HUMAN CAPITAL ACCUMULATION AND THE AIDS EPIDEMIC IN SOUTH AFRICA AND UGANDA

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I would like to recognize the work of Dr. Eric Reeves, professor of English at Smith College, and tireless anti-genocide activist. He has spent the past eight years working full-time on research and analysis of the genocide in Sudan. His dedication to that cause helped to crystallize my own inclination to explore and understand the AIDS crisis in Africa. When asked why we in the United States should care about the hundreds of thousands dead at the hands of the Janjaweed militia in Darfur, Reeves insists that it is the humanity within all of us that must compel us not only to care, but to act. I have found my own humanity awakened by the AIDS pandemic, and this paper is a response to that awakening, and to Dr. Reeves' call to action. This paper stands, therefore, not as a completed investigation, but as a first step into the economics of the African AIDS crisis.

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I. Introduction

Over the last half century, international and domestic efforts in Africa have sought to elevate living standards through improvements in health care, education, infrastructure, monetary policy, investment, and foreign trade. Generally, such efforts have found only marginal success in improving living standards and creating opportunity for Africans. With the introduction of the AIDS epidemic in the 1980s, many of those small gains were eroded. AIDS is now the leading cause of death on the African continent, and as a result of the epidemic, life expectancies in most African countries have declined. In South Africa, where the HIV prevalence rate[1] among peoples age fifteen to forty nine is near 20%, the life expectancy has dropped below fifty years for both men and women.

Before the AIDS epidemic, the African experience puzzled economists who struggled to explain its stagnant growth. Now, as AIDS ravages the continent, devastating family structures, schools, government organizations and private sector establishments, Africa vociferously demands the attention of economists and humanitarians across the globe. Young (2004) used the Black Death that tore across Europe in the late 14th Century as a model for understanding AIDS. But the Black Death is not a useful archetype for understanding AIDS; this crisis stands apart from all other epidemics in human history. While the Black Death—and so many other scourges in history— struck the young and old indiscriminately, AIDS affects adults in their most productive years. Because HIV is transmitted through sexual activity, it generally does

[1] The HIV prevalence rate is the percentage of a given population that is HIV-positive.

not affect young people until they are at least beyond primary school age.[2] Once individuals contract HIV, they often remain healthy and asymptomatic for several years. Upon becoming symptomatic with AIDS, however, they quickly become weak and susceptible to the infections that ultimately kill them.

This horrible epidemic has profound implications for the accumulation of human capital in African nations. AIDS directly erodes the current human capital stock as mortality rates rise. And given the nature of the disease, AIDS affects individuals only after they have chosen to invest (or not to invest) in the first stages of their education. This presents a complex threat to human capital investment, as the epidemic alters capital accumulation in multifarious, but not unpredictable, ways. The broader objective of this paper is to begin an exploration of the relationship between AIDS and economic growth, and to do so, I focus in particular on the effect of AIDS on human capital.

It is important to recognize that the scope of this paper does not address the many ways beyond its effect on human capital that AIDS influences growth and development. It simultaneously acts through many other channels: it forces governments to allocate continually more resources to health care and social services and away from infrastructure or other productive ends; private sector firms struggle as they confront mounting sick leave, rising pension outlays to sick persons and dependents, losses in productivity, and a declining supply of skilled labor; and as (already prohibitive) risk associated with investment in Africa rises, foreign direct investment evaporates.

The failure of economists to explain stagnant African growth and the failure of so many international aid programs to effect lasting change for the welfare of African

[2] Babies infected with HIV from birth represent an exception to this generalization, as do children who are sexually assaulted in their early years.

people makes any investigation by a (Western) economist seem quixotic. In embarking on this exploration, I recognize that not all Western models and assumptions apply readily to Africa. That is, I want to consider the possibility of an "African model," distinct from the growth path and the behavioral patterns that characterize Western development. Throughout this paper, I point out cultural values that are relevant to a discussion of AIDS in sub-Saharan Africa, and to Uganda and South Africa in particular. I do this in order to address the circumstances that make African nations distinct from each other and from the West. Such cultural values are particularly important to a discussion of gendered issues, which figure prominently in my understanding of AIDS and human capital accumulation, and which differ vastly from Western norms. For example, UNICEF (2004) points out that cultural ethics often prevent women from accessing information about their bodies and their sexual well being, while entrenched power imbalances encourage men to have multiple sexual partners, thereby endangering wives, even when they remain faithful. A survey of secondary schoolgirls in Kenya exposed the profundity of that gender power imbalance, as 40% of girls reported that they had been coerced into their first sexual experience (UNICEF 2004).

I chose to focus on Uganda and South Africa because they each represent a distinct case in the African AIDS epidemic. Uganda's per capita Gross Domestic Product (GDP) hovers around US$1,800, and its current HIV prevalence rate—down from nearly 20% at the start of the 1990s—is just under 7%. In contrast, South Africa is a much wealthier country with a much graver AIDS epidemic. Per capita GDP in South Africa is US$13,000, and, as mentioned above, its HIV prevalence rate is about 20%. There is much to learn from each country's experience. In Section III, I analyze the AIDS

intervention efforts launched by both countries, and examine their efficacy relative to a model for human capital accumulation. In Section IV, however, I conduct an empirical investigation for South Africa alone. Relevant data for educational attainment and HIV prevalence by province in Uganda were not available. That limits the scope of this paper and its potential to draw cross-country inferences.

The remainder of this paper is organized as follows. In Section II, I survey AIDS literature that addresses the effect of AIDS on human capital. In Section III, I discuss the importance of education—and female education in particular— in determining HIV transmission. I then present a framework for human capital accumulation, and use it to analyze Ugandan and South African AIDS intervention efforts. In Section IV, I explore empirically the relationship between HIV prevalence and quality and access to education in South Africa. And in Section V, I summarize my results and discuss implications for human capital accumulation and AIDS intervention efforts in the future of African development.

II. Literature Review

Much of the literature on AIDS and economic growth does not investigate the effect of the epidemic on human capital transmission. This section will briefly characterize the more typical literature of the field in order to situate this paper in its broader context. I will then survey those papers that examine the effect of AIDS on aggregate human capital, and review three studies that address how AIDS affects the household decision-making processes that determine educational outcomes for children.

IIa. AIDS and Human Capital

The typical analysis of the macroeconomic impact of AIDS compares a no-AIDS growth scenario to a path showing the effects of the epidemic on key determinants of growth. The 2005 paper by South African economists Burger and de Villiers conforms to this method of analysis, and it also focuses on the effects of AIDS on human capital. They conducted a supply-side analysis of the South African economy with a Cobb-Douglas model for growth, and they assumed effective labor to be altered not only by the sick and dying but also by those who care for the sick. They assumed that the health care costs associated with AIDS were financed largely out of household savings, and they modeled the resulting effect on aggregate savings. Finally, they assumed the level of technology would remain constant, reasoning that AIDS would affect technological progress but that in the presence of AIDS technology would be unlikely to decline. The composite of these effects suggested that AIDS would have a significant negative impact on growth after the year 2000. They projected that, by the year 2015, the AIDS growth path would demonstrate a 17% decline in real GDP relative to a no-AIDS scenario. Despite this substantial decline in aggregate GDP, they found the effect of AIDS on population growth to be greater in magnitude, yielding an effective *increase* in per capita GDP.

In her 2003 paper, Nicoli Nattrass criticized the AIDS versus no-AIDS analysis used by Burger and de Villiers. Noting that studies of this type refer to current growth as the "no-AIDS path," she pointed out that current growth no longer reflects the absence of AIDS. Indeed, AIDS has now affected human capital, and economic growth, for two decades. More poignantly, "AIDS cannot 'be treated as an exogenous influence that can be 'tacked on' to models…. HIV/AIDS has become an 'endogenous' influence on most

African countries that has adversely affected their potential for growth and development" (Nattrass, 2003, p. 434). The effect of AIDS cannot be modeled by simple population growth projections for the AIDS and no-AIDS growth paths. Instead, the ways that AIDS affects household decision making—through the threat of premature adult mortality, the presence of a foster child, or the cost of antiretroviral therapies (ARVs)—are complex, endogenous variables. Building on this important assertion by Nattrass, I will examine those studies that move beyond an analysis of AIDS and no-AIDS growth paths and focus on the particular effect of AIDS on human capital.

Although Markus Haacker (2002) used an AIDS/no-AIDS framework, his analysis addressed the multitude of channels through which AIDS affects growth. He asserted that AIDS primarily affects per capita income through its impact on population growth, human capital, and the response of investors to the rate of return to capital. He used UNAIDS data from 2000 for a sample of ten southern African nations, and projected that the human capital stock deteriorates as the level of experience in the work force declines with rising mortality rates. He then predicted a partial recovery in the level of experience in the long run, as birth rates declined. The rebound in experience level would trigger a parallel effect on per capita GDP; it initially declines, he predicted, as the AIDS epidemic reaches its peak, and then partially recovers. In his analysis of the impact on education, Haacker observed that the number of teachers declines due to AIDS, while the number of pupils simultaneously drops as a result of declining birth rates and increased child mortality. He also noted that access to education could deteriorate as the number of orphans rises. More generally, Haacker predicted that the educational process would be severely disrupted, and human capital transmission would suffer as a result.

