The HIV Epidemic, Skill Heterogeneity, and Output

Pedro de Araujo*

Abstract
This paper investigates the effect of HIV/AIDS on output using an overlapping generations model with heterogeneous agents calibrated to sub-Saharan Africa. Output is found to be below a no-AIDS output in a range between 3% (10%), when only unskilled workers are affected, and 10% (28%), when only skilled workers are affected, whenever the overall infection rate is 7% (20%). When investigating the hypothesis that AIDS affects skilled workers more severely than unskilled at the beginning of the epidemic, with the effect switching as the epidemic becomes more mature, the findings are that the economy can be 8% smaller along the transition path. In all scenarios where the epidemic is temporary, it would take four to five generations or about 90 years for sub-Saharan Africa to recover.

1. Introduction
AIDS killed an estimated 1.4 million people in 2008 (UNAIDS, 2009). According to UN-AIDS epidemic update for the year 2009, the number of people living with HIV in the world is between 31.1 and 35.8 million, and the number of newly infected is between 2.4 and 3.0 million. Within 10 years, the majority of these people will have contracted AIDS and died. This situation is exacerbated in sub-Saharan Africa, where two thirds of all HIV infected people live. This epidemic is unique because it mainly kills individuals in their prime productive years, hence, the consequences of such a disastrous event must be investigated. The question of how AIDS affects output is, therefore, extremely important.

Since the beginning of the HIV/AIDS epidemic in the 1980s, several studies were conducted to investigate the possible links between the epidemic and economic growth and well being. Most of these studies were country specific and used either Solow type growth models or computable general equilibrium (CGE) models to simulate these effects. There were also another class of papers that used regression models with cross-sectional or panel data to investigate this relationship. With the exception of a few, almost all these studies point towards quite large long-run effects of AIDS on growth of gross domestic product (GDP) with little effect on GDP per capita. Examples of such studies include Cuddington (1993a, 1993b), Botswana Institute for Development Policy Analysis (2000), and Arndt (2003).

There are several channels in which HIV can affect economic growth and output and this paper will mainly concentrate on three. Countries affected by the epidemic experience reductions in life expectancy, which in turn reduces the incentive to invest in education and, therefore, human capital accumulation. The HIV epidemic also reduces workers productivity and creates a great number of orphans.

* de Araujo: Colorado College, 14 E. Cache La Poudre, Colorado Springs, CO 80903, USA. Tel: +1-719-389-6470; Fax: +1-719-389-6927; E-mail: pedro.dearaaujo@coloradocollege.edu. The author wishes to thank Gerhard Glomm, Kim Huynh, and two anonymous referees for many helpful suggestions and discussions. All remaining errors are those of the author.
There has been some literature investigating these channels; Hamoudi and Birdsall (2002) studied the relationship between human capital accumulation and AIDS. They mainly focused on the effects of HIV in reducing workers productivity and increasing the orphan population. The main argument was that children that have infected parents tend to drop out of school to work in order to support their household, and upon their parent’s death, most likely will not go back to school, which combined with the reduction in workers productivity, reduces output and human capital accumulation.

In order to capture the interaction between parents’ health status and children’s education and the decrease in life expectancy, Corrigan et al. (2005) used an overlapping generations framework where reduced life expectancy generates reduced incentives to invest and therefore lowers both physical and human capital accumulation with great consequences for output. This result is in large part due to lower education received by AIDS orphans. Their main findings are that AIDS has large growth effects, but policies to subsidize the price of treatment medication have small remedial effects. This framework is more appropriate for analyzing the long-run implications of HIV/AIDS on growth and output.

The current paper incorporates skill heterogeneity into the framework of Corrigan et al. (2005). This adds another dimension to the analysis as it allows for the HIV epidemic to differ across skills. Hence, this paper uses an aggregate production function measuring GDP as a function of current capital stock and effective skilled and unskilled labor units.

Capital–skill complementarity will be assumed and HIV risk will differ between skill levels. Hence, this paper will combine features from the literature on socio-economic status and AIDS with the overlapping generations setting. The main goal here is to investigate how the relationship between AIDS prevalence and socio-economic status affects output. This paper calculate transition paths after the economy is affected by AIDS and shows how different these paths are with respect to different scenarios. This allows for long-run as well as short- to medium-run analysis.

Even though this paper does not incorporate socio-economic status, as defined by the individuals economic and social situation compared with others, directly into the analysis and mainly focuses on the role that skill heterogeneity plays in determining long-run growth in the presence of AIDS, one can still view this paper as contributing to the literature on socio-economic characteristics and AIDS as better skilled individuals, on average, have better socio-economic status.

The literature covering this relationship is extensive. By looking at data, there is no clear consensus on how HIV/AIDS incidence is distributed across skills. Review papers such as Hargreaves and Glynn (2002) and Wojcicki (2005) have found ambiguous results on this relationship by searching for studies where socio-economic status and HIV prevalence were investigated using population based surveys such as the demographic health surveys (DHS).

Out of a total of 36 studies, Wojcicki (2005) cites 15 studies where no association between socio-economic status and AIDS was found. In 12 studies, there was a positive association between high socio-economic status and AIDS, and in the remaining eight the association was between low socio-economic status and AIDS. Roughly the same conclusions are reported in Hargreaves and Glynn (2002). This apparent controversy has found explanation in Vandermeurtele and Delamónica (2000), where they claim that in the beginning of the epidemic, AIDS affects higher skilled individuals more relative to lower skilled; and as the epidemic runs its course and becomes more widespread, the disease becomes more prevalent among unskilled individuals relative to skilled, that is, the HIV epidemiological curves cross. Hence, studies performed in the...
1980s would have different results compared with studies performed in the late 1990s.\textsuperscript{1} In order to capture the crossing of epidemiological curves, this paper also imposes a HIV scenario to reflect this possibility.

Aside from the channels discussed above, it is important to notice that HIV can also lead to large medical expenditures on the part of the government, and possibly divert public resources from more productive endeavors. In addition, the epidemic can potentially reduce the efficiency by which firms hire workers, as firms might become hesitant to hire and invest in individuals if the likelihood of dying from AIDS is large. These two channels, albeit important, are not covered in this paper.

2. Model

This model extends Corrigan et al. (2005) to include skill heterogeneity in the labor market. The notation will be kept similar to theirs so as to facilitate comparison. The setup of the model is as follows.

