)		
Lambda	0.41	0.20		
Years Included	1960-1985	1975-1985		
No. of Obsrvtns	161	98		
R-Squared	0.817	0.916		
F on Regression	84.8 df=(8,152)	92.3 df=(10,87)		

Notes:
* The dependent variables and land and labor are in logarithmic form. The time trend is linear and the labor force variables are entered as Box-Cox transformations. The output elasticities of the labor force variables are computed at the sample means.
+ Capital is instrumented in the urban equation.

---

regions used are based on World Bank geographic country groupings and are defined as follows: Region 1: Benin, Cameroon, CAR, Congo, Cote d'Ivoire, Gabon, Togo; Region 2: Ethiopia, Kenya, Somalia, Sudan, Uganda; Region 3: Burundi, Madagascar, Rwanda, Zaire; Region 4: Ghana, Guinea Bissau, Liberia, Nigeria, Sierra Leone; Region 5: Burkina, Chad, Gambia, Mali, Mauritania, Niger, Senegal; Region 6: Botswana, Lesotho, Malawi, Tanzania, Zambia, Zimbabwe. Data problems cause the exclusion of Angola, Mozambique, Equatorial Guinea, Mauritius and Swaziland from the estimations.

mean.[12] The sum of these three elasticities is 1.29, indicating increasing returns to scale in urban production at the sample mean. These increasing returns have been offset in recent years, however, by a strong negative trend in average factor productivity of 3% per year, with an output elasticity with respect to time of -.66. This strongly negative time trend reflects both adverse external effects on African productivity and a deteriorating policy environment in many countries.

In the rural production function, for which more observations are available, the quantity of arable land makes its expected strong contribution to output with an output elasticity of .33. The two categories of rural labor both contribute substantially, with the output elasticity of workers with some primary school education being larger (at .43) than that of those without schooling (.23) at the sample mean. The returns to scale in rural production are approximately constant. A time trend was dropped from this equation because its coefficient was not significant.

Table VII reports the medians of the estimated marginal products of labor in the two productive sectors. As expected, secondary school educated labor has the highest marginal product of 2,139 1980 $US per year and workers with no schooling have the lowest marginal product of US$218 per year, ten times less. Workers with primary, but no secondary school education have an intermediate marginal product, equal to US$422 in the rural sector and US$462 in the urban sector.

Table VII Median Estimated Marginal Products of Labor (1980 US Dollars)

Labor Force Category	Rural	Urban
Unschooled	218	-
Some Primary Schooling	422	462
Some Secondary Schooling		2,139

Source: Estimated from production functions in Table VI above.

The similarity of median marginal products of primary school workers in the urban and rural sectors suggests the operation of a labor market for this category of worker, which would induce migration from one sector to the other in response to a wage rate differential. To test this hypothesis, we estimated various regressions of rural-to-urban migration rates on lagged estimated marginal products of the four categories of workers. The failure of the lagged marginal products to explain a significant proportion of the variation in differential migration rates supports the hypothesis adopted in the rest of this paper that rural-to-urban migration can be treated as an exogenous demographic pattern,

[12] These empirical results contrast with Cuddington's (op. cit.) assumption that the elasticity of output with respect to (a single category of) labor is 0.7. Higher elasticities of output with respect to labor would increase the estimated impact of the epidemic reported in the rest of this paper.

which is not primarily responsive to short-run movements in the wage differential between the urban and rural sectors.[13]

C. MODELLING AND PROJECTING AFRICAN CAPITAL ACCUMULATION

To estimate the level of capital stock in 1975, 80 and 85, we apply the perpetual inventory method, accumulating gross domestic investment since 1960, using a five percent annual depreciation rate and assuming that, by 1975, the quantity of capital left from before 1960 is an insignificant determinant of output. To project capital stock forward, we assume that gross investment in each future year will equal the sum of foreign savings, projected exogenously as described below, and domestic savings determined jointly with domestic output. Following Griffin and Enos (1970), Papanek (1972, 1973) and other authors, domestic savings is assumed to depend on foreign savings as well as on the two components of gross domestic

Table VIII Estimated Domestic Savings Behavior in Sub-Saharan African Countries, 1960-85.

Independent Variables	OLS	IV	GIV
Urban GDP	.22 (12.1)	0.20 (7.6)	.22 (8.6)
Rural GDP	.0093 (0.3)	.072 (1.4)	.060 (1.4)
Foreign Savings	-1.3 (-17.0)	-0.63 (-5.9)	-0.60 (7.1)
Years Included	1960-1985	1960-1985	1960-1985
No. of Obs.	154	148	148
R-Squared	0.95		
F-Statistic	989.0 df=(3,151)		
Root MSE	8.2e+08	2.7e+08	4,184

Notes: OLS: Ordinary Least Squares; IV: Instrumental variable estimation; GIV: Generalized instrumental variable estimation. The IV and GIV estimates treat all independent variables as endogenous. All regressions are estimated in linear form without constant terms.

[13] The absence of accurate wage and urban unemployment data prevented the estimation of a Todaro model, which might have been more successful at explaining rural-to-urban migration. See Hatton and Williamson (1992) for a recent exposition of the Todaro model and an empirical confirmation of the model for historical U.S. data. However, the African case may resemble more closely the European historical period studied by Weir (1989, p.25), who found "substantial negative consequences of population growth for real wages, at least up through 1750, [but] little effect of population growth on the rate of urbanization."

product.[14] However, as pointed out by Over (1975) and Bowles (1987) among others, the causal links between foreign and domestic savings run both ways. For comparison, Table VIII presents ordinary least squares estimates as well as the instrumental variable (IV) estimates of the parameters of the savings function. Because analysis of the residuals of the IV estimates reveals pronounced heteroskedasticity, the third column presents the final parameter estimates obtained by dividing the variables by the square root of GDP prior to estimation.

According to Table VIII, the estimated marginal (and average) propensity to save out of urban (i.e. industrial and service sector) output is approximately three and a half times larger than that out of rural (i.e. agricultural) output.[15] This result accords with the hypotheses of two-sector growth models and helps to validate the approach used in this paper for capturing the impact of AIDS. The statistically significant negative impact of foreign savings on domestic savings confirms the Griffin and Enos (1970) result both in direction and magnitude and is predictable from the assumption that countries behave as if they consider foreign and domestic savings as gross substitutes.

Although we have assumed that foreign and domestic savings have been jointly determined in the sample, we choose to project foreign saving exogenously as explained in the next section. Thus, given urban and rural output, it is possible to project future domestic savings and hence gross domestic investment and capital accumulation.[16]

---

[14] Although life-cycle models of saving behavior suggest that the dependency ratio would affect aggregate saving, Shumaker and Clark (1992) have confirmed Hammer's earlier (1986) conclusion that any such effects are unstable across countries and over time. In any event the demographic models of AIDS predict little change in the dependency ratio due to AIDS (United Nations/WHO, 1991).

[15] This estimate of the rural savings rate is approximately the same as Cuddington's (op. cit.) assumption regarding the single national savings rates in Tanzania and Malawi. The effect of modelling the African savings behavior with a single smaller savings rate is to increase the predicted percentage impact on savings of any given absolute reduction in savings due to the cost of AIDS treatment.