Bennel (2005) examined AIDS and human capital transmission by studying the educational attainment of orphans in Botswana, Uganda, and Malawi. He described the empirical difficulties in quantifying the real effect of AIDS on schooling. The Ugandan government does not have accurate records on the deaths of students' parents, and it is therefore difficult to determine if children are AIDS orphans. Bennel cited Hunter and Williamson (2002) as estimating that, in 2001, there were 11 million AIDS orphans in sub-Saharan Africa. Yet Bennel also noted that AIDS orphans make up only one third of total orphans in that region.[3] In other words, the burden of orphans was a considerable problem prior to the AIDS epidemic, and it continues to be a partially separate phenomenon. In his own analysis, he concluded that international NGOs overestimate the magnitude of the orphan problem as it pertains to AIDS. This assumption may have led him to be optimistic in his projections about educational outcomes.

Bennel asserted that orphan status does not necessarily eliminate the potential of a child to seek education or acquire important skills. He used a survey on absenteeism from a Botswana school district to buttress this contention. In the month before the survey was conducted, none of the two-parent orphans had been absent from school. Bennel reasoned that orphans would have a much stronger emotional tie to their school community than might ordinary children, and they would therefore be unlikely to miss class or drop out altogether. However, he draws these conclusions based on a single Botswana community and its records for just one month of school attendance. Bennel then cited Kadzamira et al. (2002) and a study of children in Malawi, in which only 18 of 111 orphans who were located and interviewed were not attending school. Kadzamira et

[3] Bennel uses the term "orphan" to designate a child who has lost at least one parent. There is no prevailing definition of "orphan" in Ugandan school records.

al. concluded that orphanhood does not have the strongly adverse impact on school attendance that traditional literature asserts. This inference is problematic. The data set used by Kadzamira et al. was small, and those orphans who were most easily located and interviewed were likely to be members of a stable household and in regular school attendance. Bennel conceded in his paper that Kadzamira's sample was biased, but based his own analysis on it regardless, writing that the dropout rate among orphans is "probably not appreciably higher" than that of other school children (Bennel, 2005, p. 477). In his conclusion, Bennel suggested that, given this only weakly discernable relationship between orphan status and a substandard educational outcome, a targeted policy to assist orphans where appropriate could entirely mitigate adverse effects of orphanhood on human capital achievement.

Birdsall and Hamoudi (2004) studied the impact of AIDS on student-teacher ratios in African schools, and they cited a UNICEF report that estimated 860,000 African schoolchildren had lost their teacher to AIDS in 1999. They modeled a system of two equations for the growth of the student and educator populations, respectively, and applied the model to Botswana. Their results demonstrated a steady increase in the student-to-educator ratio. Given Bennel's assertion that AIDS orphans may be only slightly less likely than non-orphans to seek education, rising rates of teacher mortality could indeed lead to precipitously high student-to-educator ratios and therefore erode the quality of education in African schools. A sizable loss of educators is a potentially devastating outcome on a continent that the World Bank estimated to have just one teacher for every fifty nine pupils (World Development Indicators 2001). Birdsall et al. projected that many nations devastated by AIDS will be in danger of falling into poverty

traps, as educational quality deteriorates and human capital accumulation declines as a result.

Brent (2006) investigated whether female educational attainment is inversely linked to HIV transmission. Intuitively, as women pursue higher levels of education and therefore increase their earning potential, they face rising opportunity costs associated with early marriage, childbearing, and risky sexual behavior, as well as reduced incentives to engage in commercial sex work. Greater educational attainment, therefore, could trigger behavioral changes that decrease women's vulnerability to HIV/AIDS. To investigate this relationship empirically, Brent used numerous measures of educational attainment, including primary and secondary school enrollment rates, female literacy, and the literacy gender gap. In his Ordinary Least Squares (OLS) regression, as well as in alternative models in which he instrumented for education and checked for endogeneity, Brent found the surprising result that female educational attainment was positively correlated with HIV infection. He hypothesized that this resulted from the particularities of his data set; among countries surveyed, the poorest (with the lowest levels of educational attainment) had large Muslim populations and, due to associated cultural practices, low rates of HIV infection. This investigation therefore failed to demonstrate the expected negative relationship between female education and HIV/AIDS transmission.

IIb. AIDS and Household Choice

Young (2004) compared the impact of AIDS on human capital transmission to its competing effect on population growth in order to predict the net outcome for per capita income. He used a Becker model for household choice to explore the relationship between AIDS, education, and fertility rates. In his model, couples maximize the utility

function $U(n, q, l_m, l_f, C)$, where n and q represent quantity and "quality" of children, respectively, l_m and l_f are male and female leisure, and C is consumption. Noting that less educated women typically have more children, and that "bad" outcomes—that is, low educational and professional achievement— in one generation tend to be replicated in the next, Young suggested that a disruption in children's education caused by AIDS could trigger a permanent decline in educational attainment.

Young calibrated his model to South African household survey data and the Federal Reserve Bank of South Africa's estimate of the 1995 capital stock. He then concluded that the decline in population growth resulting from AIDS far outweighed its impact on human capital transmission, and therefore would result in an *increase* in per capita income. He asserted that the steep decline in population growth "implicitly endow[s] the economy with extra resources which can be used to extend the lifespan of the afflicted and still leave reserves to raise the per capita welfare to future generations" (Young, 2004, p. 38). This projection is surprising, and fails to consider the millions dead as a result of the AIDS epidemic in its accounting of aggregate "welfare."

Bell et al. (2006) examined human capital transmission in the presence of the AIDS epidemic, employing an overlapping generations model calibrated to the South African economy. Setting out a two-period system of childhood and adulthood, they analyzed the effect on household decision making of a parent falling ill with AIDS. They reasoned that in a no-AIDS scenario, parents must have some minimum level of educational attainment in order to value sending their children to school, and to be able to do so. The authors then suggested that a parent's illness would affect household decision making by *increasing* that minimum level of education necessary for the parents to

finance education for their children. That is, the presence of premature adult mortality affects human capital transmission not only through the first-order effect of truncated capital transmission when a parent dies, but that the threat of premature mortality makes all parents less likely to allocate resources to their children's formal or informal schooling. Crucially, Bell et al. demonstrated that AIDS affects children's education through many channels other than the death of their parents, as Young (2004) assumed.[4]

The authors then described a scenario in which the economy falls into a poverty trap, taking for granted that those children who lose both of their parents will become immediately impoverished. Children therefore grow up in poverty and receive little formal education as a result, and they pass on a life of poverty and low educational achievement to *their* children. In this way, AIDS permanently disrupts the process of human capital transmission across generations. The authors underscored two key properties to this model: first, a permanent increase in premature adult mortality triggers the descent into poverty for individuals on an otherwise productive path; and second, their study suggests that poverty will increase through the proliferation of single-parent households, which require a new, higher level of human capital achievement on the part of the remaining parent to facilitate the education of her offspring. Bell et al. applied this model to South Africa, charting various growth paths for that country and exploring policy options. They concluded that the full effect of AIDS would not be felt until long after the epidemic had peaked. What ultimately emerged from this paper is the complex nature of the human capital losses associated with AIDS. Its first-order effects—the deaths of adults in their prime—cannot be considered the sole or primary consequence of

[4] This assumption was central to Young's paper, and was probably the key difference that led his analysis of the South African economy to yield the opposite result from that of Bell et al.

AIDS. Rather, its impact must be understood as the deterioration of human capital transmission across generations.

Deininger et al. (2005) investigated the ability of orphans to accumulate human capital after they join foster families. To explore this issue, the authors examined how "pooling"—the placement of an orphan into a foster home— affected the consumption and investment patterns of households that gained a foster child. They outlined a utility function for household k of the form $U_k (C, H_j , E_j)$, in which the household seeks to maximize consumption, C, and health and education, H_j and E_j , for each individual j. The authors considered two households in period t, where the first household experienced a shock in the form of a foster child, and the other household did not. They estimated a fixed-effects model for 1,300 Ugandan households surveyed in 1992 and again in 1999. Their econometric results indicated that the presence of a foster child had a sizable negative impact on household welfare—an outcome that was particularly pronounced among poor families—while the demand for investment decreased. Of particular note was the statistically significant positive relationship between household savings and a "natural" increase in the number of children; that is, households that added an additional biological child elected to save more, while households with a new foster child saved less. Drawing conclusions based on these results, Deininger et al. gathered that, given the number of AIDS orphans already placed in foster homes and the projected number of AIDS deaths in the future, countries hardest hit by the AIDS epidemic will experience an associated decline in savings and investment.

The authors then explored the impact of foster child status on educational attainment. They found that, in 1992, foster children were at a significant disadvantage

in obtaining education relative to their peers living with biological parents. However, the results suggested that by 2000, much of that disadvantage had diminished. This may reflect the success of Uganda's Universal Primary Education (UPE) initiative, in which the central government has attempted to eliminate school fees. The disadvantage in access to schooling associated with being female had also ebbed over that time period, suggesting that the UPE program was indeed generating positive results. These findings partially corroborate Bennel's work; the loss in education associated with orphan status may not be devastating—or is not necessarily devastating, if appropriate policy initiatives are in place.

