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AIDS and the Accumulation and Utilization of Human Capital in Africa

NANCY BIRDSALL AND AMAR HAMOUDI

Among the great challenges of development, education continues to take pride of place. In this chapter we highlight some of the channels by which the AIDS pandemic in Africa may affect the continent's ability to produce education and to use it effectively for growth and poverty reduction. Our assessment is preliminary; we hope here to sketch a larger research agenda rather than to dispose of it.

The effect of the pandemic on the supply of and demand for adequate public education matters because education is both *constitutive of* and *instrumental in* the process of development (Sen, 1999). Education is an end in itself, a vital part of individuals' capacity to lead lives that they value. Furthermore, it is an important instrument with which people can improve their lives in other ways. For example, more education, particularly of women, is associated with better family health and improved capacity to plan and time births. Education also enhances the capacity of poor people to participate in the political process, and thus to organize for other social and political rights and to demand governments that are more representative and accountable.

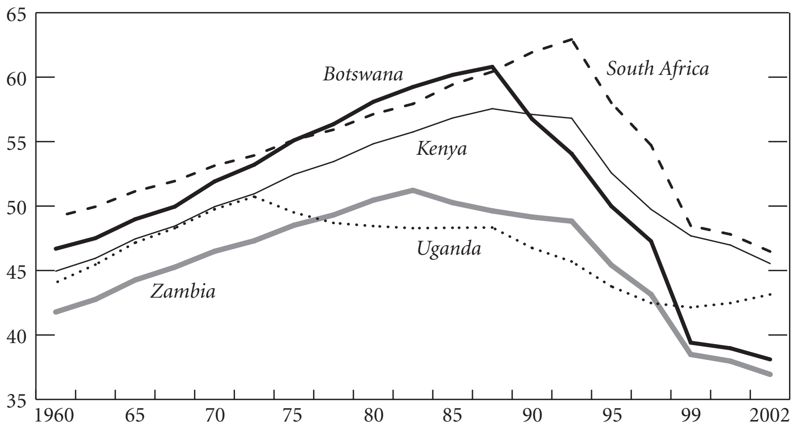
The effect of the pandemic on African economies' ability to use education to enhance growth matters because faster growth is important to sustain poverty reduction and human development. Education contributes to higher individual productivity and income, and thus to sustainable economic growth, although education alone is not sufficient for faster growth. High measured levels of education and human capital did not generate healthy growth in the Soviet Union, nor have rapid increases in average education done so in Egypt, Latin America, and much of sub-Saharan Africa in the last three decades. But microeconomic analyses demonstrate repeatedly the contribution of education to productivity at the individual, household, and farm and firm level.[1] Where the relationship between "more" education and faster growth has failed to materialize—both within countries and between countries (see, for example, Pritchett, 1999)—one or more of several difficulties may be responsible. First, "more" education is often assessed in terms of increasing public spending on education; but, if education systems are weak, more public spending may not translate into true increases in the human capital stock. Second, even where the human capital stock is increasing, problems in other policy spheres (including, for example, macroeconomic instability, civil unrest, or market distortions) may prevent these gains from being translated into economic growth.[2] Third, it may be that as long as the existing stock of human capital remains below some threshold, modest increases are relatively ineffective in producing growth; indeed, the deficit between the existing stock and this threshold, combined with an adverse economic structure and low organizational and institutional capacity, could perpetuate a poverty trap (an issue to which we will return). The contribution of education to high and relatively equitable growth in much of East Asia over the last five decades, where educational systems were relatively high in quality and where market and other distortions were limited, provides the best counterexample on all these scores (Birdsall, Ross, and Sabot, 1995).

In addition to its effect on growth, education also affects the *distribution* of incomes; universal education is essential to creating the pattern of growth that is most likely to reduce poverty. For the poor, the human capital acquired through formal education is a critical economic asset that, once acquired, cannot be appropriated by others. At the societal level, edu-

[1]Schultz (1961) first made this point; Schultz (1989) reviews the now-large microeconomic literature.

[2]In fact, various market distortions in developing countries typically keep the marginal private return, if not the average private return, high compared with that in industrial countries. In Egypt, for example, a policy of guaranteeing a public sector job to all secondary and university graduates ensured high marginal private returns, especially to higher education, but these returns were independent of the quality of education; of the actual productivity of people attributable to some combination of their human capital, their motivation, and complementary inputs on the job; and, of course, of whether or not a real demand existed for their skills in the public sector. The policy probably also reduced the demand for and the pressure on the educational system to achieve real gains in learning and skills as opposed to simply certifying graduates (Birdsall and O'Connell, 1999).

Figure 4.1. Life Expectancy at Birth in Five Sub-Saharan African Countries
(Years)

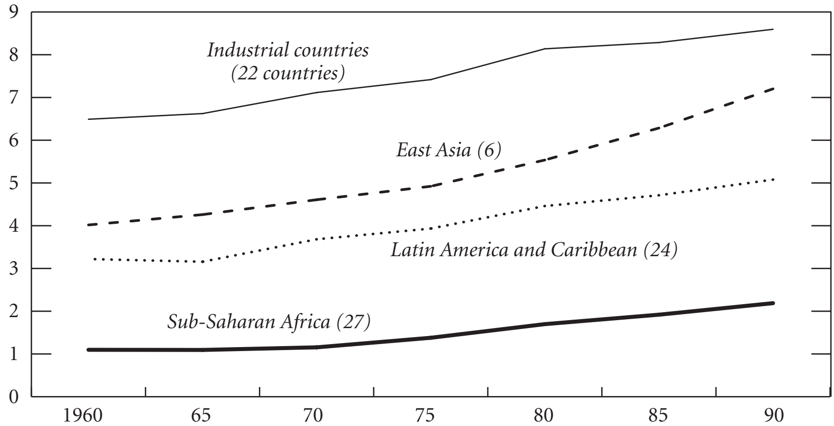


Source: Data from World Bank (2004).

cation that is broadly shared contributes to a more equitable distribution of total wealth (including human capital wealth; Birdsall, 1999; Birdsall and Londoño, 1997) and thus ultimately to a more equitable distribution of opportunities and of income.

Prospects for accumulation and effective economic deployment of education in Africa have to be assessed against the backdrop of the ongoing HIV/AIDS epidemic. According to estimates by the Joint United Nations Programme on HIV/AIDS (UNAIDS), AIDS claimed the lives of about 2 million to 2.5 million adults and children in sub-Saharan Africa in 2003. Over the same period, an estimated 3 million Africans were newly infected with HIV; barring very dramatic increases in treatment coverage, almost all of these individuals will die over the next decade (UNAIDS, 2004). As the death toll from the epidemic has mounted, life expectancies across the continent have plummeted. In Zambia, for example, life expectancy at birth increased from 43 years to 51 years between 1962 and 1982, only to decline again from 50 years to 38 years between 1985 and 1999—a loss of over 20 years' progress in less than a decade (World Bank, 2001). Figure 4.1 shows some of the more dramatic declines in life expectancy among African countries over the past four decades. Economists and others have begun to focus attention on the likely effects of the epidemic on overall social welfare and material well-being. However, its more specific effects

Figure 4.2. Mean Years of Schooling by World Region
(Years)[1]



Source: Data from Barro and Lee (1996).
[1]Regional data are unweighted country averages for the population aged over 24 years.

on the supply of, demand for, and productive use of education have not been explicitly explored.

To be sure, the problem of Africa's small human capital stock predates the arrival of the epidemic. Figure 4.2 shows the evolution of one (very crude) measure of the region's human capital stock: average years of schooling attained among the general population aged 25 years and older. Although the rate of growth in human capital by this measure in sub-Saharan Africa picked up briefly in the late 1970s, the continent continues to lag behind other developing regions.