[16] Since the savings equation of Table IX predicts annual savings, but the projection is calculated for every fifth year, additional assumptions are needed to predict the capital stock in every fifth future year. Suppose that capital stock is accumulated from investment using the perpetual inventory method: $K_t = .95\, K_{t-1} + I_t$. Then

$$K_{t+5} = (.95)^5\, K_t + \sum_{s=0}^{4} (.95)^{4-s}\, I_{t+s}$$

Assuming I_{t+s} is constant at I_t for all s = 0, 1, ..., 4, the projection equation for K_{t+5} becomes:

$$K_{t+5} = .7738\, K_t + 4.5244\, I_t\ .$$

D. PROJECTING THE EXOGENOUS GROWTH DETERMINANTS

The baseline growth projection in the absence of AIDS is founded on projections of the exogenous variables in our model: arable land, population and six categories of labor force. Although the total area of individual African countries has changed little since 1960, arable land has increased as a percentage of that total in most countries. A regression of the logit of arable land as a percentage of total land on that value lagged, a fixed effect dummy for each country and a positive linear time trend explains 99.7 percent of the variance of the transformed dependent variable. The logistic specification allows the growth rates of countries which currently use much less than their total land for agriculture to expand their arable land at a faster rate than those which are already close to their upper limit. Despite the presence of the lagged dependent variable, both the fixed effects and the time trend are significant at better than the one percent level. This equation is then used to project the growth of arable land through the year 2025 at a rate specific to each country's past land development pattern and maximum available land. The average Sub-Saharan country is projected to expand its arable land at 0.8 percent per year.

Table IX Projected Average Growth Rates of Factor Inputs in Sub-Saharan Africa without AIDS: 1990-2025*

Factor of Production	SECTOR	
	Rural	Urban
Arable Land	0.8	-
Capital+	-	4.7
Labor Force		
All workers	1.6	5.6
Workers with no schooling	-6.4	-
Workers with some primary	5.1	-5.4
Workers with some secondary	-	5.8

\+ All variables are projected exogenously except capital stock, which is endogenously determined. Averages include 34 countries.

Source: See text.

The base "no-AIDS" scenario uses the World Bank population projections through the year 2025 and the ILO labor force estimates for past years to project the aggregate size of the labor force in each African country. To subdivide each national labor force estimate into six categories requires additional projections of the urban percentage of that labor force and of the rates of secondary and primary school enrollment. We proceed as in the case of arable land above by regressing logistic transformations of the variables to be projected, including labor force as a percentage of the population, urban population as a percentage of total, and primary and secondary enrollment rates, on their lagged values, a set of country-specific dummy variables and a time trend. Having projected the labor force and the primary and secondary enrollment rates lagged ten and five years respectively, we apply the algorithm in footnote seven above to project the size of the six labor force aggregates in each year. Then, to accommodate the assumption of only two skill categories in each sector, we combine the projected rural secondary school educated labor into the primary school educated class and similarly we combine the uneducated urban labor into the primary educated urban labor force. This amounts to the assumption that the marginal productivities of the combined groups are roughly similar, given the structure of the labor markets in the respective sectors.

The first column of Table IX presents the resulting average growth rates of the exogenous inputs to the rural sector over the period 1990 through 2025. Note that uneducated labor is projected to shrink rapidly in the typical country while primary educated rural labor is projected to grow rapidly. Projections of these variables and arable land permit an immediate projection of rural output by country and quinquennial year, a projection which will clearly be affected by an alteration in the assumed growth rate of the rural labor force aggregates caused, for example, by an AIDS epidemic.

One further exogenously projected variable is the level, positive or negative, of foreign savings, which is the resource gap between imports and exports or between investment and domestic saving. Although foreign saving is likely to have been jointly determined with domestic saving in the past, for the purposes of projections we assume that any value of foreign savings different from zero is evidence of a disequilibrium, and that such disequilibria will be eroded over time by a combination of market forces and improved policy. Therefore we project future values of foreign saving by assuming that each country will gradually evolve from its 1985 value (positive or negative) towards zero by an arbitrarily chosen one-third of its current value every five years.

E. PROJECTING AGGREGATE AND PER CAPITA GROWTH WITHOUT AIDS

A straightforward projection of rural (i.e. agricultural) output using the estimated rural production function (embodying diminishing returns to each factor) and the assumed future changes in rural labor force composition produces a predictable but implausible result: the marginal product of the increasingly abundant labor force category, primary educated labor, falls toward zero, while that of the increasingly scarce category, uneducated labor climbs ever higher. Recognizing that mobility of more highly trained workers to jobs requiring less training is easier than the reverse, we assume that the primary educated workers will compete with the uneducated workers for the unskilled rural jobs until the marginal products of the two labor force categories are equal.[17]

[17] However, in view of our finding mentioned above that rural to urban migration does not respond to wage differentials, we assume that this kind of arbitrage occurs only within each of the two sectors and not between them. Furthermore, we assume that the diminishing marginal productivity of a class of workers does not decelerate the training of this class of workers, at least within the time frame of our projection.

In order to implement this assumption, define the unskilled rural labor force in country i and year t ($URLF_{it}$) as the sum of uneducated rural workers, $AGL0_{it}$, and enough primary-educated rural workers, $AGL1_{it}$, to assure that the marginal product in unskilled rural jobs is no greater than that in skilled rural jobs. If uneducated workers are sufficiently plentiful in a certain country and year to make their estimated marginal product at least as large as that of rural primary-educated workers, then $URLF_{it}$ is identically equal to the number of primary-educated rural workers. However, when uneducated rural workers become scarce, $URLF_{it}$ is never less than the output maximizing proportion of total rural labor. In our case this relationship is:

$$URLF_{it} = \max\left\{AGL0_{it},\ \left(\frac{G}{1+G}\right) AGLF_{it}\right\},$$

where

$$G = \left(\frac{\beta_0}{\beta_1}\right)^{\left(\frac{1}{1-\lambda}\right)},$$

β_0, β_1 and λ are respectively the estimated coefficients of $AGL0_{it}$, $AGL1_{it}$ and the Box-Cox transformation parameter from Table VI above.

Substituting from Table VI, the minimum proportion of the rural labor force in unskilled jobs will be 53% in all time periods. Similar analysis and computations apply to the urban sector, where the conclusion is that the minimum proportion of the urban labor force in jobs requiring only some primary education is 18%.

To estimate year $t+5$ urban output, we begin by using the equation in footnote 9 above to estimate the year $t+5$ capital stock based on year t foreign and domestic saving and capital stock. Before this information can be combined with the projected labor force, we need to address the issue raised by the negative estimated coefficient of the linear time trend in the urban production function reported in Table VI. The inclusion of such a trend in a production function is intended to capture all the excluded variables which vary systematically with time and affect economic product. Traditionally the primary such variable has been technical progress, which typically contributes positively to growth. But in the case of Africa, the time trend captures, not only technical progress, but also the deterioration in several important exogenous determinants of economic growth: the terms-of-trade, the climate and the policy environment. Since the estimated coefficient of the time trend is negative at the 99% confidence level, the combined effect of all these unmeasured influences was significantly negative over the period. The question arises whether to predict a similar negative trend into the future.

Since the purpose of the present exercise is to predict the impact of the AIDS epidemic on the growth process, and since we have no way of plausibly modeling the impact of the epidemic on the rate of technical progress, we adopt the pragmatic approach of focusing on <u>differences</u> between a baseline growth scenario for Africa and a scenario with the AIDS epidemic. We calibrate the baseline urban growth scenario arbitrarily by adjusting the coefficient on time until the average growth of per capita income is slightly positive as is projected for example in the World Bank's recent long-term projections (World Bank, 1991). The value of the time coefficient that achieves this result is one third of the estimated value, -0.011.