Table 2.1	**Overview of AIDS Literature**		
Author	**Assumption for Effect of AIDS on Per Capita GDP For y = F (K, L, H), where L is population and H is human capital**	**Method**	**Findings**
Burger and de Villiers	L, H: Smaller population, and less human capital both from direct effect of AIDS and from re-allocation of time to caring for the sick	AIDS/no-AIDS modeling for a Cobb-Douglas production function	AIDS has substantial negative impact on growth of aggregate GDP and on population growth; net effect is an increase in per capita GDP
Haacker	K, L, H: AIDS affects aggregate welfare through numerous channels, including its negative effects on the private sector, education, and the efficacy of health care	AIDS/no-AIDS modeling for effects of AIDS on health, education, government expenditures	Initial devastating impact on experience level of the work force and, thus, on per capita GDP; in the long run, the experience level partially recovers, leading to corresponding recovery of per capita GDP
Bennel	H: AIDS directly affects the welfare of children who become orphans	AIDS mortality on enrollment statistics for African schoolchildren	Targeted policy to ensure access to education for orphans could entirely mitigate the adverse effects of AIDS on orphans' educational attainment
Birdsall and Hamoudi	H: AIDS affects human capital through multiple channels, including loss of productive adults, lower demand for education, and less matching	Two equation system for changes in student and teacher populations	Projected steady increase in student-teacher ratios; associated decline in human capital transmission could trigger poverty traps for many African nations
Brent	H: AIDS stems from, and contributes to, poverty; increasing female education may alleviate poverty and decrease transmission of HIV	OLS and instrumented regressions for female education on AIDS	No evidence found that female education prevents spread of HIV
Young	L, H: Competing effects of high mortality rates and loss of productivity	Becker model for time allocation and Solow model for growth	The effect of AIDS on population growth outweighs its negative effect on GDP growth, leading to an increase in per capita GDP
Bell et al.	H: AIDS has a complex series of effects on the way that human capital is accumulated and transmitted across generations	Overlapping generations model for human capital transmission	AIDS affects human capital both through adult mortality and through the threat of premature mortality, as it discourages parents from investing in their children's education
Deininger et al.	K, H: AIDS acts through its effect on household investment and consumption as foster children place a burden on family structures	Household choice model and budget constraint for changes in consumption and investment	The presence of a foster child decreases household savings, and foster children face significant barriers to accessing health care

III. Human Capital Accumulation and AIDS Intervention Programs

The objective of this paper is to illuminate how AIDS alters economic growth through its effects on human capital accumulation. But an investigation of AIDS and growth in Africa is subject to the multitude of difficulties that plague the broader analysis of African development. As billions of dollars of aid flow into the continent, growth in many places remains stagnant or even negative, and economists struggle to explain why. Investigating the effects of AIDS on growth is still more difficult, as the epidemic is a relatively new phenomenon. Data are scarce and not always reliable. For this reason, empirical methodology is not a wholly satisfactory approach to this issue. The theoretical investigation in this section is therefore an essential counterpart to my subsequent empirical analysis.

In this section, I present a human capital production function, and I use it to describe the multitude of channels through which AIDS affects the accumulation and transmission of human capital. I then examine the AIDS intervention programs of South Africa and Uganda, and discuss how each program addresses (or fails to address) the nature of human capital achievement.

IIIa. (Female) Education as a "Social Vaccine"[5]

While this paper seeks to explain how AIDS adversely affects human capital accumulation, it is also important to address how human capital achievement stems the transmission of AIDS. That is, AIDS affects education, but education also affects AIDS.

[5] A World Bank report on AIDS called education a "social vaccine." It referred to primary school children as a "window of hope" (Bakilana et al. 2005). Nearly all primary school students are free of AIDS because children infected with HIV from birth usually do not survive to school age and primary school students are generally not yet sexually active.

Education can prevent the spread of HIV/AIDS in two ways. It can directly inform students about the dangers of risky sexual behavior and therefore facilitate the extent to which they protect themselves. Education can also combat the epidemic by raising the opportunity cost of engaging in high-risk sexual activity. By endowing students with valuable skills and creating the potential for them to seek employment beyond their local confines, education may allow young people to shun high-risk sex, early marriage, or commercial sex work, in favor of more productive activities. This effect may be especially pronounced for young African women, who often have limited professional opportunity available to them.

Shariff and Namkee (1995) and Sen (1999) demonstrated that female education is critical to growth and well being in developing nations. Sen observed that female literacy has a large and statistically significant negative impact on the mortality of children under age five. He explained this relationship as reflecting the high value mothers place on the welfare of their children, and as educated women are permitted agency within the family structure, they influence household decision making in favor of the health, education, and general well being of their children. Shariff and Namkee studied child anthropometry in Uganda in order to describe this relationship in more detail. They found a significant relationship not only between mothers' education and infant health, but also between a mother's education and the long-term well being of her offspring. They also observed a gender bias within these findings; a mother's education was likely to have the strongest positive effect on the health of her male children, suggesting the presence of cultural values that lead mothers to favor sons over daughters.

A 2005 World Bank report on education and AIDS cited these gendered cultural values as it described the difficulty of increasing access to education for African children (Bakilana et al. 2005). When household resources are scarce, girls' schooling is often sacrificed before boys' schooling or other forms of consumption. Also, the challenge of keeping young girls safe and endowing them with the ability to protect themselves from HIV is far more difficult than it is for boys. Currently, 60% of sub-Saharan adults living with HIV are women (UNAIDS 2006a). Girls are often sought as sexual partners for older men, and commercial sex work can be the only wage labor available to women. Some cultures also discourage educating girls about how they can protect themselves from HIV, considering such knowledge indicative of promiscuity (ActionAid 2006).

The potential returns to overcoming these cultural barriers are enormous; Shariff and Namkee (1995) and Sen (1999) underscore the importance of female education in improving health and welfare outcomes for all individuals of the coming generation. Ultimately, there is a complex system of causality at work, in which a population of uneducated women perpetuates commercial sex work, the spread of HIV, and the proliferation of unhealthy and uneducated children—who, in the next generation, contribute to the same unhealthy behaviors. Educated and empowered women promise healthy, educated children and slower HIV transmission. Given this critical role for female education, I will focus on it in particular within my broader analysis of human capital accumulation.

IIIb. The Effects of AIDS on Human Capital Accumulation and Transmission

I model an individual's human capital achievement as a function of her physical health, the informal schooling she receives from her parents and other caretakers, the

formal education she obtains from all levels of schooling, and the professional skills she acquires. For individual i, the human capital production function takes the form

(1) $H_i = F(W_i, I_i, E_i, K_i)$,

where *W* is physical well being, *I* represents informal schooling, *E* is formal education, and *K* is job training and experience.

AIDS influences *H* through its direct effects, its effect on the opportunity cost of education, and its income effects. AIDS directly affects *W* as individuals become sick, and it alters *E* and *K* as sickness disrupts education and job training. It also directly affects *I* as sick parents cannot dedicate themselves to their children's informal schooling. It further alters *E* as AIDS orphans have trouble accessing education and as teachers perish, decreasing overall educational quality.

AIDS affects the opportunity cost of *E* in a multitude of ways. Individuals take time away from education to care for sick relatives, while household income is allocated away from education to health care expenses. Generally, the threat of AIDS decreases the expected return to *E* for all individuals.[6] As a result, aggregate investment in education declines. Parents not only anticipate their children's premature mortality, but if the parents are sick, they will also anticipate their children becoming orphans, and because orphans often must cease their education, parents may discount education in the present period. Female education will be particularly threatened, as households sacrifice girls' education before boys', or before other forms of consumption. Recalling Shariff and Namkee (1995) and Sen (1999), this has potentially severe implications for human

[6] There is also the potential for AIDS to increase the expected return to education for some individuals who profit from the increasingly limited supply of skilled labor. It is unclear exactly how this would figure into individuals' expectations about the return to their investment in education, relative to the possibility of contracting HIV.

capital in the next generation, as a woman's education has a strong positive effect on *W* for her children.

I designate a third category as the income effect of AIDS. As orphans are placed into foster families, the pressure they add to household budget constraints compromises *E* for both foster and biological children. It also affects *W*, as households struggle to allocate resources to all individuals' health care. The expense of providing care for sick family members has a similar effect on household budgets, thus affecting *E* for household children. AIDS also imposes a kind of inter-generational poverty trap; that is, even if both parents in a household are healthy, if they were AIDS orphans as children, then their human capital achievement will be low. That negatively affects their ability to provide informal education *I* for their children. It also adversely impacts their earning power, and thus their potential to finance *E* for their children. And as stated above, a mother's lack of education will have a particularly strong negative effect on *W* for her offspring.