This chapter explores some of the ways in which the AIDS epidemic is likely to affect the rate of new human capital formation on both the supply and the demand sides, and the productivity of the existing human capital stock in Africa. We focus on four specific channels:

- The loss of millions of adults—among them tens of thousands of teachers—affects the rate at which education systems in Africa are able to train the next generation for any given cost and with any given quality.
- The foreshortening of time horizons attendant on these premature deaths reduces the expected lifetime private return to schooling and therefore may reduce demand for education. In addition, increasing household dependency ratios, as the children of AIDS victims are

transferred to the care of foster parents, may reduce the likelihood that children are enrolled in school.[3]

- The loss of so many already-educated people could reduce the social returns to skill among the educated people who survive, to the extent that there are positive externalities associated with a larger total stock of human capital. This could result in a smaller contribution of education to aggregate growth. In addition, if general human capital acquired through education does not substitute perfectly for job-specific human capital acquired through experience, the loss of experienced workers could slow growth.
- As higher production costs result in lower investment by businesses, the consequent decline in physical capital assets would likely reduce the ability of educated people to contribute to economic production, to the extent that physical capital and human capital are complementary inputs.

The last two of these channels could also affect the long-run private demand for education, insofar as average, if not marginal, private returns to education remain low in low-productivity settings. This is the case even though marginal private returns to education, especially above the primary level, could well remain high because of the relative scarcity of well-educated workers (including managers and administrators).[4]

Of course, there are other ways in which AIDS is likely to affect education and human capital in Africa. For example, increasing fears, especially for girls, about exposure to HIV in schools may reduce demand for secondary schooling. In this chapter we abstract from such social or psychological effects, to focus on the primarily economic channels, direct and indirect.

HIV/AIDS and the Supply of Schooling in Sub-Saharan Africa

Of the 25 million people in sub-Saharan Africa estimated by UNAIDS (2004) to be living with HIV infection, about 90 percent are adults and youths over the age of 15 years. Partly as a result of the epidemic, adult

[3]We do not use the phrase “AIDS orphans” here, only because many children may be fostered out to new homes before their ill parents actually die.

[4]Psacharopoulos (1994) reports that, on average, marginal private returns to education, especially higher education, are higher in developing countries than elsewhere. This does not mean, of course, that the average returns reflected in wage or salary levels are higher, but only that the additional return over and above that realized by less educated workers is greater.

mortality rates in Africa are over three times the world average. During 1999, an African between the ages of 15 and 60 stood, on average, a 1.4 percent chance of dying; the world average that same year was 0.4 percent (World Bank, 2001). According to UNAIDS, UNICEF, and USAID (2004), by the end of 2003 about 12 million African children had lost either their mother or both parents to AIDS, and, in some of the worst-affected countries, close to 20 percent of all children under age 17 had lost at least one parent, the majority to HIV/AIDS. Furthermore, empirical evidence suggests that among those adults who were infected early in the epidemic, and who are falling ill and dying now, a disproportionate number are relatively well educated, urban, white-collar workers (Ainsworth and Semali, 1998; Filmer, 1998; Deheneffe, Caraël, and Noumbissi, 1998). It is not surprising, therefore, that educators are one of the hardest-hit professions in many AIDS-ravaged African countries. In Zambia, for example, the World Bank estimates that mortality rates among teachers are 70 percent higher than among the general adult population (World Bank, 2001). The United Nations Children's Fund (UNICEF, 2000) estimates that, in 1999 alone, 860,000 African schoolchildren lost their teachers to AIDS (out of a total population of some 70 million pupils), on a continent that in 1997 had only one teacher for every 59 students (World Bank, 2001).

Demographic projections, using specialized software packages, have been employed to speculate on some of the likely effects of the loss of teachers to AIDS in specific African contexts (Malaney, 2000). One general way to assess these effects is to consider a simple two-equation model. Divide the population in the education system into two mutually exclusive groups, teachers and students, and divide each person's lifetime into two periods, childhood and adulthood. Assume that all students are children, added to the system at some constant net rate determined by the difference between enrollment and attrition. Teachers are assumed to be adults, added to the system by training some proportion of the previous period's students, and lost to the system by death, retirement, and other sources of teacher attrition.

With these assumptions, the number of teachers and students in any given period can be expressed as

$$S_t = [1 + n]\, S_{t-1}$$
$$T_t = [1 + d_t\,]\, T_{t-1} + rS_{t-1}.$$

In these equations n is the rate at which students are added to the education system (net of the rate at which they graduate or drop out), r is the proportion of the last period's students who complete school and then are retained within the system as teachers, and d is the rate of teacher attrition. Using these two equations, one can determine the teacher-student ratio in each period as a function of n, r, d, and the teacher-student ratio in the previous period:

$$\frac{T_t}{S_t} = \frac{r}{1+n} + (1-d_t)\left(\frac{T_{t-1}}{S_{t-1}}\right).$$

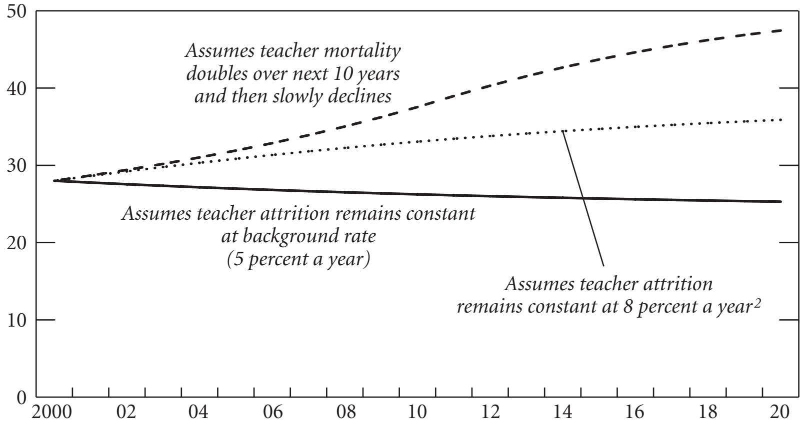
Using plausible parameter estimates, we can apply this model to a real-world case in order to speculate on the scale of the effects of future increases in teacher mortality.

According to the World Bank, the current student-teacher ratio in one of the hardest-hit countries in Africa, Botswana, is about 28. (Rather than teacher-student ratios, the World Bank reports the inverse; the ratio for Botswana is less than half the continent-wide average of 59.) According to the World Bank, the population under 14 years in Botswana is projected to grow over the next 15 years at an average annual rate of –0.4 percent.[5] Abstracting from any changes in the proportion of this population that is of primary school enrollment age, and from any changes in enrollment rates, the net rate of increase in the student population (n), therefore, would be –0.004. Data indicating the rate at which students are trained to become teachers in Botswana are not readily available. However, neighboring Namibia trains about 1,000 teachers each year, or some 0.2 percent of the student body (Malaney, 2000). Assuming that Botswana's education system retains this same proportion of its student body to become teachers, we can set $r = 0.002$. Finally, we assume that the "background" rate of teacher attrition—that is, the rate of teacher attrition due to retirement and other traditional sources—is about 5 percent a year, and that the teacher mortality rate in Botswana is about 3 percent a year (the current adult mortality rate in the country).

Given these assumptions, Figure 4.3 shows the evolution of the student-teacher ratio over the next 20 years under three scenarios. The

[5]This projected decline reflects the expected decline in fertility and the effects of forecasts of adult mortality as much as or more than any increase in mortality at young ages. Declines in fertility are occurring elsewhere in Africa, as the education of mothers and access to health care, including modern family planning services, have been increasing, the latter especially in urban areas. As noted below, our simulation results are highly robust to variations within plausible ranges of this parameter, but obviously a faster growth rate of the school-aged population would exacerbate the problem we illustrate.

Figure 4.3. Projected Student-Teacher Ratios in Botswana Under Alternative Assumptions[1]
(Students per teacher)



Source: Authors' calculations using the model described in the text.

[1]Assumptions underlying all scenarios are that there are 28 students per teacher in 2000, that the student population (net) grows at a rate of –0.4 percent a year, that 0.2 percent of each year's students are trained to become teachers the following year, and that teacher attrition is 5 percent a year plus the rate of teacher mortality, which equals the rate of adult mortality.

[2]Background rate (5 percent a year) plus adult mortality of 3 percent a year.

first scenario holds teacher attrition constant at the background rate. The second holds teacher attrition at 8 percent—of which the background rate accounts for 5 percentage points and the current adult mortality rate in Botswana for the remainder. The last scenario assumes—in keeping with projections by the United Nations Development Programme (2000)—that adult mortality (and hence, by assumption, teacher mortality) will double over the next 10 years and decline very gradually thereafter.