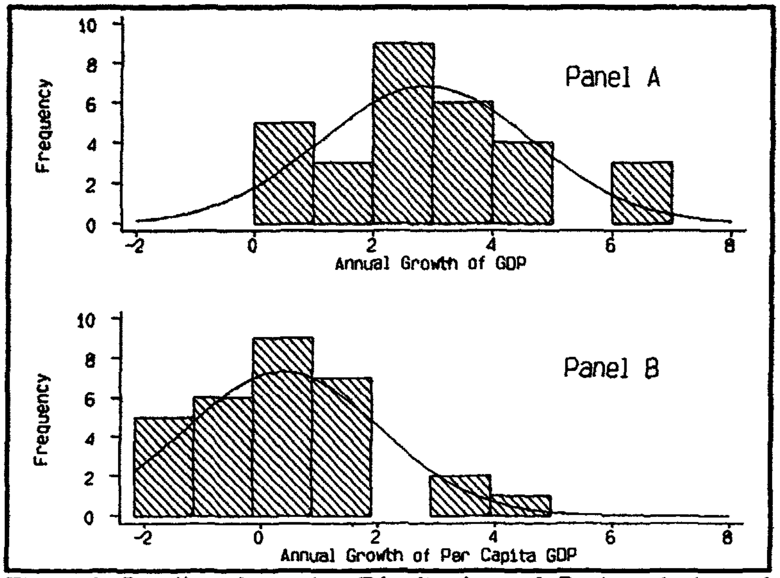

Figure 2 Baseline Scenario: Distribution of Projected Annual Growth Rates of 30 African Countries without an AIDS Epidemic

Figure 2 presents the histograms of the projected baseline growth performances of the 30 sample countries for which projections can be calculated.[18] Panel A at the top of the figure describes the distribution of estimated growth of total gross domestic product and Panel B of per capita GDP.

IV. MODELLING THE AIDS EPIDEMIC

A. A SIMPLE MODEL OF THE DEMOGRAPHIC IMPACT OF AIDS

In 1989 the United Nations sponsored a workshop at which the authors of several models of the demographic impact of AIDS on Sub-Saharan Africa were asked to run their models under similar assumptions so that the results could be compared (UN/WHO, 1991). The three sets of assumptions used might be called the optimistic, the pessimistic and the medium scenarios. While not all participating model builders complied precisely with the requested input parameters and two of the most prominent mathematical modelers of the

[18] Of the 34 countries in the estimation sample, Chad, Gabon, Lesotho and Uganda are missing 1985 capital stock estimates and thus cannot be used in the projections.

AIDS epidemic, May and Anderson,[19] refrained from submitting results of their model for comparison at the workshop, the results are nevertheless significant for revealing an initial consensual view of the most likely growth path of the AIDS epidemic in a typical West African country. That growth path is not unlike the "severe" epidemic path predicted by the earlier work of Bongaarts (1988, 1989a, 1989b). After 25 years, Bongaarts' severe AIDS epidemic reaches a plateau level of 21% of the national adult population infected, reduces the life-expectancy by about ten years and almost quadruples the mortality rate of adults. An epidemic this severe would, Bongaarts projects, reduce the population growth rate by 1.3 percentage points. Since the average SSA country is currently growing at 3.2% per year, an epidemic as severe as this will not cause a decline in the population of an average SSA country.

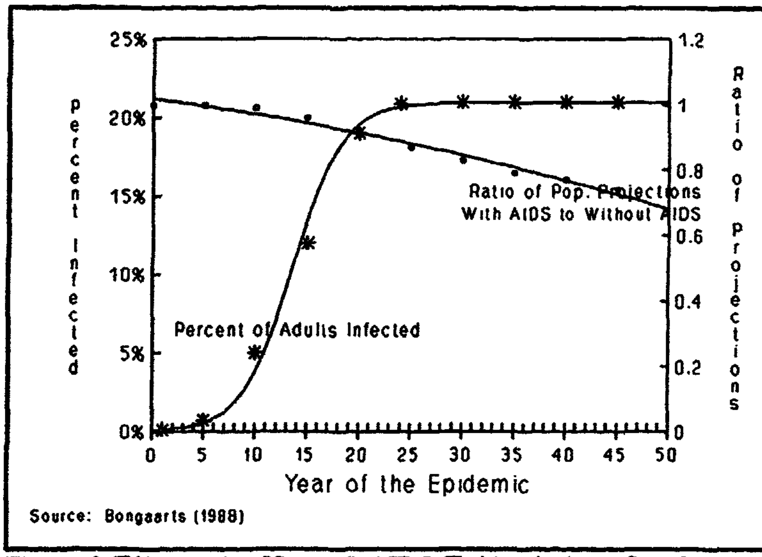

Figure 3 Effects of a "Severe" AIDS Epidemic in a Sub-Saharan Country on Infection Rate and Total Population: Left axis measures infection rate and right axis measures ratio of population without AIDS to population with AIDS in each year.

The purpose of this paper is not to investigate alternative projections of the demographic impact of AIDS, but rather to explore the effect of alternative assumptions about the distribution and financing of the epidemic on the economic consequences of an epidemic of given magnitude. Therefore, we adopt a standard temporal profile of an African AIDS epidemic based on the Bongaarts model (op cit.) as depicted in Figure 3. Given the assumed standard scenario of seroprevalence increasing to 21% among all adults by the twenty-fifth year of the epidemic (depicted by the logistic curve plotted against the left axis in Figure 3), the Bongaarts model predicts that the population growth rate would be about 1.3% smaller at the end of 25 years than it would have been without AIDS and will then continue at this lower positive rate. In Figure 3 the line plotted against the right axis is PLIVE, the ratio of the population size in the presence of this epidemic to the size the population would have attained that same year without the epidemic. Note that it declines very little the first fifteen years of the epidemic and then

[19] See May and Anderson (1988), Rowley, Anderson and Ng (1990) and Anderson et al. (1991) for expositions and references.

declines more quickly, until in the fiftieth year the population is predicted to be 32 percent smaller than it otherwise would have been because of the epidemic.[20]

A central epidemiological puzzle regarding the African AIDS epidemic is the source of variation in infection rates across countries. One hypothesis is that the only difference among countries is the date that the virus first arrived. According to this hypothesis, all countries will eventually experience the same epidemic, unless their populations change their sexual behavior. An alternative hypothesis advanced, for example, by Bongaarts and Way (1989), is that existing differences in sexual behavior, circumcision practices and the prevalence of other sexually transmitted diseases across SSA countries contributes to the explanation of current differences in infection level. Under this latter hypothesis, some countries would experience much less severe epidemics than others, even in the absence of behavioral change. In this paper we adopt the simpler and more pessimistic hypothesis - that all SSA countries are epidemiologically similar, being differentiated only by the time their first residents contracted HIV infection.