IIIc. The Campaign against HIV/AIDS in Uganda

Uganda represents a unique success story in sub-Saharan Africa for its reversal of the spread of HIV/AIDS.[7] In Kampala, Uganda's capital city, the percentage of pregnant women who were HIV-positive fell from 31% in 1993 to 14% in 1998 (World Health Organization 2006). In rural Uganda, the same statistic fell from 21% in 1990 to 8% in 1998. The Ugandan government has supported numerous AIDS intervention programs that have educated adolescents about healthy sexual behavior. Falling infection rates among girls aged thirteen to nineteen reflected the success of these adolescent-targeted

[7] Uganda's achievement in combating AIDS has been jeopardized recently, as its previously decreasing HIV prevalence rate is now increasing. This may be due to complacency after years of concerted intervention efforts. Still, I use Uganda as an important example of success—if short-term — in the African AIDS crisis.

programs. Teenage girls reported engaging in protected sex at a higher rate than any other demographic, and the proportion of fifteen-year-old boys who had never had sex rose from 20% to 50% between 1989 and 1995 (World Health Organization 2006). Section IIId explores how these intervention programs address the model for human capital and the channels through which AIDS affects human capital accumulation, as advanced in Section IIIIb.

IIId. Uganda's AIDS Intervention Programs

The Abstinence, Be faithful, use Condoms (ABC) campaign is the country's most well-known initiative, and it addresses the nature of human capital accumulation in several ways. The Ugandan government began to promote this philosophy at the outset of the epidemic, in 1987. Recognizing prevention as the only method to combat AIDS, the government sought a "policy of openness" to de-stigmatize sex education (Ugandan Think Tank on AIDS, p. 7, 2005). Abstinence and being faithful to one partner were initially emphasized more than condom use, as individuals in rural Uganda had trouble obtaining condoms.[8]

The ABC initiative attempts to preserve individuals' physical well being *W*, as it keeps agents from becoming sick. It also positively affects *E* by protecting educational quality, as fewer teachers fall ill. And de-stigmatizing sexual health and making all Ugandans more likely to engage in safe sexual practices positively affects individuals' expectations about their life span and the return to investment in *E*; similarly, parents will have stronger incentives to invest in their children. Evidence on Ugandan behavioral

[8] The ABC program has been criticized for emphasizing abstinence-only AIDS prevention, as abstinence-only sex education generally has a high failure rate. However, reported changes in sexual behavior in the years after the implementation of ABC suggest that all components of the program were important to Uganda's declining HIV prevalence rate.

patterns in the two decades since the launch of the campaign suggests great strides toward informed sexual behavioral patterns.[9] The emphasis on abstinence triggered a delay in the age that Ugandan adolescents became sexually active, from an average of fourteen years of age to eighteen. This led to a reduction in teenage pregnancy, thus allowing more Ugandan girls to seek higher education. Uganda also saw a decline in individuals reporting casual sexual encounters. Condom use also increased markedly. Between the outset of the ABC program and the Ugandan Think Tank on AIDS Report in 2005, condom use in urban areas increased by 60%. In rural areas, it increased by 40% (Uganda AIDS Commission 2005).

The Straight Talk Foundation (STF) is a UNICEF-sponsored print, radio, and outreach program that promotes sexual and reproductive health and the development of life skills among Ugandan youth (World Bank 2003). The program began in 1993, and its primary target group is fifteen-to-nineteen year olds, but it also has a division called *Young Talk* for ten-to-fourteen year olds. The STF offers information about sexual health and the risks of sexually transmitted infections (STIs). The program also aims to endow Ugandan adolescents with a strong sense of self worth and recognition of their rights—especially, their right to refuse adults' sexual advances. This pairing of sexual education with strong values is crucial to the efficacy of the program. Especially for women and girls, an understanding of how HIV is transmitted may not be enough to prevent them from high-risk sexual activity.[10] Rather, providing women with the tools to seek

[9] Of course, causality between the ABC initiative and change in sexual behavior is difficult to demonstrate. While not all change in relevant behavior can be attributed to ABC, I assume that it partially facilitated the broader shift in awareness about what constitutes safe sexual practices.

[10] Indeed, women for whom commercial sex work is the only available occupation will not be able to enforce condom use with clients. If a client demands unprotected sex—and his business is the only way a woman can feed herself or her family— then she will not turn down unprotected sex *even if* she understands the implied risk of HIV infection.

educational and professional opportunities *combined with* an understanding of HIV/AIDS may successfully steer them toward more productive paths. Of course, offering access to education for all children and adolescents is critical to this formula. I address Uganda's Universal Primary Education initiative in Section IIIe.

Parents' perception of the likelihood that their children will survive to adulthood affects the expected return to education and will negatively influence the optimal level of formal education *E* that parents choose for their children. The STF mission statement directly addresses this concern, pledging to make adolescents safe from STIs and thereby attempting to reduce or eliminate the threat of premature mortality. The STF works toward that goal through its youth outreach programs, including open debates and discussion on sexual and reproductive health issues, engagement of adolescents in theatrical portrayals of HIV-related issues, and an array of sports and community service activities that engage adolescents in community-oriented action while steering them away from sexual activity. In addition, the STF distributes 163,500 copies of its monthly publication to secondary schools, universities, churches, NGOs, and health care facilities in order to disseminate information on sexual health to a broad audience.

The STF also addresses the concerns of HIV-positive Ugandan parents as they face their own premature mortality. Parents must consider how their children's lives will unfold as orphans. If their children understand how to protect themselves from HIV, and they value education as a crucial step toward their productive adult lives, parents will be more likely to finance their early formal schooling and to dedicate time and energy to informal schooling.

The strong positive relationship between mothers' education and child health demonstrated by Shariff and Namkee (1995) and Sen (1999), and Young's (2004) suggestion of a negative relationship between the female wage and fertility[11], underscore the importance of the STF as it affects young women in particular. Combining their respective analyses, a relationship emerges in which those girls who are encouraged to be confident and independent individuals, and are set on a path toward higher education, will elect to have fewer children and will allocate more resources to the well-being of those offspring. Young illustrated this effect using a Becker model for household time allocation, in which a rising female wage negatively influences fertility, and then, as n number of children takes on lower value, q or "quality" of children, increases. That is, the children of educated, professional women themselves have access to greater E and K.

Uganda's Baaba Project offers a similar array of services to the STF, but targets street children rather than the broader adolescent population. An Irish humanitarian NGO implemented the Project, and it has faced considerable barriers to success, as normative Ugandan values discourage the public from helping homeless or vagrant peoples. The Baaba Project, named after a word for older sibling or role model, seeks to raise awareness among homeless youth about HIV/AIDS and safe sexual behavior. The Project addresses the difficult realities of street life in its attempt to teach children—especially girls—how to protect themselves from sexual or physical assault. Like the STF, the Project also aims to empower adolescents by endowing them with skills to find

[11] The negative relationship between the female wage and fertility is closely related to the relationship between female education and fertility. Better educated women command higher wages, thereby increasing the opportunity cost associated with child bearing. The IMF (2005) noted that Ugandan women with a secondary school education have an average of 3.9 children, while those with just a primary education have 7.8 children. This suggests that for women with a high school education the marginal cost of a fifth child outweighs the marginal benefit.

a productive life path. Through one-on-one counseling, peer education, and information about children's rights, the Baaba Project attempts to empower street children by building their confidence and self-esteem, helping them to make informed decisions, and educating them about the risks of HIV/AIDS. This addresses all components of *H*. That is, the Baaba Project helps to protect *W* by keeping children safe from STIs; it attempts to provide the informal schooling that street children cannot receive from parents or guardians; it encourages them to seek *E*; and it therefore enables them, ultimately, to achieve *K*.

In Section IIIb, I outline a hypothetical poverty trap, in which both adults in a household avoided HIV infection, but had been AIDS orphans as children. They would not have had access to education, and therefore, upon reaching adulthood, they would have minimal financial capacity to educate their own children. They would also have minimal human capital to transmit through informal schooling. The Baaba Project aims to intervene in the lives of AIDS orphans and offer them surrogate resources, such that when they reach adulthood and start their own families, they and their offspring will not fall victim to this poverty trap. Rather, they will have achieved *I*—and, later, *E* and then *K*—even after the loss of their biological parents. This role for the Baaba Project could also positively influence parents' allocation of resources to their children's education while they are still alive. That is, even if HIV-positive adults know that their children will become orphans during their young lives, they might still choose to finance education if they anticipate their children continuing productive activities in orphanhood.

IIIe. Universal Primary Education as AIDS *Prevention* Program

Uganda's national project to achieve Universal Primary Education (UPE) has a potentially enormous role in stemming HIV transmission. The goals of the program, as stated by the Ugandan Ministry of Education in 1999, include eliminating unequal access to education by eradicating school fees, reducing disparities in access to resources such as textbooks and school uniforms, maintaining a nationally imposed level of educational quality geared toward human resource development, and ensuring a minimum quality of school facilities (Aguti 2002). Since the program was introduced in 1999, there has been a steady increase in the number of Ugandan children enrolled in primary school and a small increase in the relative share of enrollment by girls. The Ministry of Education trained and hired more teachers at the inception of the UPE initiative, which has led to a decline in the student-to-teacher ratio even as the number of students increased. The student-to-classroom and student-to-textbook ratios have also decreased. The emphasis on improving school facilities is particularly geared toward adolescent girls, who are frequently absent from school when they are menstruating because schools lack private restrooms. The Ministry of Economic Development (2002) recognized this as creating an absolute and relative disadvantage for Ugandan girls. With assistance from UNICEF, the Ministry of Education is working to make the educational system more sensitive to girls' needs and to train teachers accordingly. Recalling my analysis in Section IIIa on the importance of female education in determining welfare outcomes for children, this gendered component to the UPE program is indispensable.