These projections are highly robust to changes in the assumptions about the rate of growth in the student population—which, after all, is likely to be affected by the epidemic as well, although almost certainly not as dramatically as the rate of growth in the teacher population. The World Bank (2001) has projected, for example, that the primary-school-aged population in Zimbabwe is likely to contract by about 0.8 percent a year over the next decade. Adjusting our assumptions to examine the effects if the school-aged population in Botswana suffered the same decline, however, does not significantly change the projections shown in Figure 4.3 over the time horizon of the simulation.

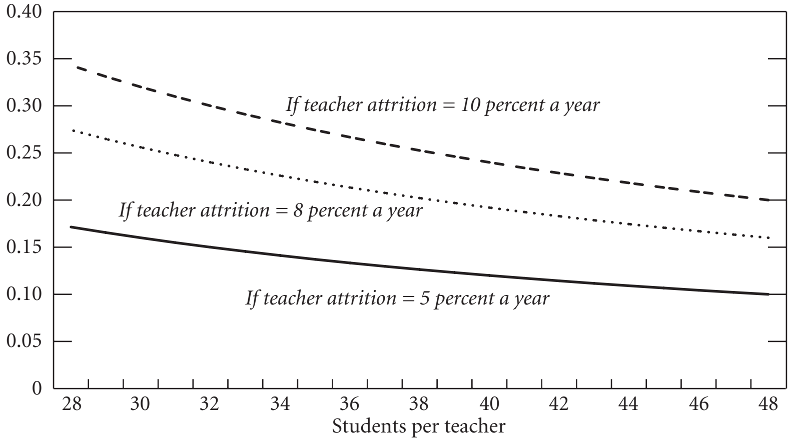
By contrast, the projections are more sensitive to assumptions about the rate of retention of students to become teachers.[6] For example, the increase in student-teacher ratios shown in the most pessimistic scenario in Figure 4.3 can be entirely averted if the rate at which students are trained to become teachers is increased from 0.2 percent a year to about 0.35 percent a year. Figure 4.4 plots the retention ratio necessary to maintain a constant student-teacher ratio for various rates of teacher attrition; at points above each line, the student-teacher ratio is improving (that is, declining), whereas at points below, it is worsening.

The focus here on student-teacher ratios is not meant to imply that this is the sole measure—or even a good measure—of school quality or efficiency. However, these ratios do reflect clearly one of the most direct effects of the HIV epidemic on the supply of schooling in sub-Saharan Africa, namely, the loss of enormous numbers of teachers over the medium term. For example, from Figure 4.4 it is straightforward to discern that, in order to maintain its current ratio in the face of excess annual adult mortality, a country like Botswana must plow nearly 150 percent more of its students back into the education system to become teachers. Therefore, in order to continue to supply schooling services at current enrollment rates, African education systems will either have to tolerate a dramatic increase in class sizes, or find ways to retain significantly more of the country's precious human capital within the education system, or both. And this must happen at a time when other sectors of the economy are also desperate to replace their own educated workers who are being lost to the epidemic (African Development Forum, 2000). The implication is that, even with increases in class size, public education systems will need to increase the salaries of teachers to attract a larger proportion of graduates into the field. Yet salaries of teachers in sub-Saharan Africa are already higher, relative to average wages in the economy, than in other regions of the world, probably reflecting the relative scarcity of postsecondary graduates.[7] These results imply an increase in an already high fiscal burden of teacher salaries relative to other regions, or the need to reduce the educational requirements for teachers. The latter adjustment is likely to be necessary, especially in rural

[6]This, of course, is not surprising, given the structure of the model, in which an increase in the size of today's student body has two effects that work in opposite directions. First, it increases the student-teacher ratio in the present, but, second, it provides a larger pool of new potential teachers in the future. The effects of a decrease in the rate of teacher training, however, are not mitigated in any analogous way.

[7]On this point, World Bank (2000) cites Alain Mingat.

Figure 4.4. New Teachers Required to Be Trained to Maintain a Constant Student-Teacher Ratio in Botswana
(Percent of preceding year's student population)



Source: Authors' model described in the text.

areas, and is likely to be even more costly in terms of quality than any increase in class size.[8]

Furthermore, focusing as these results do on nationwide averages implicitly assumes that the government is able to deploy teachers relatively easily throughout the country, in order to ensure that the effects of teacher shortages are evenly felt. The reality, of course, is decidedly more complicated. Student-teacher ratios are generally much higher in rural areas, for example, than in urban areas, and the increase in teacher morbidity and mortality may be worsening this disparity by increasing demand for posts in urban areas closer to health facilities (UNICEF, 2000). The effects of the epidemic in some rural schools, especially the smaller ones with only one or two teachers teaching multiple grades, may be far more dramatic than these model results suggest. In the Democratic Republic of the Congo, for example, some schools have reportedly been forced to close entirely for lack of teachers (African Development Forum, 2000).

[8]Behrman and Birdsall (1983) use differences in teacher education as a proxy for differences in the quality of schools across U.S. states. The resulting differences in the quality of schooling across individuals have a strong and highly robust effect on the private returns to schooling (and presumably the social returns).

HIV/AIDS and Demand for Schooling in Sub-Saharan Africa

The previous section framed an approach to assessing the possible supply-side effects of the AIDS epidemic on education. Since the basic findings—that student-teacher ratios are likely to rise unless retention increases as a proportion of the total population leaving school—are fairly robust to assumptions about demand-side changes, we were able to abstract from these. However, two of the major channels through which the epidemic is likely to affect demand for education include time horizon effects and liquidity effects. We will discuss the latter briefly, and then the former at greater length.

Liquidity Effects

For many reasons (including the fact that individuals cannot be dispossessed of their own human capital), adults cannot formally borrow on behalf of their children in order to finance their education. As a result, any private investments in children's education must be financed out of parents' or caregivers' wealth. If parents and caregivers face liquidity constraints as a result of increasing household dependency ratios, they may find that financing more difficult. Furthermore, Case, Paxson, and Ableidinger (2004), Deininger, Garcia, and Subbacao (2003), and Bishai and others (2003) all find descriptive evidence suggesting that parents may favor their own biological children over foster children. If, in fact, a causal relationship exists between biological relatedness and parental "altruism," the displacement of millions of orphans to the care of nonbiological parents may adversely affect their educational opportunities.

Time Horizon Effects

Recent theoretical and empirical work has explored the relationships between life expectancy and investment in human capital. The reasoning is that, when individuals and households anticipate a longer time horizon over which to reap returns, they are likely to be more willing to incur the up-front costs of investment in schooling. Kalemli-Ozcan, Ryder, and Weil (2000) develop a model in which individuals facing a constant probability of death weigh the earnings forgone during the time spent in school against the anticipated returns to schooling in deciding when to leave school and enter the labor force. Calibrating their model using reasonable parameters based on real-world data, these authors speculate that changes in life expectancy over the past 150 years can explain a significant fraction of the observed increases in schooling rates in the most developed countries.[9]

Such a model would also capture stylized facts from developing countries over the more recent past. In an empirical treatment of this question, Behrman, Duryea, and Székely (1999) relate the educational attainment of birth cohorts—using data from household surveys conducted in Latin America—to fixed-country effects, secular trend effects, and several year- and country-specific variables, including life expectancy, that reflect the broader economic and institutional setting.[10] Their results suggest that changes in life expectancy were associated with quantitatively and statistically significant changes in educational attainment. On average, they found a 10-year increase in life expectancy to be associated with a 0.3- to 0.4-year increase in schooling completed.