**Setup**

Each individual lives for a maximum of three periods: youth, adulthood, and old age. As adults, individuals differ with respect to their skills. That is, an adult individual can either be skilled or unskilled. For the purposes of this paper, every skilled individual carries a subscript of 1, while unskilled individuals carry a subscript of 2. As individuals turn old, there is no change in skill status. The only possibility to obtain skills in this model is by education at a young age. Educated children become skilled workers; the opportunity cost of this education is labor income foregone in that particular period. It is assumed that parents are the ones making educational decisions for their children. This way, the index assigned to children is the same as their parents. Children, therefore, in this model can only work or learn.

However, this does not imply that as children transition to adulthood, they cannot change status. For example, a child born in a skilled family could become an unskilled adult if the family decides that the child has to allocate the majority of its time to work. It is assumed though that a child born in an unskilled household remains unskilled as it enters adulthood. Since all of the model’s dynamics stems from the decisions of the adult generation, in what follows, their behavior is discussed in detail.

Starting in period 2, individual type $i$ learns about his health status. It is assumed that individuals are either healthy or unhealthy depending on their seroprevalence (HIV status). Let $\pi_i$ be the probability of type $i$ individual being infected at $t$, consequently $1 - \pi_i$ is the probability of remaining healthy. Note that this probability is conditional on skill type, which gives the model the flexibility to study how growth effects of the AIDS epidemic depend on cross-sectional correlations between incidence and skill types.

Regardless of type or health status, all adult individuals inelastically supply labor to the firm. Also, they choose current consumption $c_t$, their children’s consumption $f_t$ and education level $n_t$, which generate the level of the child’s human capital in the future $h_{t+1}$. Healthy individuals also choose how much to save $s_t$ given some interest rate $r_{t+1}$ so as to allow them to consume in the future $c_{t+1}$. Infected individuals die after period 2 and therefore do not save; however, they need to choose how much to spend on HIV/AIDS related medical expenses $m_t$.\textsuperscript{2} For the purposes of comparability, the functional form of
the utility functions mimics that of Corrigan et al. (2005). Hence, healthy type $i$ utility is given by,

$$U^h_i(c^i, f^i, c^i_{t+1}, h^i_{t+1}) = \alpha^1_i \ln c^i + \alpha^2_i \ln f^i + \alpha^3_i \ln c^i_{t+1} + \alpha^4_i \ln h^i_{t+1},$$  \hspace{1cm} (1)$$

and sick type $i$ utility is given by,

$$U^s_i(c^i, f^i, m^i, h^i_{t+1}) = \frac{\alpha^1_i}{\rho^s} \ln \left( (c^i)^{\rho^s} + \theta^s (m^i)^{\rho^s} \right) + \alpha^2_i \ln f^i + \alpha^3_i \ln h^i_{t+1}.$$  \hspace{1cm} (2)$$

Healthy adults of type $i$ face the following budget constraint

$$c^i_t + f^i_t + s^i_t = (1 - \tau^i_t)w^i_t h^i_t + (1 - n^i_t)w^i_t h^i_t \Delta,$$  \hspace{1cm} (3)$$

where $\tau$ is the government’s income tax and $\Delta$ is a parameter that captures the degree of child’s productivity relative to that of adults. Also, old age consumption $c^i_{t+1}$ is determined by

$$c^i_{t+1} = (1 + r^i_{t+1})s^i_t.$$  \hspace{1cm} (4)$$

Sick adults of type $i$ face a different budget given by,

$$c^i_t + f^i_t + \sigma_t p^i_t m^i_t = (1 - \tau^i_t)w^i_t h^i_t \Psi^i + (1 - n^i_t)w^i_t h^i_t \Delta,$$  \hspace{1cm} (5)$$

where $\sigma$ is the treatment subsidy provided by the government and $p_t$ is the worldwide HIV medication price. The parameter $\Psi^i$ measures the relative productivity of a sick individual relative to that of a healthy one.

Technology in this model is described by the following constant returns to scale production function,

$$Y_t = F(K^i_t, L^1_t, L^2_t) = \left[ \eta (L^2_t)^{\mu} + (1 - \eta) (Q_t)^{\mu} \right]^\frac{1}{\mu},$$  \hspace{1cm} (6)$$

with

$$Q_t = \left[ \delta(K^i_t)^{\phi} + (1 - \delta)(L^2_t)^{\phi} \right]^\frac{1}{\phi},$$  \hspace{1cm} (7)$$

where $K_t$ is the aggregate capital stock, $L^1_t$ is the aggregate stock of effective skilled labor, $L^2_t$ is the aggregate stock of effective unskilled labor, and $\eta$ and $\delta$ are parameters measuring the income shares of all inputs. The functional form for the technology above is a two level constant elasticity of substitution (CES) function with capital and skilled labor aggregated at the first level and then combined with unskilled labor at the second level. Duffy et al. (2004) have empirically shown that this technology is the most appropriate when confronted with cross country data. The parameters $\mu$ and $\phi$ are chosen as to impose capital–skill complementarity in the model, that is, $\phi < \mu$. Empirical support for the capital–skill complementarity hypothesis can be found in Griliches (1969), Fallon and Layard (1975), and Krusell et al. (2000).

In addition to assuming capital–skill complementarity, the parameters $\mu$ and $\phi$ are chosen to make unskilled workers substitute for the capital–skill aggregate and skilled workers and capital complements, that is, $\mu \in (0, 1]$ and $\phi < 0$. Fallon and Layard (1975), have empirically estimated these parameters to be in the ranges hypothesized above for a sample of developing countries, and Zhou (2001) empirically concluded that
unskilled and skilled labor are substitutes in a study of Zimbabwe. Also, anecdotal evidence for these hypotheses can be found in Amaral and Quintin (2004).

In order to completely characterize the technology above, one needs to define the expressions for skilled and unskilled labors. Effective skilled labor is composed of two types of labor: adult skilled healthy individuals and adult sick individuals. Assuming that the effective labor of an HIV infected skilled individual is a fraction ($\Psi_1^1 < 1$) of the effective labor of a healthy skilled individual, we have that

$$L^1_i = \left[ (1 - \pi^1_i) + \pi^1_i \Psi_1^1 \right] H^1_i,$$

where $H^1_i$ is the aggregate skilled human capital at time $t$. This assumption also implies that different types of skilled labor are perfect substitutes.