De Walque (2004) presented a model for sexual choice that demonstrates how the UPE initiative is a crucial component to Uganda's campaign against AIDS. In an empirical study for children in Uganda, De Walque demonstrated a negative association

between HIV infection and completion of primary school. He then advanced a theoretical framework for how individuals choose to protect their sexual activity from STIs, and how educational attainment affects that decision-making process. He described a utility function in which individuals derive utility from consumption *c* and from number of sexual partners *n*. He considered two types of agents: those with low human capital, which I denote as H^L, and those with high human capital, or H^H. De Walque let π denote the proportion of sexual activity protected from HIV transmission. Assuming that wage is determined by level of human capital, or $W(H^H) > W(H^L)$, and given that individuals consume normal goods, it follows that $c^H > c^L$; that is, educated individuals consume more goods because they receive a higher wage. In the absence of HIV, the author considered sexual activity a normal good, and thus $n^H > n^L$. That is, *ceteris paribus*, more educated individuals have a greater number of sexual partners. De Walque then suggested that the threat of HIV alters this positive association between education and sexual activity. All individuals who have access to information about HIV/AIDS take the implied risk into account as they choose their sexual behavior. De Walque reasoned that better educated individuals are more able to access and process information about the threat of AIDS, and, as noted above, his empirical results buttressed that theory. Greater educational achievement also raises the opportunity cost of high-risk sexual activity, and, therefore, I suggest that better educated individuals have a stronger incentive to care for their physical well being by choosing protected sexual activity. Formally, agents with H^H, relative to those with H^L, will choose π equal to one—that is, they will always choose protected sex— given a lesser threat of HIV infection.

The UPE initiative addresses this model as it attempts to raise all individuals from a low to a high level of human capital, or from H^L to H^H. As stated above, agents with H^H always choose protected sexual activity in response to a sufficiently pronounced threat of HIV infection. As UPE becomes a reality, the proportion of the Ugandan population with H^H approaches one. That is, for H^m where $m \in (H, L)$, and for a proportion of protected sexual activity π, I suggest that

(2) $\lim_{L \to H} \pi = 1;$

that is, as agents move from low to high levels of human capital, the proportion of their sexual activity that is protected approaches one. This framework demonstrates the profound role for UPE in stemming HIV transmission. Gaffeo (2003) considered the transmission of HIV to be a market failure, in which individuals do not take into account the social cost of their reckless behavior. De Walque's model demonstrates that increasing access to education potentially corrects this failure, as a growing number of agents have a strong incentive to engage exclusively in protected sexual activity.[12]

The UPE initiative aptly responds to the nature of human capital accumulation, as UPE literally means the supply of *E* to all individuals. But it also responds to the subtler implications of this model. An inverse relationship between the female wage and fertility (Young 2004) suggests that increased access to education will lead to women devoting more resources to fewer children.[13] That is, it promises dividends in the next generation, as educated, professional women raise healthy, and then educated, children; it translates first into better *W* and higher *I*, then greater *E*— and ultimately, greater *K*. The

[12] Of course, educating those who are already HIV-positive will not necessarily prevent them from endangering others. Over multiple time periods, however, this model suggests that the *incidence* of HIV—that is, annual new infections—will decline, reducing the number of HIV positive individuals in the population and hence the rate at which they transmit the infection.
[13] And assuming wage to be an increasing function of *H*.

elimination of school fees means that household budgets will not struggle to allocate money resources to children's formal education. While sending children to school still implies that children spend time on education rather than on household labor, this sacrifice is increasingly feasible as household parents have greater earning power as a result of their own, greater *E*. And sick parents who expect that their children will be able to continue their education as orphans (because they will not be accountable for school fees) will be more likely to permit—or to encourage—education during their illness, thereby helping to prevent a poverty trap induced by orphanhood.

IIIf. The Case of South Africa

UNAIDS (2006a) estimated the South African HIV prevalence rate for adults aged fifteen to forty nine at 19%. KwaZulu-Natal, the province most stricken by the AIDS epidemic, reported its 2005 HIV prevalence at just below 40% (loveLife 2004). These numbers represent some of the highest affliction rates in the world. South Africa, despite deeper financial resources than those of Uganda, has not had parallel success in combating the spread of HIV. AIDS is now considered the principal health priority in the country, even as many leading politicians deny the relationship between HIV and AIDS and suggest that Western-developed antiretroviral therapies (ARVs) do not help sick Africans.[14] Section IIIg explores the intervention efforts South Africa has launched in its attempt to slow its growing and extraordinarily deadly AIDS epidemic.

IIIg. The *Soul Buddyz* and loveLife Programs

South Africa's Institute for Health and Development Communication launched the *Soul Buddyz* television series in 1999. The series harnesses mass media to reach and

[14] See Nattrass (2004) and Specter (2007). This is a deeply political issue, in which South African politicians depict Western medicine as a vindictive force, seeking profit from African illness through the sale of expensive and ineffective ARVs.

engage a large audience, as it places educational issues in the entertaining, dramatic format of a popular television program. In a response to South African demographics, the series is geared toward a young audience; roughly 40% of the country's population is younger than eighteen (World Bank 2003). The television series was followed in 2000 by radio and print materials, and then with the airing of *Soul Buddyz 2*, for children younger than eight, in 2003. *Soul Buddyz* also distributes booklets on parenting through national newspaper delivery in order to complement its youth outreach with parental education. The mission of the *Soul Buddyz* series is to improve the lives of South African youth by expanding their understanding of sexual health. It presents issues related to HIV/AIDS and sexuality from an adolescent's perspective, and it treats such difficult topics as growing up with an HIV-positive mother. *Soul Buddyz* attempts to de-stigmatize AIDS by transforming it into a subject for mass media, and by providing all South African youth with a comprehensive understanding of the epidemic and how they can protect themselves from HIV. The secondary objective of the program is to instill in South African youth key life skills through education about children's rights, including Children's Entitlement to Social Security (ACESS).

Soul Buddyz addresses several facets of how parents and individuals choose to invest in *H*. Similar to Uganda's Straight Talk Foundation (STF) and Baaba Project, *Soul Buddyz* educates children about how they can protect themselves from HIV, which makes them likelier to remain healthy as adolescents and adults. That likelihood increases the expected return to education and therefore facilitates parents' investment in *E*. But because *Soul Buddyz* is not an interactive project—that is, it lacks community activities and peer mentoring—it is unlikely to endow South African youth with the confidence and

life skills that the STF and Baaba Project attempt. That is, it fails to provide *I*, and thus lacks a crucial step toward *E* and then *K*.

The *Soul Buddyz* emphasis on children's right to social security is a potentially very effective component to the program. It addresses the poverty trap that Bell et al. (2006) described. As many South African children lose their parents to AIDS, they surrender access to education as well as to other basic resources such as food and health care. *Soul Buddyz* confronts this issue through its attempt to expand ACESS. The model advanced by Deininger et al. (2005) for the effect of foster children on household decision making illuminates the importance of such social programs. They found that initially, Ugandan foster children were at a disadvantage in accessing education, but that over time, that disadvantage diminished. The authors considered this to be the result of UPE, which suggests that a similar educational initiative in South Africa would likewise address this issue. But the results for the health of foster children were much graver, and worsened over time.[15] This indicates that the *Soul Buddyz* emphasis on ACESS and other government services is positioned to address perhaps the gravest implication of orphan or foster child status—that is, a precipitous decline in *W* for AIDS orphans. It also implies a need for more resources allocated to such services, such that all orphans receive government support. Such an initiative would likely pay for itself by preventing inter-generational poverty traps, as orphans would be less likely to descend into poverty after their parents' deaths.

The South African loveLife program is a much more comprehensive initiative than *Soul Buddyz*. LoveLife was launched in 1999 by a consortium of NGOs dedicated

[15] Deininger et al. used vaccination against diphtheria and measles as proxies for quality of health care. They found that foster children were not at a disadvantage in 1992, but, by 2000, they were significantly less likely to receive these vaccinations than were children living with their biological parents.

to reproductive rights, and it targets youth ages twelve to seventeen. Like Uganda's STF, it seeks to educate and to open communication about topics of sexual health, while simultaneously promoting values of confidence and responsibility (loveLife 2004). The mass media image of loveLife parallels that of *Soul Buddyz* in that it exploits channels of popular culture— including television, and print and billboard advertising— to effectively create an appealing loveLife brand image. LoveLife then uses its brand to promote behaviors that reduce HIV transmission. It endorses delayed sexual activity, condom use, and fewer sexual partners. LoveLife complements its media campaign with youth centers, sexual health hotlines, and health care clinics designed for adolescent use. With support from the Global Fund for HIV/AIDS and in partnership with the South African department of health, loveLife has opened 235 clinics across South Africa. In this way, loveLife makes clear, strident efforts at boosting *W* for all South African youth.