To project the course of the HIV epidemic in each country, we observe the HIV infection rate of that country's adult population in 1985 (estimated from Table 1 in Bongaarts and Way, 1989). We then use the logistic curve in Figure 3 to determine from the infection rate (on the left axis), the year of that country's epidemic (on the horizontal axis). Finally, we use the PLIVE curve in Figure 3 to compute the AIDS scenario population in each future year. This procedure produces projections of national AIDS epidemics in the Sub-Saharan African countries which differ from one another only in their timing, not in their magnitude. Once the values of PLIVE have been generated in this way for each country and year in the sample, a country's value of PLIVE in a given year can be used to gauge whether a country is relatively early or late on the epidemic trajectory. For

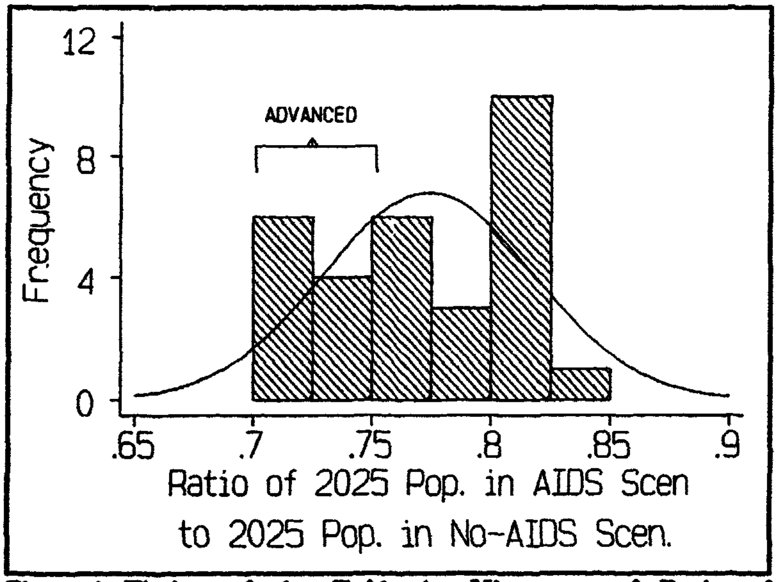

Figure 4 Timing of the Epidemic: Histogram of Ratio of Populations Projected in the AIDS and No AIDS Scenarios in the Year 2025 for 30 SSA Countries

[20] Since a population growing at 3 percent per year would have increased by 4.38 times over that period, a 32% smaller population would still be four times larger than in the base year of the projection - and would still be growing.

example, Figure 4 presents the frequency distribution of values of PLIVE in 2025 for all 30 countries in the projection sample. The figure distinguishes one group of ten countries that are "advanced" and will therefore experience more severe impacts before 2025 than the other countries. In subsequent presentation of the results, the advanced countries are singled out for special attention.

Since an AIDS epidemic is predicted to have little impact on the dependency ratio (Bongaarts, 1988, UN/WHO, 1991), the proportion PLIVE can be equally applied to the population and to the aggregate labor force projections to obtain projections of these variables in the AIDS scenario.

B. MODELLING THE EFFECT OF AIDS ON HUMAN CAPITAL

An objective of this paper is to explore the sensitivity of economic growth projections to alternative assumptions regarding the distribution over socio-economic categories of the labor lost to the AIDS epidemic. Following the notation of footnote 7, suppose that the total labor force LF_{it} in year t and country i can be disaggregated into three skill categories such that $LF = LO_{it} + L1_{it} + L2_{it}$. The proportion of the baseline labor force lost, $(1 - PLIVE_{it})$, can then be written as a weighted average of the proportions lost in each of these three skill groups in each country and year:

$$(1-PLIVE_{it}) = P0_{it}\left(\frac{L0_{it}}{LF_{it}}\right) + P1_{it}\left(\frac{L1_{it}}{LF_{it}}\right) + P2_{it}\left(\frac{L2_{it}}{LF_{it}}\right)$$

where PK_{it} is the proportion of skill group K lost to the epidemic in a given year and country. If the epidemic is evenly distributed across skill categories, then $PK_{it} = (1 - PLIVE_{it})$ for all K. However the evidence of Table IV above suggests that the proportion lost will be larger at higher skill levels. In order to parameterize this gradient for sensitivity analysis, we choose a parameter α of proportionality between adjacent skill classes, which is assumed to remain constant for all countries and all years in a given simulation. Thus,

$$P2 = \alpha P1 = \alpha^2 P0$$

so that

$$P0_{it} = \frac{(1 - PLIVE_{it})\, LF_{it}}{L0_{it} + \alpha L1_{it} + \alpha^2 L2_{it}} ,$$

defines the proportion lost in the lowest skill category for a given choice of α and the $P1$ and $P2$ are α and α^2 larger. In the sensitivity analysis, we vary α around the value one, representing the situation where all members of the population are at equal risk, to alternative values of one half, representing an epidemic which disproportionately infects the less educated, up to an extreme value of four.[21]

In order to compute the annual medical treatment cost of AIDS and its impact on national savings, we also must estimate the distribution of annual adult deaths by socio-economic class that is consistent with the epidemic scenario defined by α. Assume that the proportion of adult deaths in country i in year t and in socio-economic/education/skill class k is proportion PK_{it} of total adult deaths in that year, $DK_{it} = PK_{it} \bullet D_{it}$, where PK_{it} is defined as above as a function of the parameter α and the variable $PLIVE_{it}$ and total adult deaths is defined as two-thirds of the total deaths that are consistent with the above demographic scenario.

C. MODELLING THE EFFECT OF AIDS TREATMENT COSTS ON SAVINGS

As discussed in Section I above, AIDS treatment is costly. Furthermore, the cost of treatment varies with the socio-economic status of the individual in ways that are not entirely understood. An assumption consistent with the findings cited in Section I is that the cost of treating an AIDS case varies from one to four times the GDP per capita depending on the socio-economic class of the patient. In the simulations, we assume that an uneducated individual consumes resources worth the per capita GDP of the country, one with primary education consumes twice per capita GDP, and one with secondary education, four times per capita GDP.[22]

The macroeconomic impact of AIDS treatment costs depends on how they are financed. To the extent that these costs are financed by reducing other government or private consumption, they will have no impact on the future growth of GDP. However, if the cost of treating AIDS patients is financed from saving - and this reduction in savings is not offset by increased foreign saving - investment will be reduced and future growth will suffer. Whether this reduction is large enough to have a substantial impact on growth depends on the empirical size of aggregate saving in a given economy in comparison to the potential magnitude of AIDS treatment cost.

In order to capture the alternative possibilities, we define the parameter σ to be the proportion of AIDS treatment costs deducted from savings. In the simulations, we vary σ from 0%, the scenario in which treatment costs have no impact on future capital

[21] A value of α equal to four represents the situation where secondary educated workers are at 16 times greater risk of infection than uneducated workers.

[22] While these assumptions are consistent with observed government and behavior in Sub-Saharan African countries, they do not include the possibility that expensive anti-viral medications like AZT will become available to the African population in the future. If this were to occur without substantial price reductions, the impact on treatment costs would be substantial.

accumulation, to 50% and then to 100%, the scenario in which treatment costs have their maximum impact.

V. PROJECTING MACROECONOMIC GROWTH WITH AIDS

A. IMPACT ON GROWTH OF GDP

The simulations reported in this section explicitly explore the sensitivity of the projected growth of SSA countries with respect to the distribution and financing of the epidemic. But for any given distribution and financing assumptions, other natural differences across countries which cause variation in the productivities or the growth rates of any of the six factors of production will also vary the impact of the epidemic. The most important of these other variables is the timing of the epidemic. The ten countries which are more "advanced" along their epidemic paths as defined in Section II and Figure 4 above, are projected to experience a more severe impact between now and 2025. If the other countries follow the same pattern, they will experience similar impacts later.

Table X Average Impact of AIDS on Annual Growth of GDP 1990-2025 By Distribution, Financing and Timing of the Epidemic

	Financing Scenarios (Percent Financed from Savings)		
Distribution Scenarios	$\sigma = 0\%$	$\sigma = 50\%$	$\sigma = 100\%$
Downward Biased $\alpha = 0.5$	-.56 *-.73*	-.62 *-.80*	-.68 *-.88*
Evenly Distributed $\alpha = 1$	-.68 *-.91*	-.75 *-.99*	-.82 *-1.08*
Upwardly Biased $\alpha = 2$	-.81 *-1.09*	-.88 *-1.18*	-.96 *-1.28*
Extremely Upwardly Biased $\alpha = 4$	-.92 *-1.27*	-1.00 *-1.37*	-1.08 *-1.47*

Entries are average difference in the projected growth rate between the baseline scenario and the AIDS scenario under the designated assumptions. Averages are over 30 countries for figure in normal type and over the ten countries with the most "advanced" epidemics for the figure in italics.