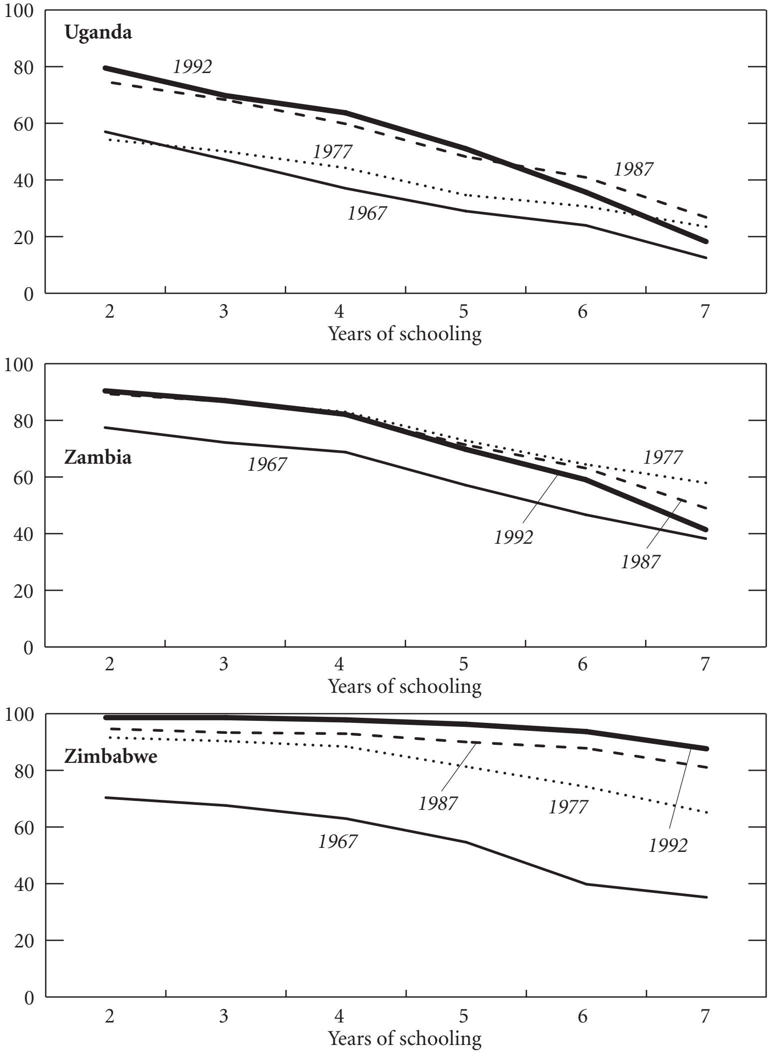
Here we use a similar "quasi-panel" technique to try to describe this relationship in African contexts over the past generation. We use data from the Demographic and Health Surveys (DHSs), in which nationally representative samples of 15- to 49-year-old women are interviewed on such topics as reproduction, household assets, children's health, employment status, and educational attainment. We emphasize that the main lesson to be drawn from our results is descriptive, not directly causal, and more qualitative than the econometric results could be taken to imply. Our findings, like those of Behrman, Duryea, and Székely, point to a decline in demand for education accompanying a decline in life expectancy; this is as far as we intend to interpret the results presented below. One of many causal interpretations of this descriptive finding includes the sort of time horizon effects that Kalemli-Ozcan, Ryder, and Weil outline in their theoretical model. Empirical analysis to identify such a causal effect is an important direction for future research.

The DHS data demonstrate steady improvements in the educational attainment of birth cohorts across the continent over time. (Figure 4.5 shows attainment profiles for five-year birth cohorts that reached ages

[9]Of course, it is not clear that increasing life expectancy per se has had a direct causal effect on these increases in schooling; life expectancy is usually closely associated with other changes, including increasing average income, technological shifts, and improving institutions, all of which would raise the returns to and the demand for education. These factors are guaranteed to confound any empirical investigation of the effects of life expectancy on demand for education, including the one we undertake here. Given the impossibility of conducting controlled experiments, any empirical analysis—including this one—will necessarily be more suggestive of the direction of such effects than conclusive regarding their magnitude.

[10]As with life expectancy, these other variables have mostly statistically significant effects in the expected direction on differences and changes in average education.

Figure 4.5. Educational Attainment Profiles of Selected Birth Cohorts in Uganda, Zambia, and Zimbabwe[1]
(Percent of cohort population)



Source: Authors' calculations using data from Demographic and Health Surveys for Uganda (1995), Zambia (1996), and Zimbabwe (1999).

[1]Profiles are constructed by stratifying survey responses according to the respondent's year of birth and tracking the proportion of respondents who reported having completed each year of school. Responses are weighted by sampling weights.

[2]Years are those in which the indicated cohort reached age 12–17.

12–17 in 1967, 1977, 1987, and 1992 in Uganda, Zambia, and Zimbabwe.) The older cohorts in almost all countries reported lower attainment. In each of the 23 countries for which surveys were available, the same general trend may be observed.[11] It is important to be careful in interpreting these observations, however. The observations are not truly longitudinal, since they are derived from cross-sectional surveys. The time component comes from subdividing the cross-sectional responses to the survey questions according to the year of birth of each respondent. We discuss this at greater length later in this section.

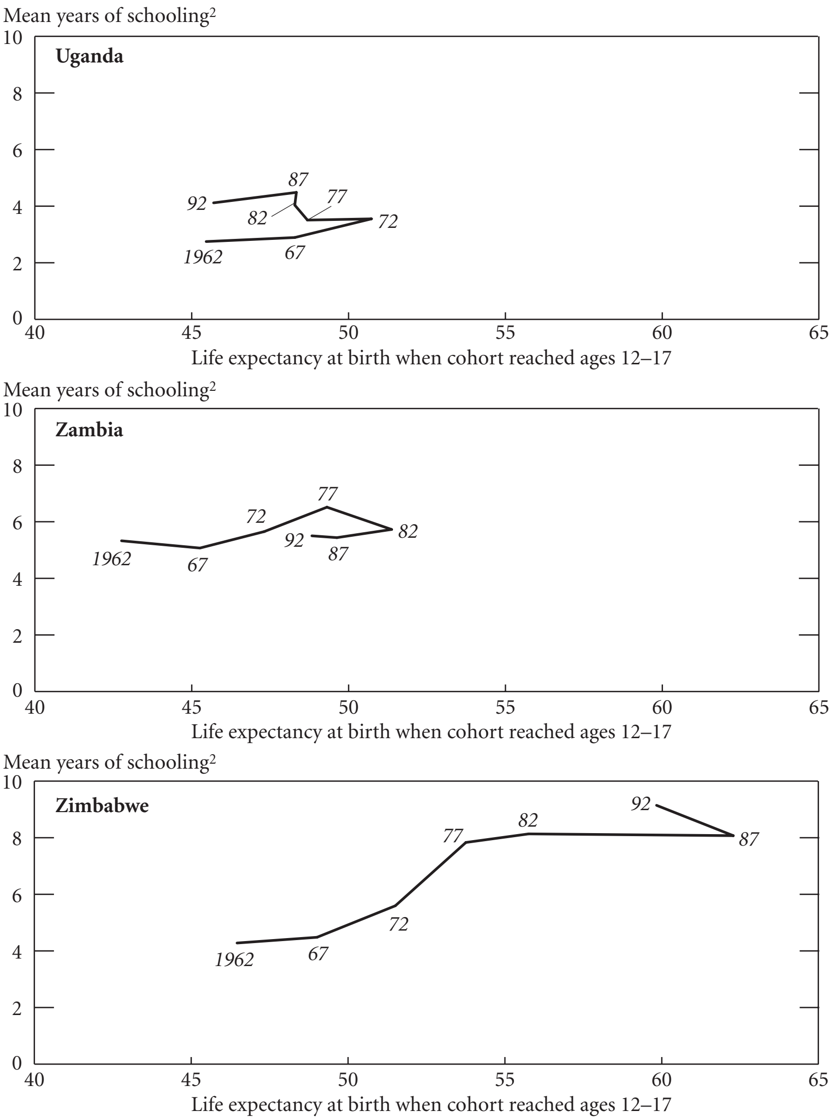
However, it is worth observing a few country experiences over time. Figure 4.6 shows differences in average years of schooling between birth cohorts and changes in life expectancy at birth in the three countries shown in Figure 4.5. In Uganda and Zambia, for example, each five-year birth cohort appears to have been more educated than the one before it until 1977. Those reaching ages 12–17 in 1982 and after, however, began to see shorter and shorter life expectancies and had the same or fewer years of schooling as the cohorts before them.