Like the STF, loveLife addresses *I* through its comprehensive approach to turning out healthier, more confident, and better-educated young women and men. As South African youth are better able to protect themselves from HIV, parents will be more inclined to predict that their children's futures will be long and healthy, and therefore will be more likely to invest in education. Although loveLife addresses human capital accumulation in ways similar to Uganda's STF, it is important to note that loveLife is still a relatively young program. While it was launched in just 1999, Uganda began a coordinated campaign against AIDS with the ABC initiative in 1987, and the STF was launched in 1993. It is likely that Uganda's initial success at slowing the transmission of HIV within its borders was the result of its prompt response to the epidemic. South

Africa is now in a difficult position, as HIV and AIDS affect a staggering number of its people.

Section IV continues this analysis of South Africa with an empirical investigation of the relationship between HIV prevalence and education in the country's nine provinces.

IV. An Empirical Investigation of HIV Prevalence and Education

This section draws on the framework for human capital accumulation developed in Section III in order to design and test an empirical model for the effect of AIDS on educational quality and on female educational attainment. In the production function for human capital that I advanced in Section IIIb,

(1) $H_i = F(W_i, I_i, E_i, K_i)$,

the human capital level for individual i, H_i, is unobserved. However, formal education E_i is an observed input for H_i. In this section, I will examine empirically the effect of HIV prevalence on the quality of, and access to, formal education in South Africa. I will also investigate the effect of HIV prevalence on female education in particular, which I argue will strongly influence physical well being *W* and informal schooling *I* for children in the next generation. While sufficient data were not available to study empirically the effect of AIDS on job training and experience *K*, I conclude this section with a discussion of private sector firms' self-reporting on the effect of AIDS on their labor supply and efficiency.

IVa. Modeling HIV Prevalence and Quality and Access to Education

I use the supply of educators, expressed in percent of province population, as a measure of educational quality. I then use student enrollment, disaggregated into primary and secondary enrollment and also expressed in percent, as a measure of access to

education. I use three variables for HIV prevalence; each is the HIV prevalence rate lagged one, two, or three years, respectively, relative to the other included variables. I lag the HIV prevalence rate because I reason that new HIV-positive status of a teacher will not immediately affect her employment. Rather, it will alter employment over time, as individuals become sick with AIDS. Similarly, I reason that it will likely take at least one year for a parent's HIV-positive status to negatively influence her children's school enrollment. I also include the unemployment rate as a control variable; it is a measure of economic well being that captures change in school quality resulting from economic hardship *not* caused by HIV/AIDS.[16]

I alternately include educators and students, respectively, as explanatory variables. I reason that the supply of educators affects student enrollment rates, as parents are more likely to send their children to school if teachers are in greater supply. Similarly, the number of students should be important in determining the number of educators, as school systems hire teachers based on demand for schooling. By including these measures of education as explanatory variables, I attempt to capture changes in educational quality due to factors unrelated to HIV prevalence. Indeed, South Africa is working hard to strengthen its educational system, and the positive consequences of that initiative could counteract the estimated negative effect of HIV. But because educators and learners are both endogenous to my model, the inclusion of them as right-hand-side variables potentially introduces simultaneity bias into the Ordinary Least Squares (OLS) estimation procedure. Ideally, I would correct for endogeneity by identifying instruments

[16] I reason that the unemployment rate is a good measure of economic well being exogenous to this model. That is, per capita income over these years reflects the income effect of AIDS. Unemployment, however, is the number of economically active individuals—that is, those seeking work, and therefore *not* those who are too sick to work—who cannot find employment.

for students and educators and using the Two Stage Least Squares estimation procedure rather than OLS. However, I was unable to find appropriate instruments.

I therefore model reduced form equations, in which I express the dependent variable exclusively in terms of the exogenous explanatory variables. The resulting HIV coefficients then capture both the direct and indirect effects of HIV on the dependent variable. That is, for a dependent variable of educators, a reduced form coefficient to HIV will capture the negative effect of HIV on the supply of educators, *as well as* the negative effect of HIV on student enrollment that creates a secondary negative effect on educators. Similarly, for a dependent variable of student enrollment, the HIV coefficient will measure the effect of HIV on student enrollment and the effect HIV on educators, which negatively influences enrollment. I therefore expect that the HIV coefficients in the reduced form equations are larger in magnitude relative to those in the structural models.

To control for differences across time and region, I model fixed effects equations, in which I include dummy variables for year and for the South African provinces. This isolates the effect of HIV on the dependent variable by holding constant the many other unmeasured variations on the quality and access to education.

First, I model the fixed effects structural equation for the supply of educators. In the following equation, where *lrnrs* is combined primary and secondary school enrollment,

(2) $\text{educ}_{tj} = \beta_1 + \Sigma^4_{t=1} \beta_{2t}\, \text{dum}_t + \Sigma^8_{j=1} \beta_{3j}\, \text{dum}_j + \Sigma^3_{i=1} \beta_{4i}\, \text{HIV}_{j,t-i} + \beta_5\, \text{lrnrs}_{tj} + \beta_6\, \text{unem}_{tj} + \varepsilon_{tj}$,

I examine the effect of HIV on educators at time *t* in province *j*. I expect a positive

coefficient to learners and negative coefficients to the HIV variables, as teachers become sick and drop out of the work force.

Next, I present the structural model for the effect of HIV prevalence on access to education. In the model,

(3) $prim_{tj} = \alpha_1 + \Sigma^4_{t=1}\ \alpha_{2t}\, dum_t + \Sigma^8_{j=1}\ \alpha_{3j}\, dum_j + \Sigma^3_{i=1}\ \alpha_{4i}\ HIV_{j,t-I} + \alpha_5\, educ_{tj} + \alpha_6\, unem_{tj} + \varepsilon_{tj}$,

I observe the effect of HIV on primary school enrollment at time *t* in province *j*. I predict a positive coefficient to educators and negative coefficients to the HIV variables. Similarly, in the equation

(4) $sec_{tj} = \alpha_1 + \Sigma^4_{t=1}\ \alpha_{2t}\, dum_t + \Sigma^8_{j=1}\ \alpha_{3j}\, dum_j + \Sigma^3_{i=1}\ \alpha_{4i}\ HIV_{j,t-I} + \alpha_5\, educ_{tj} + \alpha_6\, unem_{tj} + \varepsilon_{tj}$,

I model how HIV affects secondary school enrollment at time *t* in province *j*.

Next, I present the reduced form models. In equation (2), the explanatory variable for student enrollment *lrnrs* is the combined enrollment for primary and secondary schooling. Although I do not examine empirically the effect of HIV on the aggregate of primary and secondary enrollment, I present a model for it here, and use it to derive the reduced form equation for the supply of educators:

(5) $lrnrs_{tj} = \alpha_1 + \Sigma^4_{t=1}\ \alpha_{2t}\, dum_t + \Sigma^8_{j=1}\ \alpha_{3j}\, dum_j + \Sigma^3_{i=1}\ \alpha_{4i}\ HIV_{j,t-I} + \alpha_5\, educ_{tj} + \alpha_6\, unem_{tj} + \varepsilon_{tj}$.

I then substitute equation (5) into equation (2) to obtain the reduced form equation

(6) $educ_{tj} = \lambda_1 + \Sigma^4_{t=1}\ \lambda_{2t}\, dum_t + \Sigma^8_{j=1}\ \lambda_{3j}\, dum_j + \Sigma^3_{i=1}\ \lambda_{4i}\ HIV_{j,t-i} + \lambda_6\, unem_{tj} + \varepsilon_{tj}$,

where $\lambda_4 = (\beta_4 + \beta_5\alpha_4)/(1-\beta_5\alpha_5)$. That is, the reduced form coefficient to HIV in equation (6) reflects the direct effect of HIV on educators, denoted as β_4 in equation (2), the effect of HIV on *lrnrs*—that indirectly affects educators— denoted as α_4 in equation (5), *and* the product of the effects of HIV on *lrnrs* and *lrnrs* on educators.

I substitute equation (2) into equation (3) to obtain a reduced form estimate for the effect of HIV on primary school enrollment. I note that the explanatory variable *lrnrs* in equation (2) is not identical to the dependent variable of primary school enrollment in equation (3); rather, primary enrollment is a sub-set of general enrollment *lrnrs*. For algebraic simplification, let $lrnrs_{tj} = prim_{tj}$. In the model,

(7) $prim_{tj} = \lambda_1 + \Sigma^4_{t=1} \lambda_{2t}\, dum_t + \Sigma^8_{j=1} \lambda_{3j}\, dum_j + \Sigma^3_{i=1} \lambda_{4i}\, HIV_{j,t-i} + \lambda_6\, unem_{tj} + \varepsilon_{tj}$,

let $\lambda_4 = (\alpha_4+\alpha_5\beta_4)/(1-\alpha_5\beta_5)$. Again, the reduced form coefficient to HIV reflects its direct effect on primary school enrollment, or α_4 in equation (3). It also reflects the effect of HIV on educators, β_4, from equation (2), and the product of the effects of HIV on *lrnrs* and *lrnrs* on educators. In the reduced form for secondary school enrollment, I model an equation identical to (7), in which secondary enrollment replaces the dependent variable of primary enrollment.