Table X presents the average impact on the growth rates of GDP for both the advanced and the average SSA country over the period 1990 through 2025, by the epidemic's distribution and financing. Figure 5 below presents graphically the italicized figures from Table X, which are the impacts on the ten countries with the most advanced epidemics.

Since the AIDS epidemic reduces the growth rate of the labor force, it is not surprising that ***it reduces the growth rate of aggregate GDP under all twelve combinations of distribution and financing assumptions.*** Furthermore, note that both the distribution and the financing parameters influence the impact in the expected direction: ***when a larger proportion of the lost labor is from the more highly educated groups (α = 2 or 4), or when a larger proportion of the cost of treating AIDS patients is financed from savings (50% or 100%), the negative impact on the growth rate of gross domestic product is larger,*** up to a maximum of a percentage point reduction in the GDP growth rate for all 30 countries and a 1.47 point reduction in the GDP growth rate of the countries with the most advanced epidemics in the worst s^enario.

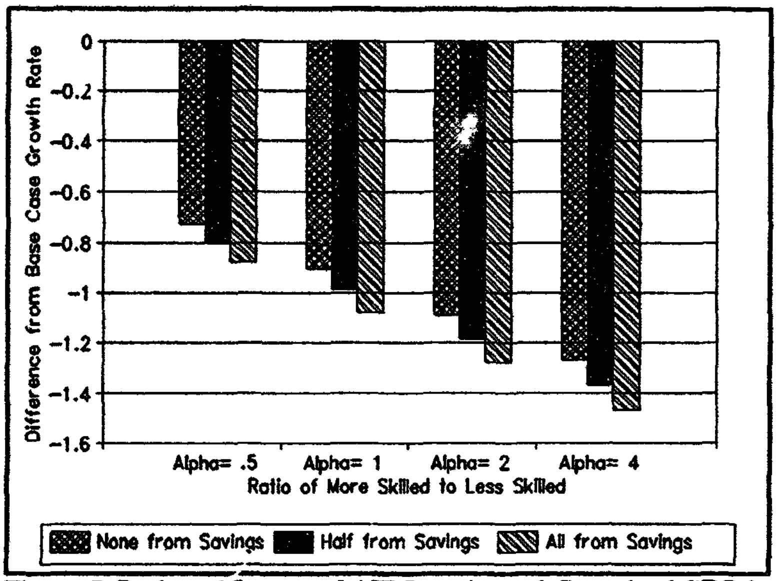

Figure 5 Projected Impact of AIDS on Annual Growth of GDP in 10 Countries with Most Advanced Epidemics: Sensitivity to Distribution and Financing Parameters

Since the secondary educated AIDS patients are assumed to consume four times more medical treatment resources than those with no education, an expected result is that ***the impact of financing medical treatment out of savings will be higher if the epidemic is biased toward the more educated classes.*** Table X demonstrates this interaction effect between the distribution of the epidemic and the way it is financed. The impact of increasing the percentage of AIDS treatment costs financed from savings from zero to 100% is one third larger when the epidemic strikes disproportionately those individuals whose treatment cost is larger (α=4), than when it spares them (α=0.5).

B. IMPACT ON GROWTH OF GDP PER CAPITA

Since the alternative distribution and financing scenarios are assumed to have no effect on the aggregate size of the epidemic, each country experiences reduced population growth of the same magnitude in all simulation runs. The average impact on population growth is -0.73 across all 30 countries and -0.86 in the ten countries with the most advanced epidemics. If a projection scenario predicts a negative impact of AIDS on GDP growth which is smaller (larger) than the projected negative impact on population growth, the consequence is projected to be an increase (decrease) in the growth rate of per capita GDP. Thus examination of Table XI reveals that the impact of AIDS on per capita growth will only be negative in the average country if the epidemic is at least evenly distributed across the skill classes and at least half of the treatment costs are financed from savings. In the countries with the most advanced epidemics, the impact on per capita growth will be slightly negative even when the epidemic is distributed toward the poorest groups, provided 100% of the treatment costs are financed from savings. Table XI presents these per capita growth rates for the same scenarios analyzed in Table X and Figure 6 portrays the results for the ten most advanced epidemics.

Table XI Average Impact of AIDS on Annual Growth of GDP Per Capita 1990-2025 By Distribution, Financing and Timing of the Epidemic

	Financing Scenarios (Percent Financed from Savings)		
Distribution Scenarios	$\sigma = 0\%$	$\sigma = 50\%$	$\sigma = 100\%$
Downward Biased $\alpha = 0.5$	.17 *.13*	.11 *.06*	.05 *-.02*
Evenly Distributed $\alpha = 1$	.04 *-.05*	-.02 *-.13*	-.09 *-.22*
Upwardly Biased $\alpha = 2$	-.08 *-.23*	-.15 *-.32*	-.23 *-.41*
Extremely Upwardly Biased $\alpha = 4$	-.18 *-.40*	-.27 *-.50*	-.35 *-.60*

Entries are average difference in the projected growth rate between the baseline scenario and the AIDS scenario under the designated assumptions. Averages are over 30 countries for figure in normal type and over the ten countries with the most "advanced" epidemics for the figure in italics.

Under the worst of the analyzed scenarios of Table XI, the reduction in per capita growth rates for the average Sub-Saharan African country is projected to be approximately one third of a percentage point. Remembering that the average African country has achieved no better than a two percent growth rate in GDP per capita since 1960 and that average growth in recent years has been zero or even negative (see Table II above), a reduction of one third of a percentage point is a substantial decrease over the next 35 years. However, note that ***the maximum reduction in the growth rate of the ten countries with the most advanced epidemics is projected to be almost twice as large, -0.6 percentage points.***

While the extreme assumptions give the most negative results, these assumptions may not be the most realistic. The evidence presented on urban populations in Table IV above is more consistent with a value of α, the socio-economic gradient of the epidemic, closer to two than to four. On the other hand, the seroprevalence rates in urban areas continue to be five or more times greater than in rural areas. Thus a conservative assumption is that the epidemic is "upwardly biased" in the average SSA country with a value of α equal to two. While no evidence is available on the likely proportion of AIDS treatment costs to be drawn from savings, a conservative assumption would be 50%.[23] Under these plausible assumptions, ***the net impact of the epidemic on per capita GDP growth remains negative at 0.15 percentage points for the average Sub-Saharan African country and increases to a full third of a percentage point for the ten most advanced epidemics.***

For these most plausible parameter values, Figure 7 presents a histogram of the individual countries which lie behind the averages in Table XI and Figure 6. Note that the impact of AIDS is positive on the per capita income of nine of the 30 countries in this scenario and on one of the 10 countries with the most advanced epidemics. However, 21 of the 30 countries experience negative impacts of different degrees of severity under this plausible scenario. Of these, the per capita income of three countries is projected to grow almost a full percentage point slower than it otherwise would have.