Perfect substitutability is also assumed for the composition of unskilled labor. This input is composed of six types of labor: adult unskilled healthy individuals and their children, adult unskilled unhealthy individuals and their children, and the children of both skilled healthy and skilled sick individuals. Here, it is also assumed that the effective labor of an HIV infected unskilled individual is a fraction ($\Psi_2^2 < 1$) of the effective labor of a healthy unskilled individual. Also, it is assumed that the effective labor of all children is a fraction ($\Delta < 1$) of the effective labor of a healthy unskilled individual. Hence, the equation for effective unskilled labor units is given by,

$$L^2_i = \left[ (1 - \pi^2_i) \left[ 1 + (1 - n^{2h}_i) \Delta \right] + \pi^2_i \left[ \Psi_2^2 + (1 - n^{2s}_i) \Delta \right] \right] + \left[ (1 - \pi^2_i) (1 - n^{2h}_i) \Delta + \pi^2_i (1 - n^{2s}_i) \Delta \right] H^2_i,$$

where $H^2_i$ is the aggregate unskilled human capital at time $t$, and $n^{ij}$ is the fraction of type $i, j$; where $i \in \{1, 2\}$ and $j \in \{h = \text{healthy}, s = \text{sick}\}$, children’s time devoted to education.

The government taxes labor income of all adult types at a rate $\tau^i_t$, but not the income of the children. As in Corrigan et al. (2005), this assumption captures the fact that children mostly work in the informal sector of the economy. It uses the proceeds to finance its own consumption and investment in some non-productive capital $G^i_t$; and subsidize the price $p_i$ of HIV medication $M^i_t$ at rate $\sigma$, which is taken as exogenous, in the form of antiretroviral (ARV) treatment. Also, the government balances its budget every period; hence its budget equation is given by

$$G^i_t + (1 - \sigma^j_t) \sum_{i=1}^2 \left[ \rho^j_t M^i_t \right] = \sum_{i=1}^2 \left[ (\pi^j_i + (1 - \pi^j_i) \Psi^j_i) \tau^j_i w^j_i H^j_i \right].$$

To finalize the set up of the model, one still needs to define the laws of motion for the children’s human capital accumulation. Differently from Corrigan et al. (2005), it is assumed here that the child’s human capital technology is only a linear function of time but not a function of the parent’s human capital, that is,

$$h^{i,j}_{t+1} = B^{i,j} n^{i,j}_t$$

where $i \in \{1, 2\}$, $j \in \{h, s\}$, and $B$ is a productivity parameter. This functional form guarantees the model’s tractability of aggregate human capital ($H^j_t$) without jeopardizing the results. Aggregate human capital evolves according to:

$$H^1_{t+1} = (1 - \pi^1_i) h^1_{t+1}$$

and

© 2012 Blackwell Publishing Ltd
\[ H_{t+1} = \pi_i h_{t+1}^s + \pi_i h_{t+1}^u + (1 - \pi_i) h_{t+1}^s, \] (13)

where children from healthy skilled parents will also be skilled, while all other children will be unskilled.

**Equilibrium**

An adult individual has a different maximization problem conditional on health status; however, the maximization problem is the same conditional on type. Hence, for any type \(i\) healthy individual, the maximization problem is to maximize (1) with respect to \([c_i^h, f_i^h, n_i^h, c_{t+1}^h]\) subject to equations (3), (4), and (11).

The maximization problem for HIV infected individuals of type \(i\) is to maximize (2) with respect to \([c_i^s, f_i^s, m_i^s, n_i^s]\) subject to equations (5) and (11). Given the maximization problems described above, a competitive equilibrium for this economy can be defined in the following manner:

**Definition.** A set of household decisions \([c_i^h, f_i^h, n_i^h, c_{t+1}^h]\) for healthy individuals, a set of decisions \([c_i^s, f_i^s, n_i^s, m_i^s]\) for sick individuals, sequences of aggregate physical capital \([K_t^i]\) and effective labors \([L_t^i]\) for all \(i \in \{1, 2\}\), such that, given sequences of prices \([w_i^t, r_i^t, p_i^t]\):

1. \([c_i^h, f_i^h, n_i^h, c_{t+1}^h]\) solve both skilled and unskilled healthy household problems;
2. \([c_i^s, f_i^s, n_i^s, m_i^s]\) solve both skilled and unskilled sick household problems;
3. The capital market clears, that is, \(K_{t+1} = \sum_{i=1}^2 (1 - \pi_i) s_i^t\);
4. All human capital will evolve according to: \(h_{t+1}^i = B^{i/h} n_i^t\) for all \(i\) and \(j\);
5. Factor prices are determined by their respective factor demands' productivity, that is, \(w_i^t = F_i^t\) and \(r_i = F_i\);
6. The government budget constraint is cleared every period.

**Solving the Model**

The model exhibits closed form solutions in all decision rule variables. This implies the following physical capital law of motion:

\[ K_{t+1} = \sum_{i=1}^2 (1 - \pi_i) s_i^t = \sum_{i=1}^2 \left(1 - \pi_i\right) \frac{\alpha_i^j}{\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4} (1 - \tau_i^t + \Delta) w_i^t H_i^t. \] (14)

and equilibrium wage rates:

\[ w_i^1 = \frac{(1 - \eta)(1 - \delta)\left[\eta(L_t^1)^\mu + (1 - \eta)(Q_t^1)^\mu\right]^{1-\mu} Q_t^{\mu - \phi}}{(L_t^1)^{1-\phi}} \] (15)

and

\[ w_i^2 = \frac{\eta \left[\eta(L_t^2)^\mu + (1 - \eta)(Q_t^2)^\mu\right]^{1-\mu}}{(L_t^2)^{1-\mu}}. \] (16)

The equations above guide the interpretation of transition paths in what follows. All remaining endogenous variables have almost identical solutions as in Corrigan et al. (2005).
3. Calibration

The parameters chosen for the simulations reflect roughly the economy of sub-Saharan Africa. Table 1 contains the baseline calibrated values. As in Corrigan et al. (2005), this paper imposes no preference heterogeneity and chooses the same parameter values as they have for all utility functions in this model. Corrigan et al. (2005) is also followed in this choices for taxes and labor productivity parameters. The choice of the labor productivity parameter $\Psi$ is also consistent with Cuddington (1993a) for the economy of Tanzania as well as Guinness and Alban (2000). Human capital productivity is assumed to be the same across agents making human capital accumulation only dependent on the parents’ choice of their children’s schooling. Sensitivity analysis is performed on $\Psi^r$, $\Delta$, and $B^{ij}$ since the results could be sensitive to the choice of these parameters.