With this approach we seek to explore the extent to which changes in educational attainment among individuals and cohorts can be correlated with differences in life expectancy in the years when the individuals and cohorts are making decisions about whether to remain in school. To this end we compiled comparable data from 37 DHSs conducted in 23 sub-Saharan African countries over 12 years, resulting in individual data on some 192,000 respondents. We collapsed these respondents into 214 five-year birth cohorts and related average years of schooling within these cohorts to household and national characteristics. The oldest of the cohorts was born during 1935–39, and the youngest during 1980–84. The choice of functional form is similar to that employed by Behrman, Duryea, and Székely, with household and country characteristics relating to schooling attainment in a linear fashion.[12] Table 4.1 shows the results of ordinary-least-squares (OLS) regressions of average years of schooling in each five-

[11]The attainment profiles for the other 20 countries are not shown but are available on request from the authors.

[12]Although the objective here is description, this linear functional form refers back to a specific structural model, namely, the standard Mincerian (Mincer, 1974) model in which individuals seek to maximize their expected income, weighing forgone time in the labor force against the wage premium attributable to schooling. In such a model, individuals would be expected to remain in school until the present value of their expected lifetime returns to an additional year of school equals potential earnings from a year in the labor force. These expected returns are of course linearly related to life expectancy, with each additional year of life in the labor force bringing one additional year of returns.

Figure 4.6. Educational Attainment and Life Expectancy for Selected Birth Cohorts in Uganda, Zambia, and Zimbabwe[1]



Source: Authors' calculations using data from Demographic and Health Surveys for Uganda (1995), Zambia (1996), and Zimbabwe (1999) and World Bank (2001).

[1]Each point represents the five-year birth cohort that reached ages 12–17 in that year.

[2]Calculated by collapsing DHS respondents into cohorts based on birth year and averaging the years of education reported by respondents in each group, weighted by survey sampling weights.

Table 4.1. Ordinary-Least-Squares Regressions of Educational Attainment on Life Expectancy and Other Variables

	Regression[1]					
Independent Variable	(1)[2]	(2)[2]	(3)	(4)	(5)[2,3]	(6)[2,3]
Life expectancy at birth (in years)	0.175 (0.053)	0.064 (0.045)	0.170 (0.085)	0.086 (0.075)	0.070 (0.051)	0.062 (0.050)
Real GDP per capita (in 1987 international dollars)[4]			0.002 (0.001)	0.001 (0.001)		
Year[5]	.0069 (0.027)	0.494 (0.069)	–0.068 (0.052)	0.513 (0.159)	0.055 (0.023)	0.404 (0.180)
Year squared		–0.003 (0.000)		–0.004 (0.001)		–0.002 (0.001)
Number of observations	144	144	107	107	105	105
R^2	0.97	0.98	0.96	0.97	0.95	0.96

Source: Authors' regressions using data from Demographic and Health Surveys (DHS) and World Bank (2001).

[1]The dependent variable is average years of schooling; data are calculated from the DHS for cohorts reaching ages 12–17 in 1962, 1967, 1972, 1977, 1982, 1987, and 1992 in 23 sub-Saharan African countries. Cohort averages are taken by collapsing individual respondents into five-year cohorts defined by the year of their birth and taking an average of responses (weighted by survey sampling weights). Some cohorts were omitted from the regressions for lack of data. For robustness to heteroskedasticity, standard errors of coefficient estimates (in parentheses) are calculated using the Huber-White estimator of the variance-covariance matrix. All regressions include country-specific intercepts and country-specific time trends except where noted otherwise.

[2]Regressions include indicators of household asset wealth (percent of cohort with electricity, radio, bicycle, motorcycle, car).

[3]Only those cohorts that reached the ages of 12–17 before 1987 are included. Country-specific time trends are not included.

[4]Dollars adjusted for differences in purchasing power across countries.

[5]Variable defined as year minus 1900.

year birth cohort on national average life expectancy at birth when the cohort was aged 12–17. (Sample sizes in some of the regressions are reduced because of lack of data on many of the DHS wealth variables or on GDP per capita adjusted for purchasing power parity.[13]) Control variables for each cohort in each country include indicators of household asset wealth or average income per person, the proportion of each cohort living in urban

[13]Because of incomplete data, our regressions do not include all 214 birth cohorts. No aggregate data were available for those birth cohorts that reached ages 12–17 before 1962, leaving 161 cohorts. For some of these, data on household wealth and GDP per capita were not available. However, we used a probit regression to test for systematic differences between those observations for which GDP and household wealth data were available and those for which they were not; the two groups were not statistically different in terms of the other regressors or the dependent variable.

areas, a separate time trend for each country, and country dummy variables to capture fixed effects on demand for schooling within countries.

As already noted, this "quasi-panel" technique is not truly longitudinal, since the time-varying component in the data comes from sorting individual respondents into groups based on the five-year period in which they were born. One difficulty that arises from this procedure relates to the question of selection bias due to mortality rates possibly being correlated with education level. Say, for example, that the more educated individuals in each birth cohort are likely to live longer than their less educated peers. Then, even in the absence of any true secular trend, older birth cohorts would appear relatively more educated than younger ones at any moment in time, since the less educated among the older cohorts will be more likely to have been removed (by death) from the sample of potential respondents.[14] To correct for this effect, we include a linear time trend in the regressions relating schooling attainment to life expectancy, which implicitly assumes that the effect of education on an individual's mortality risk is constant across birth cohorts.[15] This assumption may fail, however, because of the nature of the AIDS epidemic: as noted above, the epidemic (at least in its first wave) appears to have greatly increased the risk of mortality among younger, more educated people *relative to* younger, less educated people. As a result, the younger birth cohorts may have been purged by the time of the surveys of the more educated among them, whereas the older birth cohorts would have been purged of the less educated. Even in the absence of any true time trend, this would create an apparent concave relationship between time and average schooling. We know (see Figure 4.1) that the same sort of relationship holds between life expectancy and time, because of the epidemic. Therefore some of the *apparent* relationship between life expectancy and schooling may simply be an artifact of this "differential mortality" problem. One way to try to separate out this effect from the "true" relationship between schooling and life expectancy is to include the square of the year in the regressions, as we do in columns (2) and (4) of Table 4.1. The difficulty with this approach, however, relates to multicollinearity in the data: life expectancy among the 138 "quasi-cohorts" in columns (1) and (3) is almost perfectly quadratic in time, after

[14]Of course, selection bias may result from dynamics other than just mortality risk. For example, if educated people are more likely at any time to emigrate, the same problem would result. The reasoning is essentially the same, regardless of the selection factor.

[15]Of course, this is not the *only* reason we include a time trend. Including a year trend also captures institutional and technological changes and other developments, so long as these things occur monotonically (and in fact linearly) over time.

controlling for the other factors.[16] It is difficult, therefore, to determine from the existing data how much of the apparent relationship between schooling and life expectancy is simply an artifact of selection bias.

Another way to deal with this is to restrict the period of analysis to the time before the epidemic, as we do in columns (5) and (6) of Table 4.1. After all, it is likely that any effect of education on the relative risk of mortality would be constant across time during this period, so that including time linearly in this regression would control for the possibly differential effect of education on mortality.[17] But, again, before 1987 improvements in life expectancy were almost perfectly linear with time across Africa, after controlling for household wealth and country-specific factors.[18] Therefore this approach does not entirely solve the problem.

Nonetheless, it is worth underlining that we account for time-invariant country-specific differences (such as differences in economic and social policy and institutions) by including a country-level fixed effect, and for any country-specific effects that change linearly with time by including country-year interaction terms.[19] These results suggest that, in cohorts whose life expectancy was 10 years longer, schooling attainment was some 0.6 to 0.9 year higher.

Table 4.2 reports results of the same regression, but with each individual entered into the regression as a single observation, rather than with individuals aggregated into birth cohorts. Because schooling attainment for individuals is truncated at zero years (one cannot spend a negative number of years in school), we use a tobit specification.[20] The results sug-

[16]A regression of life expectancy at birth against the other regressors in column (2) of Table 4.1 produces an R^2 of 0.99.

[17]The coefficient on year squared in column (6) is not statistically significantly different from zero at the 5 percent confidence level.

[18]A regression of life expectancy at birth against the other regressors in column (5) of Table 4.1 produces an R^2 of 0.96, with each additional calendar year bringing an additional 0.39 year of life expectancy (with a standard error of 0.02).