This distribution suggests that some countries are more vulnerable to an AIDS epidemic than others. We have maintained the hypothesis of a common production and savings

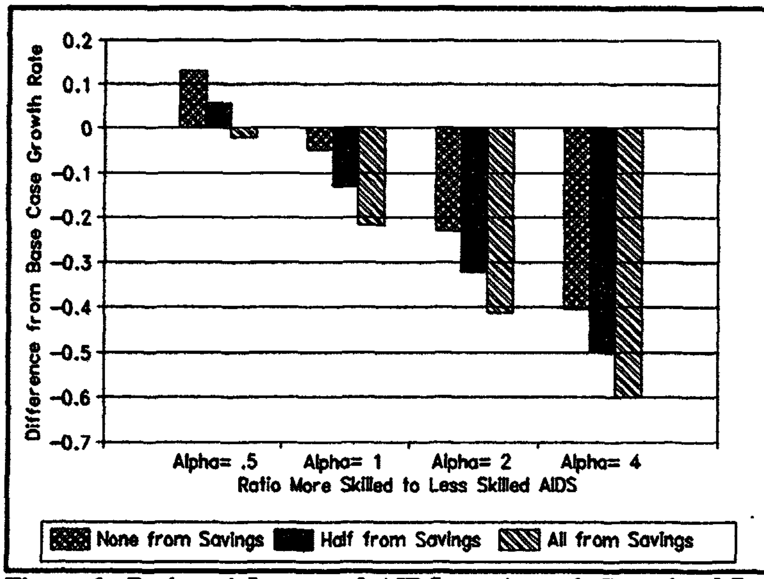

Figure 6 Projected Impact of AIDS on Annual Growth of Per Capita GDP in 10 Countries with Most Advanced Epidemics: Sensitivity to Distribution and Financing Parameters

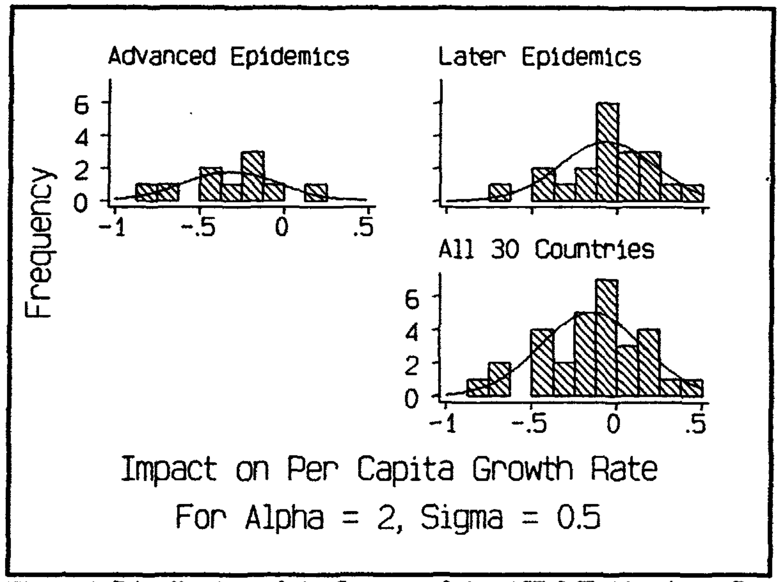

Figure 7 Distribution of the Impact of the AIDS Epidemic on Per Capita Growth Rates of 30 SSA Countries, $\alpha = 2$ and $\sigma = 0.5$, by Timing of the Epidemic.

[23] Cuddington (1991) uses 100%, but a recent study of the effect of government consumption on investment in OECD countries estimates that 40% of every consumption dollar is withdrawn from investment (Dowrick, 1991).

functions across all 30 countries. Therefore the difference in vulnerability in these projections is due to difference in the starting levels of productive factors in the countries and differences in the exogenously projected growth of the enrollment rates and of land. In this model, when the socio-economic gradient of the epidemic is ascending (α is large), vulnerability is greatest when secondary-educated labor is unusually scarce. The implication is that ***countries can partially protect themselves from the worst effects of the epidemic by increasing the proportion of the work force with a secondary education.***

VI. SUMMARY AND CONCLUSIONS

In order to estimate the macroeconomic impact of AIDS on the Sub-Saharan economies, we have projected the growth trajectories of 30 countries with and without the AIDS epidemic and defined the "impact" to be the difference between the trend growth rates with and without AIDS. If the only effect of the AIDS epidemic were to reduce the population growth rate, it would increase the growth rate of per capita income in any plausible economic model. The central question addressed by this paper has been whether the specific characteristics of the AIDS epidemic would be sufficient to reverse this prediction, such that per capita income growth would be negative rather than positive. The characteristics we have examined are the effect of the epidemic on savings and the distribution of the epidemic by socio-economic class, which we call the "socio-economic gradient" of the epidemic.

In order to capture the effect of the socio-economic gradient on both the loss of production and the reduction in savings, we have postulated and estimated a partial equilibrium two-sector model of the economy with three behavioral equations, a production function for each sector and a savings function. Though we assume rural/urban distribution and educational attainment of the labor force are exogenous over the period of the projection, we allow job mobility within each sector in order to prevent the marginal product of the higher educated workers from falling below that of the less-educated ones in that sector. We project all exogenous variables to continue their growth trajectories at past trends.

With these assumptions, we show that an AIDS epidemic can reduce the growth rate of per capita income in the average country even when it is evenly distributed across productivity classes, provided at least 50% of treatment costs are extracted from savings. Either raising the percentage of treatment costs financed from savings or biasing the epidemic toward the more productive workers increases the negative impact on per capita growth and the two combined effects interact to produce an even larger impact - especially on the ten countries with the most advanced epidemics. For the assumptions we regards as most plausible, that 50% of the treatment costs be financed out of savings and that each education class has double the risk of the one beneath it, ***the net effect of the AIDS epidemic on the growth of per capita GDP is a reduction of about a third of a percentage point in the ten***

countries with the most advanced epidemics.[24] In a continent which is struggling to escape negative growth of per capita income this is a substantial additional burden.

The policy implications of these findings must be drawn with care. If the maximization of per capita GDP growth were the only objective, the results would seem to argue for targeting prevention efforts at the more highly educated members of society. Furthermore, the finding that economies with higher educational attainments were less vulnerable to an AIDS epidemic biased towards the more educated, argues that education budgets be reallocated away from primary education towards secondary.

However, there are at least two other considerations which must be weighed in targeting prevention efforts. First, per capita GDP growth is not the only index of development. Societies also value health of their populations and its equitable distribution for their own sake. Even if the socio-economic gradient of the epidemic were smaller than unity so that the less educated are more affected and per capita GDP growth is increased, most societies would consider their net welfare to be reduced by the increase in mortality among the less educated and the dramatic worsening in the distribution of health across income classes that would result. Equity considerations would argue for intervention resources to be allocated to achieve an equal reduction in risk of all income groups.[25]

Second, prevention of infection by a communicable disease has positive externalities, which are larger when infection is prevented in an individual more likely to infect others. For the example of sexually transmitted diseases, Over and Piot (1991) have estimated the size of those externalities and found them to be five to ten times higher when the prevention effort is targeted at a more sexually active individual than when targeted at the less sexually active one.

In view of these considerations, ***a prevention policy must balance the need to protect future income growth with the desire for the equitable distribution of risk reduction by income class and the need to focus intervention resources on the people whose behavior puts themselves and others at the greatest risk.*** In some cases two of these criteria will argue for focusing on the same group. For example, some university students may also be among those who change sexual partner most frequently and therefore should be targeted on two of the above criteria. Prostitutes, on the other hand, are potential targets of prevention campaigns both

---

[24] Cuddington (1991) and Cuddington and Hancock (1992) obtain effects on per capita GDP growth of a similar magnitude without allowing for the socio-economic gradient of the epidemic, but including an hypothesized reduction in productivity of AIDS cases prior to death. Either adding a socioeconomic gradient of the epidemic to their model or adding reduced productivity of AIDS cases to the present model would exacerbate the predicted impact of the AIDS epidemic of either model.