The income share parameters $\eta$ and $\delta$ are calibrated using a combination of data and previous studies on sub-Saharan African economies. Gollin (2002) estimated income shares for a crosssection of countries and using his results for sub-Saharan African countries only, the income share owing to labor can be roughly calculated to be 0.65 (0.35 for capital). To determine what fraction of the labor income share is due to skilled labor vs unskilled, this paper uses the World Development Indicators database for a poll of sub-Saharan African countries where data on education is available between the years 1996 and 2008. It is assumed that all individuals that at least completed secondary education were skilled, which is consistent with Fallon and Layard (1975), otherwise they are put in the unskilled category. Using each country’s labor force as weights, the labor fractions are computed to be 0.37 for skilled and 0.63 for unskilled.

In order to determine how much each type contributes to income, a wage skill premium of 3:1 is assumed (Mwabu and Schultz, 2000) to obtain income shares of 0.23 for unskilled workers and 0.42 for skilled workers. This implies that $\eta = 0.23$ since $\eta$ is the

<table>
<thead>
<tr>
<th>Parameter value</th>
<th>Data moment</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_1$ = 1</td>
<td></td>
<td>Corrigan et al. (2005)</td>
</tr>
<tr>
<td>$\alpha_2$ = 0.4</td>
<td></td>
<td>Corrigan et al. (2005)</td>
</tr>
<tr>
<td>$\alpha_3$ = 1</td>
<td></td>
<td>Corrigan et al. (2005)</td>
</tr>
<tr>
<td>$\alpha_4$ = 0.2</td>
<td></td>
<td>Corrigan et al. (2005)</td>
</tr>
<tr>
<td>$\theta = 0.05$</td>
<td>Private health care expenditure</td>
<td>Corrigan et al. (2005)</td>
</tr>
<tr>
<td>$\rho = -0.5$</td>
<td>Private health care expenditure</td>
<td>Corrigan et al. (2005)</td>
</tr>
<tr>
<td>$\tau_1 = \tau_2 = 0.2$</td>
<td></td>
<td>Corrigan et al. (2005)</td>
</tr>
<tr>
<td>$\eta = 0.23$</td>
<td>Factors income share</td>
<td>Gollin (2002)</td>
</tr>
<tr>
<td>$\delta = 0.45$</td>
<td>Factors income share</td>
<td>Gollin (2002)</td>
</tr>
<tr>
<td>$\mu = 0.01$</td>
<td>Wage skill premium</td>
<td>Fallon and Layard (1975)</td>
</tr>
<tr>
<td>$\phi = -0.025$</td>
<td>Wage skill premium</td>
<td>Fallon and Layard (1975)</td>
</tr>
<tr>
<td>$\Psi^r = \Psi^t = 0.5$</td>
<td>Proportion sick days due to AIDS</td>
<td>Cuddington (1993a)</td>
</tr>
<tr>
<td>$\Delta = 0.15$</td>
<td>Relative wage income from child labor</td>
<td>Corrigan et al. (2005)</td>
</tr>
</tbody>
</table>
coefficient that corresponds to the unskilled labor share of income. The capital share of income is 0.35, which according to the production function should be equal to \((1-\eta)\delta\). Hence, \(\delta\) can be derived to be 0.45.

As mentioned before, the parameters \(\mu\) and \(\phi\) are selected to capture capital–skill complementarity \((\mu > \phi)\). In addition, \(\mu\) is chosen to capture some degree of substitutability between unskilled labor and the capital–skill aggregate, and \(\phi\) is chosen as to impose complementarity between skilled workers and capital. Another important feature in the choice of these parameters is that they are selected as to ensure that the model generates a wage skill premium of at least 2. Extensive sensitivity analysis is performed on these parameters since they play a very important role in the model.

4. Computational Experiments and Results

The purpose of this section is to compute transition paths for different scenarios where AIDS affects the economy and compare output across these states relative to a hypothetical no-AIDS case. Five scenarios are computed and in all the simulations, the model reaches a steady-state no-AIDS output first and then a positive probability of infection that varies across skills is imposed. The economy evolves for 10 periods and output is reported as a percentage of the no-AIDS steady state for every generation after the shock.

The model’s share of skilled vs unskilled labor is used in order to compute the infection probabilities as to keep the overall infection rate constant in each scenario. Letting the disease distribution vary across skills, but keeping the mean overall infection rate the same; that is, using mean preserving spreads, allows for an analysis of how the distribution of the disease across skills affects the economy. It will be possible then to investigate if there are any significant differences in the effect of AIDS on output as one moves from a case where only skilled people are infected to a case where only unskilled people are infected given the same overall infection level.

In the first two scenarios with AIDS, it has been chosen to keep HIV infection around 7%, which corresponds to the current average HIV infection prevalence in sub-Saharan Africa (World Development Indicators) weighted by each country’s population where data is available. In the next two scenarios the overall infection probability is 20%, which corresponds to the levels of infection reported in southern Africa in countries like South Africa, Botswana, Lesotho, Namibia, and Zambia. Hence, it seems appropriate to investigate scenarios where the overall probability is quite high. Scenarios 1 and 3 are attempts to compute the effects of AIDS on output in a situation where there is no cure or reduction in infection rates. These scenarios could be considered worst case scenarios. Scenarios 2 and 4 assume AIDS will no longer be a problem after two generations.

The following scenarios were considered in this experiment:

1. **Scenario 1**: At \(t = 20\), the overall infection probability is 7% and remains at this level forever. Five variations of this scenario are chosen with respect to \(\pi^1\) and \(\pi^2\) (see Table 2).
2. **Scenario 2**: At \(t = 20\) and \(t = 21\), the overall infection probability is 7% and returns to zero after that. The same five variations as above are chosen for \(\pi^1\) and \(\pi^2\) here.
3. **Scenario 3**: At \(t = 20\), the overall infection probability is 20% and remains at this level forever. Five variations of this scenario are chosen with respect to \(\pi^1\) and \(\pi^2\) (see Table 2).
4. **Scenario 4**: At \(t = 20\) and \(t = 21\), the overall infection probability is 20% and returns to zero after that. The same five variations as in scenario 3 are chosen for \(\pi^1\) and \(\pi^2\) here.
5. **Scenario 5**: At $t = 20$, $p_1 = 0.08$ and $p_2 = 0.024$; at $t = 21$, $p_1 = 0.05$ and $p_2 = 0.31$. After $t = 21$, all infection rates return to zero.