[19]Analysis of the country dummies and country-specific year trends (not shown) indicates that among the large positive outliers are Ghana and Uganda, and among the large negative outliers are war-torn Ethiopia as well as Nigeria and Niger; these findings are consistent with our intuition about at least institutional variation across countries in the region.

[20]The tobit functional specification assumes that the schooling attainment data are truncated, not censored by some independent set of dynamics that determines whether individuals go to school separately from those that determine how long they remain in school, once enrolled. To test whether this assumption is appropriate, we estimated the probability that a respondent will have obtained any schooling at all—regardless of how much—and compared the coefficient estimates from this regression with those of the tobit regression in Table 4.2. If the assumption underlying the tobit specification holds, we should expect the coefficient estimates (scaled by the standard error of the estimate) to be equal. The estimates were indeed quite close.

Table 4.2. Tobit Regressions of Educational Attainment on Life Expectancy and Other Variables

	Regression[1]			
Independent Variable	(1)	(2)	(3)[2]	(4)[2]
Life expectancy at birth (in years)	0.058 (0.019)	0.029 (0.019)	0.107 (0.020)	0.060 (0.022)
Year	0.097 (0.017)	0.947 (0.058)	0.156 (0.007)	0.677 (0.118)
Year squared		–0.005 (0.000)		–0.003 (0.001)
Dummy variable for urban residence	3.135 (0.058)	3.126 (0.058)	3.475 (0.078)	3.475 (0.078)
Number of observations	54,830	54,830	37,650	37,650
Left-censored observations (zero years of school)	24,985	24,985	18,577	18,577

Sources: Authors' regressions using data from Demographic and Health Surveys (DHS) and World Bank (2001).

[1]The dependent variable is average years of schooling; regressions are as in Table 4.1 except that each individual respondent is entered as a separate observation rather than included in a five-year birth cohort. Only those individuals who reached age 12 in 1962, 1967, 1970, 1972, 1977, 1980, 1982, 1985, 1987, 1990, and 1992 are included in the regressions. All regressions include country-specific intercepts, country-specific time trends (except where noted otherwise), and indicators of household asset wealth (whether the respondent's household has electricity, radio, bicycle, motorcycle, car).

[2]Regression includes only those individuals who reached age 12 before 1987 and does not include country-specific time trends.

gest that individuals facing 10 years greater life expectancy attained some 0.3 to 0.6 year more schooling—somewhat less than the 0.6 to 0.9 year obtained using the "quasi-cohort" data.

Another way to attack the problem empirically—one that is less subject to the differential mortality problem—is to examine the relationship between gross primary enrollment ratios at the national level and life expectancy at birth. In generating internationally comparable estimates of schooling attainment, Barro and Lee (1996) employ a "perpetual inventory" method to translate gross enrollment ratios and demographic structure into stocks and flows of population at various levels of educational attainment (no schooling, incomplete primary, complete primary, and so on).[21] They estimate, for example, that the population over age 15 who has completed at least some primary education in any five-year period is equal to the primary-educated population from the previous period that has

[21]They have subsequently used "adjusted gross enrollment ratios" in order to avoid double-counting individuals who repeat grades (Barro and Lee, 2000).

survived, plus the population that turned 15–19 over the previous five years and attended any primary school. The latter population is estimated by multiplying the total population of each five-year birth cohort by the gross primary enrollment ratio in the period when that cohort was aged 10–14.

The assumption, therefore, is that the gross primary enrollment ratio when a five-year birth cohort is aged 10–14 indicates the proportion of 15- to 19-year-olds who have at least some primary education. Employing this assumption, we regress gross national primary enrollment ratios across countries and over time against period- and country-specific life expectancy at birth, income per person, and time trends. This approach is useful for comparison with our previous results, since it is not subject to the differential mortality problem. As Table 4.3 shows, the results suggest that, in environments where life expectancy at birth was 10 years longer, primary enrollment ratios were about 0.2 to 0.3 (or about 20 to 30 percentage points) higher.[22]

Of course, more than one causal model can be constructed to account for these descriptive results. However, the most obvious causal stories—specifically, those involving factors that are time invariant, or secular trends within countries—can be ruled out, since the relationship observed is net of such effects. Such effects might include, for example, differences among countries in the quality of social services or the rate of improvement of these services. Furthermore, Table 4.4 shows the results of first-difference regressions, in which the *change* in gross primary enrollment ratios in each country from one five-year period to the next is related to the proportional change in GDP and life expectancy over the same period. Consistent with the results in Table 4.3, these results suggest that countries in which life expectancy increased by 10 years between one five-year period and the next also saw improvements in school enrollment ratios of about 0.2 (or 20 percentage points) over the same interval. This is also compatible with our descriptive findings using the DHS data.[23]

[22]Since gross primary enrollment ratios are not bounded from above at one as net enrollment ratios are, and since there were no country-period observations where gross enrollment ratios were at the lower bound of zero, a functional form that is linear, rather than tobit or cumulative normal or logistic, is not inappropriate.

[23]In translating enrollment rates into average schooling attainment, Barro and Lee multiply the proportion of the population enrolled at each educational level by the number of years in that level, and then by the probability of completion. The Barro-Lee data suggest that about 25 percent of those in Africa who enroll in primary school complete it. Therefore, assuming six years in primary school, an increase in enrollment of 0.2 would translate into an increase of $(0.2) \times (0.25) \times 6 = 0.3$ year in attainment.

Table 4.3. Regressions of Primary Enrollment Ratios on Life Expectancy and Other Variables

	Regression[1]			
Independent Variable	Africa only (1)[2]	World (2)[2]	World (3)	World (4)[2]
Life expectancy at birth (in years)[3]	0.023 (0.013)	0.021 (0.002)	0.016 (0.002)	0.016 (0.002)
Life expectancy × Africa dummy			0.012 (0.006)	0.014 (0.002)
Real GDP per capita (in 1987 dollars)[4]	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Year				0.020 (0.008)
Year squared				0.000 (0.000)
Constant				–0.921 (0.296)
Country- and region-specific intercepts	39 countries[5]	8 regions[6]	8 regions[6]	None
Number of observations	224	743	743	743
R^2	0.93	0.45	0.46	0.32

Sources: Authors' regressions using data from World Bank (2001).

[1]The dependent variable is the ratio of gross primary enrollment to the number of children of primary-school age; data are from 122 countries (including 39 African countries, listed below) at five-year intervals beginning in 1965. Some observations were omitted from the regressions for lack of data. Standard errors of coefficient estimates (in parentheses) are robust to heteroskedasticity and are calculated using the Huber-White estimator, adjusting for clustering by country. All regressions include country-specific time trends except where noted otherwise.

[2]Regression includes fixed country effects and does not include time trends.

[3]In latest year of the preceding five-year period for which data were available.

[4]Not adjusted for purchasing power parity because of lack of data before 1980.

[5]Algeria, Angola, Benin, Botswana, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Côte d'Ivoire, Comoros, Democratic Republic of Congo, Republic of Congo, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Swaziland, Tanzania, Togo, Uganda, Zambia, and Zimbabwe.

[6]Sub-Saharan Africa; East Asia; Eastern Europe; Latin America and Caribbean; Mediterranean, Middle East, and North Africa; South Asia; South Pacific and Southeast Asia; and industrialized countries of North America and Europe and Japan.

Of course, any causal conclusions that one might draw from these cross-country regressions are subject to the usual caveats. Among other things, it may be that decisions about whether and how much to invest in education are too complex to be captured in linear cross-country or cross-household regressions. This is essentially similar to the criticism leveled by many against cross-country regressions to explain economic growth.

Table 4.4. Regressions of Changes in Primary Enrollment Ratios on Changes in Life Expectancy and Other Variables

	Regression[1]		
Independent Variable	(1)	(2)	(3)
Change in life expectancy at birth over previous five years (in years)	0.015	0.025	0.020
	(0.005)	(0.015)	(0.010)
Change in real GDP per capita over previous five years (in 1987 dollars)	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Constant			0.003
			(0.021)
Country- and region-specific intercepts	8 regions	39 countries	None
Number of observations	613	181	181
R^2	0.05	0.25	0.04

Sources: Authors' regressions using data from World Bank (2001).