[25] As a criterion for allocating intervention resources, equal reduction in risk is different than equal allocation of resources across groups, because the latter consideration does not take into account the externalities involved in preventing an infectious diseases. See the next paragraph.

because of their poverty and their large numbers of sexual partners. Thus the point of this paper is not to target prevention according to economic status to the exclusion of other criteria, but to consider economic status together with these other criteria in selecting groups to receive intense programs designed to reduce the frequency of high risk behavior.

The evidence of this paper and the demographic/epidemiologic information at its foundation argue that interventions to prevent the transmission of HIV must be accelerated throughout sub-Saharan Africa. However, the fact that the average HIV-infected African remains healthy for eight to ten years implies that today's prevention efforts have little impact on economic well-being for ten years or more. In the meantime, the already high rates of HIV infection in many African countries will lead inevitably to increases in premature adult mortality, with severe consequences for the affected households and communities. African governments, assisted by non-governmental organizations and by bilateral and multilateral foreign donors are already engaged in programs to help the survivors of the AIDS epidemic in the worst affected communities. There is an urgent need for policy guidance in directing these programs so that the limited resources can have the greatest possible helpful effect. Such guidance can only come from microeconomic studies which investigate the determinants of the impact's magnitude on surviving household members and the effectiveness of alternative approaches to mitigating that impact.

REFERENCES

Allen, Susan, C. Lindan, A. Serufilira, P. Van de Perre, A.C. Rundle, F. Nsengumuremyi, M. Carael, J. Scwalbe, S. Hulley, 1991, "Human Immunodeficiency Virus Infection in Urban Rwanda: Demographic and Behavioral Correlates in a Representative Sample of Childbearing Women," Journal of the American Medical Association, September 25, 1991, Vol. 266, No. 12, pp. 1657-63.

Anderson, R.M., W. Ng, J. Rowley and A.R. McLean, 1991, "The Anderson Approach: Potential Demographic Impact of AIDS - Uncertainties in Prediction," in UN/WHO (1991, op cit.) pp. 63-76.

Baldwin, R.E., and B.A. Weisbrod, 1974, "Disease and Labor Productivity," Economic Development and Cultural Change, Vol. 22, pp. 214-435.

Barlow, R., 1967, "The Economic Effects of Malaria Eradication," American Economic Review, Vol. 68, pp. 130-144.

Barlow, R.E. and G. Davies, 1974, "Policy Analysis with a Disaggregated Economic-Demographic Model," Journal of Public Economics, Vol. 3, pp. 43-70.

Benjamin, N. and S. Devarajan, 1985, "Oil Revenues and Economic Policy in Cameroon: Results from a Computable General Equilibrium Model," World Bank Staff Working Paper, No. 745, The World Bank.

Bongaarts, J. and P. Way, 1989, "Geographic Variation in the HIV Epidemic and the Mortality Impact of AIDS in Africa," New York: The Population Council, Research Division, Working Paper No. 1.

Bongaarts, J., 1988, "Modeling the Spread of HIV and the Demographic Impact of AIDS in Africa," New York: The Population Council, Working Paper No. 140, October 1988.

Bongaarts, J., 1989b, "Modeling the Demographic Impact of AIDS in Africa," in R. Kulstead (ed.) AIDS 1988: AAAS Symposium Papers AAAS Press.

Bongaarts, J., 1989a, "A Model of the Spread of HIV Infection and the Demographic Impact of AIDS," Statistics in Medicine, January.

Bos, E. and R.A. Bulatao. "The Demographic Impact of AIDS in Sub-Saharan Africa: Short- and Long-Term Projections," Draft, February 6, 1992.

Bowles, P., 1987, "Foreign Aid and Domestic Saving in Less Developed Countries: Some Tests for Causality," World Development, Vol. 15, No. 6, pp. 789-96.

Cooper, B.S. and D. P. Rice, 1976, "Economic Cost of Illness Revisited," Social Security Bulletin, Vol. 39, No. 2, pp. 21-36.

Dowrick, S. "Government Consumption: Its Effects on Productivity and Investment," Australian National University, November 1991.

Foster, Susan and S. Lucas, 1991, Socioeconomic Aspects of HIV and AIDS in Developing Countries, London: PHP Departmental Publication No. 3, 1991, London School of Hygiene and Tropical Medicine.

Gottfried, R.S., 1983, The Black Death, New York: Free Press.

Griffin, K.B. and J.L. Enos, 1970, "Foreign Assistance: Objectives and Consequences," Economic Development and Cultural Change, Vol. 18 (April, 1970), pp. 313-27.

Hammer, J., 1986, "Population Growth and Savings in LDCs: A Survey Article," World Development, Vol. 14, pp. 579-591.

Hatton, T. J. and J.G. Williamson, 1992, "What Explains Wage Gaps between Farm and City? Exploring the Todaro Model with American Evidence, 1890-1941" Economic Development and Cultural Change, Vol. 40, No. 2, (January) pp. 267-294.

Institute of Medicine, 1986, New Vaccine Development: Establishing Priorities, Volume II: Diseases of Importance in Developing Countries, Washington, D.C.: National Academy Press.

Jamison, Dean T., and W. Henry Mosley (eds.), (forthcoming) Disease Control Priorities in Developing Countries. New York: Oxford University Press for the World Bank.

Kambou, G., S. Devarajan and M. Over, (1992), "The Economic Impact of AIDS in an African Country: Simulations with a General Equilibrium Model of Cameroon," Journal of African Economies, Vol. 1, No. 1.

Klarman, H.E., 1965, "Syphilis Control Programmes," in R. Dorfman (ed.) Measuring the Benefits of Government Investments, Washington, D.C.: The Brookings Institution, pp. 367-414.

Lau, L., D.T. Jamison and F.F. Louat. "Education and Productivity in Developing Countries: An Aggregate Production Function Approach," Working Paper Series No.612, The World Bank, March 1991.

May, R.M. and R. M. Anderson, 1988, "The Transmission Dynamics of the Human Immunodeficiency Virus," Philosophical Transactions of the Royal Society of London, Series B, Vol. 321, No. 1207, pp. 505-507.

McEvedy, C. "The Bubonic Plague," pp. 118-123.

McNeil, W.H. Plagues and Peoples. December 1975.

Melbye, M. et al., 1986, "Evidence for the Heterosexual Transmission and Clinical Manifestations of Human Immunodeficiency Virus Infection and Related Conditions in Lusaka, Zambia," Lancet, pp. 1113-5.

Ndilu, M. et al., 1988, "Medical, Social and Economic Impact of HIV Infection in a Large African Factory," Poster, IV International Conference on AIDS, Stockholm, Abstract 9583.

Over, Mead, R.P. Ellis, J.H. Huber, O. Solon, 1991, "The Consequences of Adult Ill Health," Chapter 4 in R.G.A. Feachem, T. Kjellstrom, C.J.L. Murray, M. Over, M. Phillips (eds.), The Health of Adults in the Developing World, Washington: Population and Human Resources Department, World Bank.

Over, M. and P. Piot, 1991, "HIV Infection and Sexually Transmitted Diseases," Forthcoming in Dean T. Jamison and W. Henry Mosley (eds.), Disease Control Priorities in Developing Countries. New York: Oxford University Press for the World Bank.

Over, M., S. Bertozzi and J. Chin, 1989, "Guidelines for Rapid Estimation of the Direct and Indirect Costs of HIV Infection in a Developing Country," Health Policy, 11, 169-186, Elsevier Science Publishers B.V.