Scenario 5 captures the effect of AIDS whenever the epidemiological curve differs in timing across skills, that is, the epidemic affects skilled individuals more heavily first relative to unskilled and then switches to affecting the unskilled more relative to skilled. That is, the two epidemiological curves should cross at some point. It is also assumed that, in this scenario, the overall level of infection increases from 5% to 20% in subsequent generations. This fifth scenario is consistent with Vandermoortele and Delamonica (2000) and with evidence presented in Hargreaves et al. (2002) using demographic health survey data for an urban population in Kenya where the argument is that once the epidemic becomes more widespread, it affects unskilled individuals more relative to skilled since the latter have the means to protect themselves against the disease as they learn how AIDS is transmitted. In fact, empirical studies have shown the positive association between education, which is often used as a proxy for socio-economic status, and safer sexual behavior (de Walque, 2006).

### Table 2. Output Levels Relative to no AIDS Scenario (in %)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Period:</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No AIDS</strong></td>
<td></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td><strong>Scenario 1</strong></td>
<td>$p_1 = 0, p_2 = 0.129$</td>
<td>100</td>
<td>98.69</td>
<td>97.14</td>
<td>96.67</td>
<td>96.50</td>
<td>96.44</td>
<td>96.40</td>
</tr>
<tr>
<td></td>
<td>$p_1 = 0.035, p_2 = 0.10$</td>
<td>100</td>
<td>98.27</td>
<td>95.74</td>
<td>95.40</td>
<td>95.28</td>
<td>95.24</td>
<td>95.21</td>
</tr>
<tr>
<td></td>
<td>$p_1 = 0.07$</td>
<td>100</td>
<td>97.85</td>
<td>94.26</td>
<td>94.06</td>
<td>93.99</td>
<td>93.96</td>
<td>93.95</td>
</tr>
<tr>
<td></td>
<td>$p_1 = 0.10, p_2 = 0.044$</td>
<td>100</td>
<td>97.49</td>
<td>92.92</td>
<td>92.84</td>
<td>92.80</td>
<td>92.79</td>
<td>92.78</td>
</tr>
<tr>
<td></td>
<td>$p_1 = 0.152, p_2 = 0$</td>
<td>100</td>
<td>96.81</td>
<td>90.41</td>
<td>90.51</td>
<td>90.55</td>
<td>90.57</td>
<td>90.57</td>
</tr>
<tr>
<td><strong>Scenario 2</strong></td>
<td>$p_1 = 0, p_2 = 0.129$</td>
<td>100</td>
<td>98.69</td>
<td>97.14</td>
<td>97.96</td>
<td>99.34</td>
<td>99.76</td>
<td>99.99</td>
</tr>
<tr>
<td></td>
<td>$p_1 = 0.035, p_2 = 0.10$</td>
<td>100</td>
<td>98.27</td>
<td>95.74</td>
<td>97.08</td>
<td>99.50</td>
<td>99.82</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>$p_1 = p_2 = 0.07$</td>
<td>100</td>
<td>97.85</td>
<td>94.26</td>
<td>96.12</td>
<td>99.70</td>
<td>99.89</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>$p_1 = 0.10, p_2 = 0.044$</td>
<td>100</td>
<td>97.49</td>
<td>92.92</td>
<td>95.23</td>
<td>99.91</td>
<td>99.97</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>$p_1 = 0.152, p_2 = 0$</td>
<td>100</td>
<td>96.81</td>
<td>90.41</td>
<td>93.50</td>
<td>100.35</td>
<td>100.13</td>
<td>100</td>
</tr>
<tr>
<td><strong>Scenario 3</strong></td>
<td>$p_1 = 0, p_2 = 0.356$</td>
<td>100</td>
<td>96.22</td>
<td>91.72</td>
<td>90.32</td>
<td>89.81</td>
<td>89.63</td>
<td>89.52</td>
</tr>
<tr>
<td></td>
<td>$p_1 = 0.10, p_2 = 0.269$</td>
<td>100</td>
<td>95.17</td>
<td>88.03</td>
<td>87.30</td>
<td>87.03</td>
<td>86.94</td>
<td>86.88</td>
</tr>
<tr>
<td></td>
<td>$p_1 = 0.20$</td>
<td>100</td>
<td>93.80</td>
<td>83.15</td>
<td>82.96</td>
<td>82.89</td>
<td>82.86</td>
<td>82.85</td>
</tr>
<tr>
<td></td>
<td>$p_1 = 0.295, p_2 = 0.10$</td>
<td>100</td>
<td>92.71</td>
<td>78.48</td>
<td>78.79</td>
<td>78.90</td>
<td>78.94</td>
<td>78.97</td>
</tr>
<tr>
<td></td>
<td>$p_1 = 0.41, p_2 = 0$</td>
<td>100</td>
<td>91.01</td>
<td>71.44</td>
<td>72.19</td>
<td>72.46</td>
<td>72.56</td>
<td>72.61</td>
</tr>
<tr>
<td><strong>Scenario 4</strong></td>
<td>$p_1 = 0, p_2 = 0.356$</td>
<td>100</td>
<td>96.22</td>
<td>91.72</td>
<td>93.87</td>
<td>97.97</td>
<td>99.26</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>$p_1 = 0.10, p_2 = 0.269$</td>
<td>100</td>
<td>95.17</td>
<td>88.03</td>
<td>91.73</td>
<td>98.69</td>
<td>99.52</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>$p_1 = p_2 = 0.20$</td>
<td>100</td>
<td>93.80</td>
<td>83.15</td>
<td>88.45</td>
<td>99.64</td>
<td>99.87</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>$p_1 = 0.295, p_2 = 0.10$</td>
<td>100</td>
<td>92.71</td>
<td>78.48</td>
<td>84.99</td>
<td>101.07</td>
<td>100.39</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>$p_1 = 0.41, p_2 = 0$</td>
<td>100</td>
<td>91.01</td>
<td>71.44</td>
<td>79.33</td>
<td>103.23</td>
<td>101.16</td>
<td>100</td>
</tr>
<tr>
<td><strong>Scenario 5</strong></td>
<td>No AIDS</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>AIDS</td>
<td>100</td>
<td>98.10</td>
<td>92.33</td>
<td>94.24</td>
<td>98.80</td>
<td>99.56</td>
<td>100</td>
</tr>
</tbody>
</table>