[1]The dependent variable is the change in the gross primary enrollment ratio (see Table 4.3) over the preceding five years; data are from 122 countries (including 39 African countries, listed in the notes to Table 4.3) at five-year intervals beginning in 1970 (change from 1965) and ending in 1995. Some observations were omitted from the regressions for lack of data. See Table 4.3 for other details of the regression.

Direct causal analysis is also hampered by the lack of truly longitudinal data in Africa. In its absence, more detailed and qualitative "case study" approaches, which examine changes in educational attainment, attitudes toward investment in human capital, and health status in specific communities or countries over time, could serve well. As these data become available in sufficient detail in African contexts, this line of inquiry deserves a high priority.

Furthermore, even if life expectancy has had an effect on demand for schooling similar to the effects we estimate here, that effect may be dramatically different depending on the *direction* in which life expectancy is changing. That is to say, even if 10 additional years of life expectancy really did increase demand for schooling by some number of years, this by no means necessarily implies that a *loss* of 10 years of life expectancy would *reduce* demand for schooling by the same number of years. In an epidemic, after all, past trends are not always replicated in the future.

This is particularly the case if life expectancy in the past reflected a range of institutional and policy factors that would remain relatively constant (or could even improve) in countries hit by the epidemic. On the other hand, we cannot be sure that the future relationship will not be tighter (and thus worse where life expectancy declines), since the effect of demand for education could be exacerbated by the disproportionate number of adults affected, compared with the past when increased life expectancy resulted heavily from improvements in infant mortality. In short, although our results are only illustrative and certainly not definitive in terms of causality, they do at least provide a point from which to begin thinking about the effects of declining life expectancy on the demand for education.

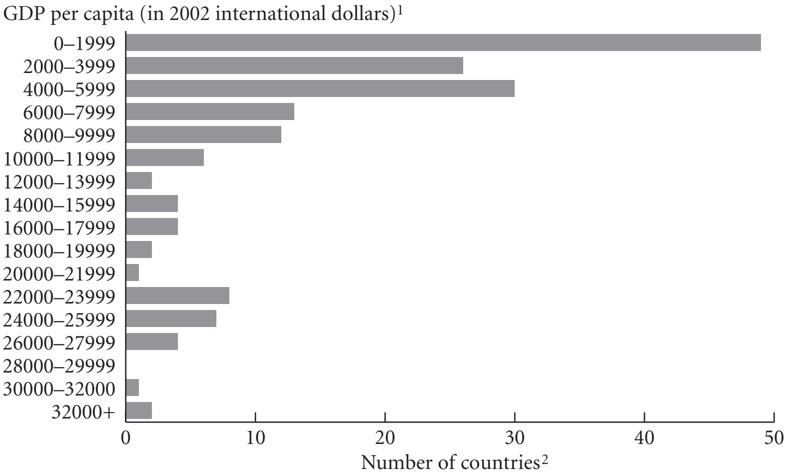
HIV/AIDS and the Productivity of Africa's Human Capital

AIDS is unlike many other diseases in that it disproportionately affects adults of working age. Furthermore, at least for the first decade of the epidemic, HIV was much more likely to infect the relatively well educated. The epidemic will therefore carry off an unprecedented proportion of Africa's existing human capital stock. Beyond the incalculable human tragedy visited upon those who die prematurely and their loved ones, we can expect these deaths to have effects on the productivity of those who survive.

An agglomeration of skilled workers is much more productive than an equal number of skilled workers acting alone. One of the most dramatic illustrations of this principle of increasing marginal returns to human capital is the stylized fact of the "brain drain." Skilled workers in many industries tend to migrate from places where they are relatively scarce to those where they are relatively abundant, in order to increase their income. Indian engineers, for example, can quadruple their income by moving from Kerala to Silicon Valley. Similarly, African professionals in many fields are likely to be concentrated in urban rather than rural areas, wherever they may have been born. Another indication of this phenomenon is in the formation of universities, which, after all, exist because they offer individuals with particularly specialized skills the opportunity to be in a community with others of similar or complementary skills.

Becker, Murphy, and Tamura (1990) use the idea of increasing returns to human capital to generate a model of multiple equilibria in the size, overall schooling, and welfare of households. Their reasoning is that, in the more desirable equilibrium, each household has fewer children but invests more heavily in the "quality" of each child. This increases aggregate human capital in the succeeding generation, which increases the opportunity cost of the grown children's time and the future returns to their skills, thereby inducing them, as parents themselves, also to have fewer children while increasing the attractiveness of investment in the "quality" of those children. This in turn increases their productivity, leading to the long-run persistence of a highly skilled and productive workforce. In contrast, in the less desirable equilibrium, where skills are relatively scarce, returns to

Figure 4.7. Distribution of Countries Worldwide by Real GDP per Capita, 2002



Source: Data from World Bank (2004).
[1]Real GDP per person in 2002, corrected for purchasing power parity.
[2]Data were available for 148 countries, including 39 in sub-Saharan Africa.

investment in schooling are smaller and the opportunity cost of parents' time is relatively low. Parents are therefore inclined to invest time and resources in a larger number of children, who obtain less schooling, thereby perpetuating the scarcity of skills.[24]

The real world does indeed seem to bear out these sorts of stories based on multiple equilibria. For example, as Figure 4.7 demonstrates, the distribution of average income per capita across the countries of the world is highly bimodal, with a large cluster of very poor countries (with GDP per capita, adjusted for purchasing power parity, of up to $2,000), another cluster of very rich ones (with GDP per capita at or around $22,000 to $28,000), and a smattering of countries in between. In the case of sub-Saharan Africa, only 7 of the 39 countries included in Figure 4.7 have GDP per capita (adjusted for purchasing power parity) at or above $4,000.

This highly bimodal distribution of countries is consistent with any number of stories about the nature of economic growth. However, it also

[24]Empirical evidence offered in studies by Psacharopoulos that private and social rates of return to education are fairly constant across countries might appear to militate against such a hypothesis. However, these studies do not capture the true social returns to education (Birdsall, 1996).

rules out many traditional ones. For example, it is much easier to reconcile this stylized fact with the notion of a poverty trap—whereby very poor economies remain very poor until some positive external shock breaks the vicious cycle—than with some stagewise model of development. Therefore, although of course the stylized fact of bimodal income distribution does not by itself imply the existence of poverty traps, it is quite consistent with such a hypothesis.

A sufficiently large increase in life expectancy could jump-start an economy (Bloom and Canning, 2000), as could a large decline in fertility, since the latter subsequently produces a greatly increased ratio of workers to children (Kelley and Schmidt, 1996, 1999; Williamson, 1998). In these and other cases, the story is generally applied to various of the so-called miracle economies of East Asia, where large gains in life expectancy, declines in fertility, and subsequent huge increases in the number of workers relative to children (and the elderly) occurred throughout much of the high-growth decades of the 1970s and 1980s.[25] In a case study in Uganda, Bigsten and Kayizzi-Mugerwa (1999) suggest that the structural constraints typical of a poverty trap (although they do not use that expression) make it difficult to capture the benefits of globalization in the short run, even with a substantially improved policy environment.

Similarly, the accumulation of human capital beyond some critical mass is likely to be one such shock in itself. Lau and others (1996), analyzing cross-sectional evidence from Brazilian states, find that the impact of education on total economic output becomes particularly dramatic only after the average level of education of the workforce reaches a certain threshold; in Brazil this threshold was reached when average educational attainment reached about three to four years. Most African nations, especially in the southern part of the continent, have made progress in building their own critical mass of skills. In Botswana gross secondary school enrollment increased from 19 percent of the school-aged population at the beginning of the 1980s to 56 percent in the mid-1990s. Over the same period this rate increased from 8 percent to 47 percent in Zimbabwe, and from 3 percent to 98 percent in Malawi. Between the early 1970s and the mid-1990s, South Africa's gross secondary school enrollment ratio increased from 20 percent to 84 percent (World Bank, 2001). The AIDS epidemic, however, has hit

[25]Similarly, Bloom, Canning, and Malaney (1999) describe for East Asia a world of "cumulative causation," in which low incomes and adverse demographic and health conditions in East Asia formed a web of cause and effect until the early 1960s. These authors attribute the escape from the vicious cycle to rapid improvements in health, which reoriented the causal cycle, resulting in extremely rapid economic growth.

these nations hardest: the six countries worst affected by HIV/AIDS are located in Southern Africa, with adult HIV prevalence ratios exceeding 20 percent in 6 countries, including Botswana and Swaziland where they approach 40 percent (UNAIDS, 2004). By skimming off the most skilled workers in the economy (at least in the first wave), HIV/AIDS threatens to forestall the emergence of a critical mass of these workers.