Over, M., 1975, "An Example of the Simultaneous Equation Problem: A Note on 'Foreign Assistance: Objectives and Consequences,'" Economic Development and Cultural Change, Vol. 23, No. 4, (July, 1975), pp. 751-6.

Papanek, G., 1973, "Aid, Foreign Private Investment, Savings and Growth in Less Developed Countries," Journal of Political Economy, Vol. 81, pp. 120-30.

Papanek, G., 1972, "The Effect of Aid and Other Resource Transfers on Savings and Growth in Less Developed Countries," Economic Journal, Vol. 82, pp. 934-80.

Rice, Dorothy P., 1967, "Estimating the Cost of Illness," American Journal of Public Health, 57(3):424-40.

Rowley, J.T., R.M. Anderson and T.W. Ng. "Reducing the Spread of HIV Infection in Sub-Saharan Africa: Some Demographic and Economic Implications." AIDS 1990, 4(1):47-56.

Scitovsky, A.A. and N. McCall, 1976, "Changes in the Costs of Treatment of Selected Illnesses: 1951-1964-1971," Health Policy Discussion Paper, University of California School of Medicine.

Scitovsky, A.A., 1967, "Changes in the Costs of Treatment of Selected Illnesses, 1951-65," American Economic Review, 57(5):1182-95.

Scitovsky,A.A. and M. Over, 1988, "AIDS: Costs of Care in the Developed and the Developing World," AIDS 1988, 2(suppl 1):S71-S81, Gower Academic Journals Ltd.

Shepard, D.S., (ed.), 1991, "Economic Impact of Malaria," Tropical Medicine and Parasitology, Supplement I of Vol. 42, September, 1991, pp. 157-318.

Fardoust, S. and A. Dhareshwar. "A Long-Term Outlook for the World Economy: Issues and Projections for the 1990s," Policy and Research Series No.12, The World Bank, September 1990.

Shepard, Donald S.(ed.), 1991, "Economic Impact of Malaria in Africa," Tropical Medicine and Parasitology, Vol. 42, Supplement I, September, 1991, pp. 157-318.

Shumaker, L.D. and R.L.Clark, 1992, "Population Dependency Rates and Savings Rates: Stability of Estimates," Economic Development and Cultural Change, Vol. 40, No. 2, (January) pp. 319-332..

United Nations and World Health Organization (eds.), 1991, The AIDS Epidemic and its Demographic Consequences, Proceedings of the UN/WHO Workshop on Modelling the Demographic Impact of the AIDS Epidemic in Pattern II Countries: Progress to Date and Policies for the Future, New York, 13-15 December, 1989.

Way, Peter O., and Mead Over, 1992, "The Projected Economic Impact of an African AIDS Epidemic," Paper presented at the Annual Meeting of the Population Association of America, April 30 - May 2, 1992, Denver, Colorado.

Walsh, Julia A., 1988, Establishing Health Priorities in the Developing World, Under the auspices of the United Nations Development Programme, Boston: Adams Publishing Group.

Walsh, Julia A. and K. S. Warren, 1986, Strategies for Primary Health Care: Technologies Appropriate for the Control of Disease in the Developing World, Chicago: The University of Chicago Press.

Walsh, Julia A. and K. S. Warren, 1980, "Selective Primary Health Care: An Interim Strategy of Disease Control in Developing Countries," Social Science and Medicine, Vol. 14C, pp. 145-163.

Webb, S.B. and H.S. Zia. "The Effect of Demographic Changes on Saving for Life-Cycle Motives in Developing Countries," Working Paper Series No.229, The World Bank, July 1989.

World Bank. "Global Economic Prospects and the Developing Countries." Washington, D.C. May 1991.

Weisbrod, B.A., 1961, Economics of Public Health, Philadelphia: University of Pennsylvania Press.

ANNEX
Estimated Impact of AIDS on Growth of Per Capita GDP by Country, Socio-Economic Gradient of the Epidemic and Financing Alternative*

Socio-Economic Gradient (α):	No Direct Cost from Savings				All Direct Cost from Savings			
COUNTRY	0.5	1	2	4	0.5	1	2	4
1 Benin	0.19	0.1	0.03	-0.03	0.07	-0.04	-0.13	-0.2
2 Botswana	0.36	0.3	0.25	0.21	0.2	0.11	0.05	0
3 Burkina Faso	0.23	0.06	-0.17	-0.44	0.14	-0.03	-0.28	-0.56
4 Burundi	0.27	0.16	0	-0.18	0.19	0.06	-0.1	-0.3
5 Cameroon	0.05	-0.13	-0.27	-0.36	-0.13	-0.32	-0.48	-0.58
6 Central African Republic	0.23	0.14	0.05	-0.03	0.08	-0.04	-0.16	-0.25
7 Congo	0.33	0.26	0.22	0.21	0.2	0.12	0.07	0.05
8 Cote d'Ivoire	0.01	-0.22	-0.38	-0.48	-0.14	-0.39	-0.58	-0.7
9 Ethiopia	-0.18	-0.28	-0.37	-0.44	-0.28	-0.4	-0.51	-0.59
10 Gambia	0.48	0.42	0.38	0.35	0.4	0.33	0.27	0.23
11 Ghana	-0.02	-0.12	-0.18	-0.21	-0.22	-0.35	-0.44	-0.48
12 Guinea-Bissau	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
13 Kenya	-0.04	-0.18	-0.29	-0.36	-0.23	-0.38	-0.51	-0.59
14 Liberia	0.26	0.24	0.22	0.21	0.17	0.14	0.11	0.09
15 Madagascar	0.13	0.04	-0.03	-0.07	-0.02	-0.12	-0.21	-0.26
16 Malawi	0.22	-0.02	-0.34	-0.7	0.13	-0.12	-0.46	-0.83
17 Mali	0.26	0.11	-0.02	-0.12	0.18	0.02	-0.14	-0.26
18 Mauritania	0.29	0.21	0.13	0.07	0.22	0.12	0.02	-0.06
19 Niger	0.24	0.11	-0.06	-0.23	0.17	0.04	-0.14	-0.33
20 Nigeria	-0.24	-0.43	-0.59	-0.71	-0.38	-0.59	-0.77	-0.9
21 Rwanda	0.27	0.09	-0.18	-0.53	0.19	0.01	-0.27	-0.62
22 Senegal	0.22	0.12	[illegible]	-0.03	0.12	0	-0.11	-0.18
23 Sierra	0.21	0.2	0.19	0.18	0.13	0.11	0.09	0.07
24 Somalia	0.21	0.14	0.09	0.04	0.14	0.06	-0.01	-0.06
25 Sudan	0.04	-0.07	-0.16	-0.22	-0.08	-0.22	-0.32	-0.39
26 Tanzania	0.04	-0.26	-0.69	-1.21	-0.07	-0.38	-0.83	-1.36
27 Togo	0.24	0.18	0.14	0.11	0.11	0.04	-0.01	-0.05
28 Zaire	-0.17	-0.42	-0.6	-0.72	-0.38	-0.65	-0.86	-0.99
29 Zambia	0.19	0.02	-0.09	-0.16	0.03	-0.15	-0.28	-0.36
30 Zimbabwe	0.2	0.03	-0.11	-0.2	0	-0.19	-0.35	-0.47

* Table entries are percentage point differences in per capita growth rates over the period 1990 - 2025 estimated as one less than the coefficient of a regression of the logarithm of GDP per capita on time. Negative (positive) entries indicate that AIDS has reduced (increased) the rate of growth of per capita income.