5. **Scenario 5**: At $t = 20$, $p_1 = 0.08$ and $p_2 = 0.024$; at $t = 21$, $p_1 = 0.05$ and $p_2 = 0.31$. After $t = 21$, all infection rates return to zero.
The study of the effects of AIDS under these different scenarios can help in answering some important questions. For example, under scenarios 1 and 3, one can investigate the economy’s transition path towards a new output steady state compared with the no-AIDS case. Scenarios 2 and 4 permits one to investigate how long would it take for an economy to recuperate from the epidemic. For purposes of interpretation, the short/medium run is defined as generations 1–3 and the long run as generation 5 and above. While, scenarios 1 and 2 can assist in predicting what future damage AIDS can still cause giving the current situation (7% or 20% prevalence), scenario 5 can assist in understanding the course of the epidemic and its effect on output since the advent of the disease in the late 1970s and early 1980s.

Before analyzing each scenario in detail, it is important to notice that in every scenario parameters are chosen to keep the wage skill premium between 2 and 5, which is consistent with the findings in Mwabu and Schultz (2000) for South Africa.

Table 2 presents the results for the baseline parameter values for all scenarios. Under scenario 1, which imposes an overall infection probability of 7%, AIDS reduces output in the first generation by 1.3% for the case where $p_1 = 0$ and $p_2 = 0.129$, 2.15% for the case where $p_1 = p_2 = 0.07$, and 3.2% when $p_2 = 0$ and $p_1 = 0.152$. From generation 1 to generation 2, the epidemic has its greatest dive with the effect ranging from 2.8% (case 1a) to 9.6% (case 1e) of output. This happens because capital is mostly affected in generation 2. The fact that the epidemic is more severe in cases where skilled people are affected harder has been explained above. After the second generation, output stabilizes and by generation 10, the effect ranges from 3.6% to 9.4% of output. These results are very similar to Cuddington and Hancock (1995).

Scenario 3 is qualitative similar to scenario 1. However, since the overall infection probability is much higher (20%), the effects are much larger. In generation 1, output decreases by 3.8% for case 3a and 9% for case 3e. In the long run output will settle from 10.5% to 27.4% below the no-AIDS scenario. The variability across cases is alarming and suggests that the long-run effects of AIDS are very sensitive to how the disease is distributed across skills. The magnitude of these results are very much in line with Cuddington (1993a, 1993b), Botswana Institute for Development Policy Analysis (2000), and Arndt (2003). As explained above, the fact that the results are very sensitive to the prevalence across skills can be attributed to physical capital accumulation. Whenever, the epidemic is more prevalent among skilled individuals, and given that these individuals are the greatest contributors to saving, physical capital will be very much affected if a larger proportion of these individuals are sick.

Two other conclusions stem from these tables; first the effect of the epidemic varies significantly across cases as case (a) in both scenarios lies 60% above the benchmark (case (c)), while case (e) lies 40% below the benchmark case. Second, it appears that changing the overall level of infection does not introduce significant variations across cases, that is, both scenarios are very much alike with respect to shape and magnitudes.

Scenarios 2 and 4 behave exactly like scenarios 1 and 3 for the first two generations after the start of the epidemic. Because in these scenarios, the disease no longer exists after two generations, they can be used to assess how long it would take for recovery. In both scenarios, recovery starts in generation 3, however, very modestly. This is due to the fact that the accumulation of physical capital will only significantly increase during generation 4 because it takes one generation for a reduction in $\pi$ to affect physical capital (see equation (14)). It is between generations 4 and 5 that in most cases output has almost recovered. Assuming each generation is about 20 years, this model indicates that it would take sub-Saharan Africa between 80 and 100 years to recover.
Scenario 5, which imposes the hypothesis that the epidemic switches from being higher among skilled to being higher among unskilled individuals, suggests that while infection rates are still low and mainly affecting skilled workers, output will be 1.9% lower. The greatest effect is felt during generation 2, with output 7.7% below the no-AIDS scenario. The economy starts to recover after that and, similarly to scenarios 2 and 4, takes five generations to recover.

In order to understand each scenario in more detail, it is important to investigate how each affected variable affects output in the advent of the epidemic, that is, in which direction and in what strength will output move as skilled labor, unskilled labor, and capital is affected by AIDS. For these purposes, in what follows only scenario 2 (see Table 3) is analyzed. All other scenarios have very similar interpretations.

Given the calibrated parameters, the steady-state wage rate of skilled workers is greater than the steady-state wage rate of unskilled workers, that is, $w_{ss}^1 > w_{ss}^2$. Also, it is easy to verify that around the steady state $r_{ss} > w_{ss}^1$, since $K_{ss} < \frac{\delta}{(1-\delta)} \frac{11}{1-11} L_{ss}^1$, which implies that changes in capital provide the greatest contribution to output, followed by skilled labor and unskilled labor respectively.

In the model, AIDS affects the economy through $\pi^1 > 0$ and/or $\pi^2 > 0$; hence, it is important to understand how changes in these parameters affect the factors of production. Because the effects of AIDS on all of the aggregate variables and wages either increase or decrease as one moves from case (a) to (e), that is, the relationship is monotonic with respect to cases; there is no need to show the transition paths for all five