IVb. Modeling HIV Prevalence and Female Education

In addition to examining quality and access to education, I want to show how AIDS affects female education in particular. I use the number of female students enrolled in primary and secondary school, respectively, again expressed in percent of province population, as measures of girls' access to schooling. I use structural models identical to equations (3) and (4), replacing the dependent variables with female enrollment in primary school and then secondary school, and reduced form models identical to equation (7). I expect the coefficients in these regressions to be similar in sign to those in which I model general primary and secondary enrollment, as female enrollment is a sub-set of general student enrollment. I also expect coefficients of greater

magnitude, corroborating my theory that hardship caused by HIV/AIDS will more directly impede girls' access to education relative to boys'.

IVc. Data

I used several sources to compile panel data on HIV prevalence rates in the nine South African provinces from 1998 through 2005. These sources included the South African Department of Health and the Reproductive Health Research Unit of the University of Witwatersrand, and their reporting on the percentage of antenatal clinic attendees who tested HIV-positive. Four hundred such clinics from across rural and urban South Africa contributed to that report. I also used data from the 2002 and 2003 Nelson Mandela Foundation surveys, and the 2005 National HIV survey. The findings from all of these studies were similar, and the minimal variation between them was attributed to differences in sample populations (loveLife 2004).

For educational data, I use the annual reports from the South African Department of Education from the years 2001 through 2005. The majority of the data comes from "snap surveys" conducted on the tenth day of each school year. Population and unemployment statistics come from Statistics South Africa's population census reports and its 2006 Labor Force Survey.

IVd. Results

Table 4.1 presents results for the estimated effect of the lagged HIV variables on the supply of educators. The significance of the F-statistics for the year and province dummies in columns (2) and (4) indicates that the fixed effects are important in controlling for unmeasured differences over time and between provinces, and I will therefore focus my analysis on those columns, in Table 4.1 and in the subsequent tables.

In column (2) of Table 4.1, I report the results for the structural model of the effect of HIV on the supply of educators. The coefficients to the two- and three-year lagged HIV variables have the expected negative sign, while the HIV variable lagged just one year has a positive sign. The two-year lag shows the most convincing negative effect on the dependent variable, with significance at a 5% confidence level. This may indicate that it takes at least two years for HIV-positive status to adversely affect individuals' ability to work. The sum of the HIV coefficients—that is, the net effect of HIV—is negative and significant at a confidence level of 10%, suggesting that the effect of HIV on the supply of educators is indeed negative. In practical terms, these results indicate that in KwaZulu-Natal, South Africa's largest province with a population of 9.6 million, a 5% increase in the HIV prevalence rate triggers a loss of about 5,000 educators. The student-to-educator ratio in the KwaZulu-Natal school system was 33.6 in 2005; a loss of 5,000 teachers therefore leads to about 170,000 school children losing their teacher.

Column (4) exhibits results for the reduced form model. Opposite to my prediction, column (4) shows a smaller negative coefficient to the sum of the HIV variables, relative to the structural model in column (2). Also, the coefficient to the sum of the HIV variables, which is statistically significant in column (2), loses its significance in the reduced form. Comparing the fixed effects reduced form of column (4) to the uncontrolled reduced form in column (3), I observe that the HIV coefficients are sensitive to the inclusion of fixed effects. In column (3), the coefficient to the sum of the HIV variables is significant at the 10% level, while it is insignificant at traditional confidence levels in column (4). Conversely, the coefficient to the two-year-lag HIV variable gains

significance when the fixed effects are added; in column (4), that coefficient is comparable in its magnitude and significance to that of the structural model in column (2).

Table 4.1

Estimated Effect of HIV on Supply of Educators

(43 observations, t-statistics in parentheses)
The dependent variable is educators expressed in percent of province population
Columns (1) and (2) are structural models; columns (3) and (4) are the reduced form models.
Columns (2) and (4) include province fixed effects
The variable learners is primary and secondary learners in percent of province population
F-Tests are for joint significance for year and province dummies and the three HIV variables

	(1)	**(2)**	**(3)**	**(4)**
F-Statistic for Years	1.792	4.441***	1.771	2.731**
F-Statistic for Provinces		11.3***		59.77***
Learners	2.088***	2.633**		
	(-11.94)	(-2.58)		
Unemployment	0.0073***	-0.001	0.0256***	-0.004
	(-2.73)	(-0.325)	(-5.12)	(-1.291)
HIV (-1)	0.001	0.0016	-0.005	0.0034
	(-0.17)	(0.563)	(-0.519)	(1.086)
HIV(-2)	-0.0017	-0.0076**	-0.0067	-0.0066**
	(-0.43)	(-2.602)	(-0.742)	(-2.059)
HIV(-3)	-0.001	-0.0038	0.0068	-0.0013
	(-0.15)	(-1.311)	(-0.71)	(-0.434)
Sum of HIV Coefficients	-0.0016	-0.0098*	-0.005*	-0.0046
	(-1.446)	(-1.973)	(-2.007)	(-0.912)
F-Statistic for HIV	0.856	2.796*	1.373	1.917

* Significant at 10% Level; ** Significant at 5% Level; *** Significant at 1% Level

In Table 4.2, I report the impact of HIV on primary school enrollment. Table 4.2 shows a slightly larger negative coefficient to the sum of the HIV variables in the reduced form of column (4), relative to the structural model, as expected. Table 4.3, however,

Table 4.2

Estimated Effect of HIV on Primary School Enrollment

(43 observations, t-statistics in parentheses)
The dependent variable is primary school learners expressed in percent of province population
Columns (1) and (2) are structural models; columns (3) and (4) are the reduced form models.
Columns (2) and (4) include province fixed effects
The variable educators is expressed in percent of province population
F-Tests are for joint significance for year and province dummies and the three HIV variables

	(1)	(2)	(3)	(4)
F-Statistic for Years	0.317	0.39	0.044	0.322
F-Statistic for Provinces		4046***		4180***
Educators	-1.645**	0.138		
	(-2.197)	(1.344)		
Unemployment	0.0464	0.138	0.0043	-0.0018
	(1.597)	(0.457)	(0.187)	(-1.102)
HIV (-1)	-0.0653	-0.0013	-0.057	-0.0008
	(-1.533)	(-0.786)	(-1.274)	(-0.51)
HIV(-2)	-0.022	-0.0005	-0.0109	-0.0014
	(-0.55)	(-0.283)	(-0.26)	(-0.835)
HIV(-3)	0.052	-0.0002	0.041	-0.0003
	(1.229)	(-0.102)	(0.922)	(-0.214)
Sum of HIV Coefficients	-0.035***	-0.002	-0.027**	-0.0026
	(-3.026)	(-0.744)	(-2.312)	(-0.98)
F-Statistic for HIV	3.184**	0.272	1.191	0.345

* Significant at 10% Level; ** Significant at 5% Level; *** Significant at 1% Level

demonstrates the opposite trend, similar to Table 4.1. In the structural and reduced form fixed effects regressions, the coefficients to the HIV variables are negative but statistically insignificant. Similarly, Table 4.3 displays results for the effect of HIV on secondary schooling, and columns (2) and (4) show uniformly negative but insignificant HIV coefficients. These results, therefore, do not clearly confirm my hypothesis that HIV prevalence adversely affects access to education in the general student population. However, the large and statistically significant coefficients to the sum of the HIV variables in columns (1) and (3) of Tables 4.2 and 4.3 do indicate that the provinces with the highest rates of HIV prevalence are also those with the lowest school enrollment.

Table 4.3

Estimated Effect of HIV on Secondary School Enrollment

(43 observations, t-statistics in parentheses)
The dependent variable is secondary school learners expressed in percent of province population
Columns (2) and (4) are province fixed effects
The variable educators is expressed in percent of province population
F-Tests are for joint significance for year and province dummies and the three HIV variables

	(1)	(2)	(3)	(4)
F-Statistic for Years	0.318	0.39	0.044	0.322
F-Statistic for Provinces		4047***		4181***
Educators	-0.909	0.0765		
	(-2.2)**	(1.344)		
Unemployment	0.0256	-0.0007	0.0024	-0.001
	(1.597)	(-0.755)	(0.187)	(-1.102)
HIV (-1)	-0.036	-0.0007	-0.0315	-0.0005
	(-1.533)	(-0.786)	(-1.274)	(-0.51)
HIV(-2)	-0.012	-0.0003	-0.0006	-0.0008
	(-0.55)	(-0.283)	(-0.26)	(-0.835)
HIV(-3)	0.0288	-0.000	0.0226	-0.0002
	(1.229)	(-0.102)	(0.922)	(-0.214)
Sum of HIV Coefficients	-0.0195	-0.0002	-0.015	-0.0014
	(-3.047)***	(-0.74)	(-2.366)**	(-0.982)
F-Statistic for HIV	3.184**	0.272	1.913	0.345

* Significant at 10% Level; ** Significant at 5% Level; *** Significant at 1% Level

Tables 4.4 and 4.5 show the effects of HIV on female enrollment. In both tables, the coefficients to the HIV variables lagged one and two years have negative signs, while the three-year lagged HIV variable has a positive sign. That may suggest that HIV-positive status has an initially negative impact on female school enrollment through the changes it imposes on household expenditures, but that spending rebounds due to epidemiological factors. That is, over time, as HIV-positive individuals become sick with AIDS and then perish, household spending on education may recover. In Table 4.4, the sign of the sum of the HIV coefficients in the structural model reported in column (2) is positive and insignificant, and in the reduced form of column (4) it is negative and

insignificant. In Table 4.5, columns (2) and (4) both demonstrate negative signs to the sum of the HIV coefficients, but again, they are insignificant. Also, the statistically insignificant F-statistic for the province dummies in column (2) indicates that the fixed effects are not as important for controlling unmeasured differences across provinces when the dependent variable is female secondary schooling. Comparing Tables 4.3 and 4.4 to Tables 4.2 and 4.3, I find that the effect of HIV on female enrollment is not noticeably different from its effect on general student enrollment. These results, therefore, do not provide clear evidence in support of my theory that HIV has a more salient adverse effect on girls' access to education relative to boys'.