These effects are difficult to quantify at the microeconomic level, since they follow a dynamic in which the number of already-educated people increases the social (that is, external to individuals) return to education, but not necessarily the private return. The measured private return may actually decline, as noted above, as more people are educated and skilled workers become relatively more plentiful. This is what explains Psacharopoulos's finding that private returns, especially to higher education, tend to diminish as country GDP per capita rises.[26] (Implicitly, the model presented by Becker, Murphy, and Tamura assumes that, other things equal, some of the positive externalities associated with a larger total stock of human capital are reflected at least in the form of higher absolute private returns.) At the aggregate level, however, it is individuals' decisions about these investments that determine the number of educated people. Increasingly sophisticated empirical techniques have been employed to quantify effects in the context of these sorts of causal cycles. In the meantime, however, it is sufficient to understand the qualitative implications of the loss of the positive externalities generated by Africa's stock of skilled and educated workers. The first of these is an increase in the rate of brain drain, as skilled workers move to take advantage of these externalities elsewhere. The second is a decrease in the average productivity of those workers (unskilled as well as skilled) who do survive. The third is a decline in the demand for schooling among workers in the future, attendant on a decline in the absolute, if not the marginal, private returns to education.

HIV/AIDS, Physical Capital, and Human Capital

Human capital and physical capital are complementary. For example, Birdsall, Pinckney, and Sabot (1997) posit that, where credit markets are incomplete or imperfect, poor households must finance their investments

[26]Psacharopoulos (1994) also reports diminishing social returns to education with higher GDP per capita, but this is because he measures the "social" return at the country level as simply the private return minus the country-specific cost of schooling at different levels.

entirely out of their own savings. These credit-constrained households, therefore, save not only to buffer against stochastic income shocks, but also to finance investment. Because they will invest only when the expected return exceeds the (relatively high) discount rate, investments available to the poor are likely to have higher returns than those available to the rich, who are unable to take advantage of these investment opportunities because of imperfections in the credit market.

This situation holds particularly true for investments in human capital, which yield extremely high private returns relative to most other investments, but are nontransferable and hence extremely difficult to guarantee. For example, once trained, an individual has no reason to fear expropriation of his or her newly acquired skill, and so, in the absence of sophisticated credit monitoring mechanisms, that individual may choose not to make good on any commitment to repay the training costs. The rich, therefore, supplement investments in their own human capital with investments in third-party instruments, including, for example, equity markets and other traditional instruments. These are easier to guarantee, but they are also likely to be less productive than the investments of the poor (in their farms and businesses as well as in their human capital).[27] In such contexts, if the poor are forced to forgo investments in their own education for lack of savings, the potential benefits are lost to the economy.

One of the most salient clinical characteristics of HIV/AIDS is the long period of illness before the infected person finally succumbs. Evidence from a recent cohort study in rural Uganda suggests that the median time from infection to death in that setting is about 10 years, during which the illness becomes more and more debilitating, with the last 10 months usually spent in a state of complete incapacity (Morgan and others, 2002). Since those infected are likely to be adults of working age, this protracted illness hits household saving and investment twice: first by depriving the household of a wage earner, and then by requiring an outlay of household resources to care for the infected person. Although some of these outlays are financed by diverting present consumption or through interhousehold transfers, evidence suggests that most of it is financed by reductions in saving and the selling off of physical assets (Menon and others, 1998; Béchu, 1998). Poorer households, when forced to make these adjustments, are obviously more likely to have to forgo investment in the human capital of their children. Amplifying this effect is the fact that the loss of adults in a household often increases the opportunity cost of the children's time,

[27] See also Acemoglu (1997) and Acemoglu and Pischke (1999).

because their work becomes more vital to the ongoing operation of the household (Mutangadura, 2000).

Furthermore, using year- and country-specific data from Latin America, Behrman, Birdsall, and Székely (2001) find evidence that, when and where the financial markets in the region have been more open to international capital flows, the skill premium in wages has been higher; that is, the returns to secondary and higher education are greater relative to the returns to primary schooling. They infer that skilled labor is complementary to capital, so that new investments in physical capital generate increased demand for skills. Intuitively, the idea that physical capital and human capital are complementary is appealing—specialized skills are required, for example, in the operation and maintenance of most machines. The AIDS epidemic is likely to have a dramatic effect not only on domestic saving (through the foreshortening of time horizons and the increased demand for present consumption to finance medical care), but also on the attractiveness of foreign investment. These effects together are likely to erode the physical capital stock in many of the hardest-hit countries. Insofar as this in turn reduces the skill premium, it will reduce incentives for households to invest resources and time in the education of their children beyond the basic, primary level.

Conclusion

This chapter has explored four channels by which the epidemic of HIV/AIDS in Africa may affect the size, rate of growth, and productivity of the continent's human capital stock. It would make for a compelling presentation, no doubt, if we could add up the effects of these four channels both on the future expected stock of total human capital and on economic growth itself through any change in the economy-wide return to the adjusted stock. We have not developed the complex model that might guide us in doing that, and we believe in any event that the results of any such simulation would be highly sensitive to some basic assumptions about the dynamics of the process. Such models must take into account the likelihood of multiple equilibria, the interactions between general and local characteristics, and other complicating factors about which we still have very little information. This is true both in terms of the expected total stock and certainly in terms of the expected economic effects.

However, we do believe that the evidence for the channels described adds up to the qualitative conclusion that, absent offsetting policies and programs, the AIDS epidemic is likely to worsen Africa's dearth of human capital. The epidemic could have this effect not only from the supply side, by reducing the capacity of the educational system to train the next generation, but also from the demand side, by foreshortening time horizons and increasing the opportunity cost of children's time, thus making investment in schooling less attractive. These effects will slow the rate of Africa's *accumulation* of human capital. The epidemic also threatens to erode the already *existing* human capital stock, as the death of many of the continent's most skilled workers reduces the average productivity of those left behind. Finally, the epidemic threatens to sap away the savings and physical capital assets of households and nations across the continent, thereby reducing the productivity of workers who rely on physical capital to make use of their skills.

Of course, the effects of the epidemic on the accumulation and productivity of human capital in Africa are likely to go beyond those explored here. For example, to the extent that states are forced to reorient their fiscal priorities to health spending, to care for those already infected and dying, education systems may find themselves starved for funding. Furthermore, the orphaning of millions of children across the continent may be expected to leave communities unable to rear children with the traditional level of care or attention. The four effects emphasized in this chapter are relevant to understanding the economics of human capital and have the potential over the long run to, if not offset, at least reduce the stock of human capital and the economic gains from that capital in countries affected by HIV/AIDS.

Our analysis is not meant to be a counsel of despair, however. Rather, it illustrates the likely need for adjustment, for example in countries' educational policies and priorities, including teacher salaries and placement, class size, spending on student transportation (given the particular difficulties in staffing small rural schools), and other changes to minimize the effects of AIDS on the availability and quality of schooling. It also illustrates the logic of ensuring that information about public efforts to contain the epidemic, and successes in those efforts, are well publicized, because this may help maintain demand for schooling in the face of short-term perceptions of declining returns. The analysis has implications for expected growth in the region, and thus for fiscal expectations and the sustainability of the large debt stock borne by many African countries. For the countries worst hit by the AIDS epidemic, it reinforces the logic of massive donor support, to reduce the probability of countries falling into the wrong, low-level, "poverty trap" equilibrium by fighting the disease itself and by helping finance the additional costs of meeting all the development challenges the region faces, including the education challenge. Finally, for the community of research economists, it illustrates the multiple links among health, education, and economic growth; the relevance of the demand as well as the supply side for sustaining and increasing education; and, more generally, the centrality of human capital to development progress.

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