---

Table 3. Transition Paths after AIDS Shock under Scenario 2

<table>
<thead>
<tr>
<th>Period:</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y$</td>
<td>$\pi^1 = 0, \pi^2 = 0.129$</td>
<td>100</td>
<td>98.69</td>
<td>97.14</td>
<td>97.96</td>
<td>99.34</td>
<td>99.76</td>
</tr>
<tr>
<td></td>
<td>$\pi^1 = \pi^2 = 0.07$</td>
<td>100</td>
<td>97.85</td>
<td>94.26</td>
<td>96.12</td>
<td>99.70</td>
<td>99.89</td>
</tr>
<tr>
<td></td>
<td>$\pi^1 = 0.152, \pi^2 = 0$</td>
<td>100</td>
<td>96.81</td>
<td>90.41</td>
<td>93.50</td>
<td>100.35</td>
<td>100.13</td>
</tr>
<tr>
<td>$L^1$</td>
<td>$\pi^1 = 0, \pi^2 = 0.129$</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>$\pi^1 = \pi^2 = 0.07$</td>
<td>100</td>
<td>96.50</td>
<td>89.75</td>
<td>93.00</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>$\pi^1 = 0.152, \pi^2 = 0$</td>
<td>100</td>
<td>92.40</td>
<td>78.36</td>
<td>84.80</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>$L^2$</td>
<td>$\pi^1 = 0, \pi^2 = 0.129$</td>
<td>100</td>
<td>94.46</td>
<td>93.74</td>
<td>99.24</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>$\pi^1 = \pi^2 = 0.07$</td>
<td>100</td>
<td>97.02</td>
<td>103.01</td>
<td>106.17</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>$\pi^1 = 0.152, \pi^2 = 0$</td>
<td>100</td>
<td>100.06</td>
<td>114.37</td>
<td>114.30</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>$K$</td>
<td>$\pi^1 = 0, \pi^2 = 0.129$</td>
<td>100</td>
<td>100</td>
<td>96.16</td>
<td>94.85</td>
<td>98.17</td>
<td>99.33</td>
</tr>
<tr>
<td></td>
<td>$\pi^1 = \pi^2 = 0.07$</td>
<td>100</td>
<td>100</td>
<td>94.17</td>
<td>93.60</td>
<td>99.16</td>
<td>99.70</td>
</tr>
<tr>
<td></td>
<td>$\pi^1 = 0.152, \pi^2 = 0$</td>
<td>100</td>
<td>100</td>
<td>91.50</td>
<td>91.81</td>
<td>100.99</td>
<td>100.36</td>
</tr>
<tr>
<td>$w_1$</td>
<td>$\pi^1 = 0, \pi^2 = 0.129$</td>
<td>100</td>
<td>98.70</td>
<td>97.11</td>
<td>97.90</td>
<td>99.32</td>
<td>99.75</td>
</tr>
<tr>
<td></td>
<td>$\pi^1 = \pi^2 = 0.07$</td>
<td>100</td>
<td>101.45</td>
<td>105.07</td>
<td>103.34</td>
<td>99.69</td>
<td>99.89</td>
</tr>
<tr>
<td></td>
<td>$\pi^1 = 0.152, \pi^2 = 0$</td>
<td>100</td>
<td>104.86</td>
<td>115.51</td>
<td>110.29</td>
<td>100.36</td>
<td>100.13</td>
</tr>
<tr>
<td>$w_2$</td>
<td>$\pi^1 = 0, \pi^2 = 0.129$</td>
<td>100</td>
<td>100.85</td>
<td>91.59</td>
<td>90.63</td>
<td>99.70</td>
<td>99.89</td>
</tr>
<tr>
<td></td>
<td>$\pi^1 = \pi^2 = 0.07$</td>
<td>100</td>
<td>100.85</td>
<td>91.59</td>
<td>90.63</td>
<td>99.70</td>
<td>99.89</td>
</tr>
<tr>
<td></td>
<td>$\pi^1 = 0.152, \pi^2 = 0$</td>
<td>100</td>
<td>100</td>
<td>94.17</td>
<td>93.60</td>
<td>99.16</td>
<td>99.70</td>
</tr>
<tr>
<td>$H^1$</td>
<td>$\pi^1 = 0, \pi^2 = 0.129$</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>$\pi^1 = \pi^2 = 0.07$</td>
<td>100</td>
<td>100</td>
<td>93.00</td>
<td>93.00</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>$\pi^1 = 0.152, \pi^2 = 0$</td>
<td>100</td>
<td>100</td>
<td>84.80</td>
<td>84.80</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>$H^2$</td>
<td>$\pi^1 = 0, \pi^2 = 0.129$</td>
<td>100</td>
<td>100</td>
<td>99.24</td>
<td>99.24</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>$\pi^1 = \pi^2 = 0.07$</td>
<td>100</td>
<td>100</td>
<td>106.17</td>
<td>106.17</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>$\pi^1 = 0.152, \pi^2 = 0$</td>
<td>100</td>
<td>100</td>
<td>114.30</td>
<td>114.30</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
cases, therefore only the transition paths for the two extreme cases where AIDS only affects skilled or unskilled individuals and the case where AIDS prevalence is the same across skills are reported.

It is easy to verify that there are two channels in which $p_1$ affects $L_1$. A direct channel and an indirect channel, through $H^1$, given by equations (8) and (12) respectively. However, these effects come at different generations since $H^1$ is only affected in the following period as aggregate human capital today is only affected by yesterday’s infection probabilities. This implies that a one time increase in $p_1$ decreases skilled labor for two generations. After the second generation, effective skilled labor returns to the same level as before the shock. In Table 3, the reason why skilled labor only returns to the same level as before the beginning of the epidemic in generation 4, is because AIDS affected the economy for two generations.

The equation determining effective unskilled labor is more complicated because it depends on both infection probabilities as well as effective unskilled human capital, which in turn depends on both $p_1$ and $p_2$. As with skilled labor, a one time change in any infection probability will affect unskilled labor for two generations. The direction of this effect depends on the distribution of AIDS prevalence across skills. For the cases where AIDS only affects unskilled individuals, effective unskilled labor behaves exactly the same way as skilled labor did in the explanation above. Whenever AIDS only affects skilled people, unskilled labor will increase for two generations and then return back to the pre-AIDS level. During generation 1, an increase in $p_1$ increases $L_2$ because $n^{1^h} > n^{1^l}$, that is, children of infected skilled parents work more than children from uninfected skilled parents. Also, the children from infected skilled workers increase aggregate unskilled human capital (equation (13)) causing effective unskilled labor to increase in generation 2. The case in which both skills are affected causes $L_2$ to decrease in generation 1 as the effect caused by $\Psi^e < 1$ dominates $n^{1^h} > n^{1^l}$, and increase in generation 2 as the effect of $p_1$ on $H^2$ is greater than the effect of $p_2$ on $H^2$. These results can be easily verified from (13).