The coefficient to unemployment in column (4) of Table 4.4 does suggest that the economic hardship triggered by unemployment has a stronger negative impact on girls' primary school enrollment than on general primary enrollment reported in Table 4.2. This may indicate that HIV/AIDS will more clearly influence female education through its long-run effect on economic well being; that is, while I was unable to discern a statistically significant negative relationship between HIV prevalence and girls' access to education, that relationship may emerge over time, as AIDS takes its toll on household welfare.

Table 4.4

Estimated Effect of HIV on Female Primary School Enrollment

(43 observations, t-statistics in parentheses)

The dependent variable is female learners in primary school expressed in precent of province population

Columns (2) and (4) are province fixed effects

The explanatory variable educators is expressed in percent of province population

F-Tests are for joint significance for year and province dummies and the three HIV variables

	(1)	**(2)**	**(3)**	**(4)**
F-Statistic for Years	1.48	1.749	0.242	1.765
F-Statistic for Provinces		13.82***		52.58***
Educators	0.113	0.039		
	(8.95)***	(1.428)		
Unemployment	0.0002	-0.001	0.0031	-0.066
	(0.345)	(-1.18)	(4.56)***	(-1.548)
HIV (-1)	-0.000	-0.0003	-0.0006	-0.015
	(-0.069)	(-0.636)	(-0.475)	(-0.339)
HIV(-2)	-0.0003	-0.0001	-0.0011	-0.038
	(-0.476)	(-0.256)	(-0.888)	(-0.837)
HIV(-3)	0.0004	0.001	0.0011	0.072
	(0.513)	(1.834)**	(0.877)	(1.686)
Sum of HIV Coefficients	-0.000	0.0004	-0.0006	-0.0026
	(-0.002)	(0.516)	(-1.643)	(-0.98)
F-Statistic for HIV	0.0005	0.265	2.823	0.069

* Significant at 10% Level; ** Significant at 5% Level; *** Significant at 1% Level

Table 4.5

Estimated Effect of HIV on Female Secondary School Enrollment

(43 observations, t-statistics in parentheses)

The dependent variable is female learners in secondary school expressed in percent of province population

Columns (1) and (2) are structural models; columns (3) and (4) are the reduced form models.

Columns (2) and (4) are province fixed effects

The variable educators is expressed in percent of province population

F-Tests are for joint significance for year and province dummies and the three HIV variables

	(1)	(2)	(3)	(4)
F-Statistic for Years	8.927***	8.487***	4.648***	8.614***
F-Statistic for Provinces		1.236		6.2***
Educators	0.095	0.0415		
	(6.068)***	(0.619)		
Unemployment	-0.0005	-0.0004	0.0019	-0.0005
	(-0.805)	(-0.341)	(2.97)***	(-0.515)
HIV (-1)	-0.001	-0.0011	-0.0014	-0.001
	(-0.993)	(-1.053)	(-1.073)	(-0.956)
HIV(-2)	-0.0005	-0.0005	-0.0011	-0.0008
	(-0.583)	(-0.452)	(-0.949)	(-0.747)
HIV(-3)	0.002	0.0016	0.0023	0.002
	(1.842)*	(1.565)	(1.807)*	(1.536)
Sum of HIV Coefficients	-0.0195	-0.000	-0.0002	-0.0003
	(-3.047)***	(-0.039)	(-0.673)	(-0.151)
F-Statistic for HIV	1.985	1.036	1.111	1.054

* Significant at 10% Level; ** Significant at 5% Level; *** Significant at 1% Level

IVe. Note on HIV/AIDS, *K*, and Firm Productivity

The above empirical investigation does not explain how AIDS affects the job training and experience input to the human capital production function. However, the results in Table 4.1, expressing how HIV prevalence affects teacher employment, can be extrapolated to the broader workforce. They suggest that, over time, an escalating HIV prevalence rate in South Africa—and, indeed, across many African nations—will trigger considerable losses in the private sector as skilled labor evaporates.

A 2005 Bureau of Economic Research report detailing the effects of HIV/AIDS on the South African private sector substantiates this hypothesis (Ellis and Terwin 2005). That report was based on a survey of various private sector industries, including mining, manufacturing, retail, and wholesale, and it described how firms judge the impact of

HIV/AIDS on their own productivity. The survey results suggest that AIDS strongly and negatively impacts the livelihood of South African firms. About 60% of companies in all industries reported that the AIDS epidemic adversely affected productivity; specifically, they experienced losses associated with high labor turnover rates and the costs associated with recruiting and training new employees. Many firms reported an increase in their demand for skilled labor, and projected hiring additional employees to compensate for absenteeism and worker mortality. Over 50% of responding firms already had a policy in place to combat the impact of AIDS on business productivity, while about a third of the financial services and mining firms reported offering anti-retroviral therapies at their place of work. That finding demonstrates the extent to which firms view AIDS as affecting their productivity through its impact on *K*, and how they project continued and profound consequences from the epidemic in the future.

V. Conclusion

In Section III, I advanced a production function for human capital achievement, reasoning that the inputs to human capital are physical well being, informal schooling, formal education, and job training and experience. Building on the analyses of Shariff and Namkee (1995) and Sen (1999), I detailed the importance of women's education in generating positive welfare outcomes for their children in the next generation. Using de Walque's (2004) framework for sexual choice, I demonstrated the potential for Uganda's Universal Primary Education (UPE) initiative to stem HIV transmission, as better-educated individuals have strong incentives to protect themselves from infection. I also explained how the multitude of AIDS intervention efforts launched both by Uganda and South Africa are positioned to address the effects of AIDS on the inputs to human capital.

In particular, I explained that by endowing youth with self-confidence and educating them about sexual health, intervention programs can offset the negative impact of AIDS on the expected return to education, both from the standpoint of parents choosing to finance their children's education, and from the point of view of young people who must choose how to invest in themselves.

Section IV explored empirically the theories introduced in Section III. Generally, my results suggested that HIV/AIDS adversely affects the supply of educators, and that there is a trend, though statistically insignificant, in households adjusting expenditures away from education in order to accommodate the demands of an HIV-positive household member. Section IV also showed that the HIV prevalence rate does not have an immediate effect on teacher employment—and therefore on school quality— but rather, it alters the supply of teachers after several years, likely coincident to individuals becoming symptomatic with AIDS. The opposite trend was true for female enrollment; HIV prevalence seemed to affect girls' enrollment rates after just one year, and after three years, that effect was no longer discernable. Finally, I outlined evidence of the effects of AIDS on the private sector and the necessity of action (that is already underway) to counteract those effects.

Taken together, these findings begin to illustrate the multitude of ways that AIDS disrupts the processes of human capital accumulation. The results in Section IV suggest that a response to the epidemic might focus on education, and on the supply of educators in particular, in order to offset the detrimental effects of HIV/AIDS. This implies a need for programs that seek to encourage adults to engage in protected sexual activity, in order to prevent teachers from contracting HIV, *and* for programs that address the already

climbing number of African children who have lost their teacher to AIDS. That is, initiatives such as the ABC and loveLife campaigns—which de-stigmatize AIDS and sexual health and force them into public debate—encourage adults to alter their behavior in light of potential HIV infection, while Uganda's Baaba Project seeks to intervene in the lives of street children who have no mentor or guardian, potentially compensating for the loss of teachers as positive role models.

I also emphasize the importance of Uganda's Universal Primary Education (UPE) initiative as a crucial step toward creating incentives in the lives of all young people to protect themselves from infection, as it endows them—or their children— with greater human capital *H* in all its inputs. UPE is still not a reality in Uganda—that is, not every Ugandan child has access to primary education— and certainly children in many other African countries stricken with AIDS also cannot access formal education. But the contention of this paper is that while AIDS potentially erodes quality and access to education across Africa, education can also act as a "social vaccine" against infection, thereby preventing HIV transmission. Targeted policy initiatives toward educational funding promise dividends in the form of healthier children, and then adults, in this generation and the next.

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