Physical capital depends directly on the probability of infection $p_1$ and $p_2$ as well as wages and aggregate human capital (equation (14)). As with aggregate human capital, it takes one generation for physical capital to be affected by the epidemic. It is easy to check that increases in infection probabilities and decreases in wages and human capital cause capital to decrease. Since it is never the case that all wages and all human capital move in the same direction, it might not be possible to determine unambiguously how capital moves after the AIDS shock. However, for the cases analyzed in this paper, the effect on capital of changes in infection probabilities always dominates any other effect; hence, capital always decreases one generation after AIDS affects the economy. Also, since the model generates a skill premium in the order of 2, the proportion of total savings that can be attributed to skilled workers is larger; therefore, capital is more greatly affected whenever the epidemic hits skilled people more relative to unskilled. This fact combined with the condition that changes in capital causes the greatest changes in output, explains why in Table 2 output is smaller for the cases where the epidemic is more prevalent among skilled workers.

Note that a one time increase in the infection probability can cause capital to move for more than two subsequent generations. That is, it takes longer for capital to adjust. Even though, in all of the scenarios investigated in this paper the probability of infection lasts for at least two generations, skilled and unskilled labor either adjust to a new level or return to the pre-AIDS level much faster than capital. The fact that there is a dynamic relationship between capital and wages explains this behavior. Hence, once the epidemic begins, wages are affected because labor is affected (equations (15))
and (16)). These wages will affect capital next period and capital next period will affect wages in that same period, which in turn will affect capital in the subsequent period.

Two interconnected results stem from scenarios 2 and 4. First, it seems that even though the epidemic more greatly affects output in cases where HIV infects skilled workers more relative to unskilled, it also recovers faster in those cases. Second, whenever the epidemic affects skilled workers more relative to unskilled, output can overshoot and stay for sometime above the no-AIDS scenario. These results can be explained by looking at Table 3 and observing the behavior of skilled wage, skilled labor, skilled human capital, and physical capital for the case where $p_1 = 0.152$ and $p_2 = 0$. As the epidemic struck during generation 1, skilled labor fell pushing its wage up. Skilled human capital and physical capital fell drastically by generation 2. The decrease in $H_1$ caused $L_1$ to decrease even further, which pushed $w_1$ even higher. When the epidemic was over in generation 3, skilled labor recovered but not to the level before AIDS since it would take one more generation for $H_1$ to recover. This caused $w_1$ to decrease, but to remain above its pre-AIDS level. Hence, physical capital increased above its pre-AIDS level causing output to do the same. This does not happen in other cases because the decrease in $p_1$ is not large enough as to make capital jump as much and have the skilled wage effect large enough to dominate the unskilled wage effect. It is because of these dynamics that one can see output recovering faster and overshooting in cases where more skilled workers are infected.

Sensitivity analysis is performed with respect to parameters $Y_i$, $D_i$, $B_{ij}$, $m$, and $\phi$; and overall, the results are not very sensitive to the choice of most of these parameters. The parameter $Y_i$ measures the work productivity of an infected individual relative to that of a healthy individual. Since the baseline model assumes $Y_1 = Y_2 = 0.5$, it seems reasonable to investigate two issues. First, changes in $Y_1$ and $Y_2$ are chosen as to keep $Y_1 = Y_2$, but for levels not equal to 0.5. Second, $Y_1$ is chosen to be relatively higher than $Y_2$ in order to capture the possibility that skilled individuals are more capable to treat themselves, hence, not losing as much in productivity compared with a healthy individual. The parameter $Y_1$ was chosen to range from 0.4 to 0.54, while $Y_2$ was chosen to vary from 0.4 to 0.5. Reducing the values of both $Y_1$ and $Y_2$ to 0.4 is consistent with the findings in Guinness and Alban (2000). All scenarios are robust to the choice of $Y_1$ and $Y_2$ with maximum variation for any given case in the order of one percentage point. The results are also very robust to the choice of parameters $\Delta$ and $\phi$ with maximum variation for any given case in the order of one percentage point. The same result is true for different choices of the parameters $B_{ij}$, which measures the efficiency of school training.

The effect of the epidemic on output is very insensitive to $\mu$ in scenario 3. In scenarios 1 and 2, the results only become sensitive for $\mu$ values above 0.1. That is, for these large values, the effect of the epidemic on output presents almost no variation across all five cases. However, increasing $\mu$ has a negative effect on the skill premium. This is due to the fact that around the steady state, the ratio between $Q$ and $L_2$ is less than one. Because the skill premium falls below 2 as $\mu$ is set above 0.0295 and there is evidence indicating that in sub-Saharan Africa this premium should be between 2 and 5 (Mwabu and Schultz, 2000), the parameter $\mu$ can be restricted to range between zero and 0.03. Therefore, for this imposed range, the results are quite robust to the choice of $\mu$.

5. Conclusion

This paper investigates the effects of HIV/AIDS on steady-state output for an economy resembling sub-Saharan Africa with skill heterogeneity. Assuming different effects of
the AIDS epidemic across skills, the results are found to be sensitive to the distribution of the disease across skills. In a scenario where the overall infection rate is permanently at 7%, output settles after generation 3 at 3.5% below steady-state no-AIDS output for the case where AIDS only affects unskilled workers. This same result jumps to 10% whenever AIDS only affects skilled workers. For any different combination of infection probability across skills, the results are between the above numbers. Hence the relationship between the effect of AIDS on output and the distribution of AIDS across skills is monotonic. For a similar scenario, where the overall probability was set at 20%, the effect of AIDS on output ranged from 10% to 28% after generation 3.

For scenarios where the epidemic is over after two generations, it takes between four and five generations for the economy to recover. Assuming each generation encompasses 20 years, this corresponds to a recovery time in the order of 80–100 years. Most of the results are not sensitive to the choice of parameters.

There are some extensions to this paper that might be of some importance. First, one might want to endogeneize the labor productivity parameters as to make them a function of each individual demand for medication. This could potentially assist in answering questions about governmental policy with respect to subsidy levels and its distribution across skills and how could changes in these policies affect output. Also, one could endogeneize infection probabilities making them a function of some prevention policy parameter. This could help answering questions about optimal governmental policy, that is, what is the best combination of prevention and treatment in order to minimize the effect of the epidemic. These questions are left for a different paper.

References


© 2012 Blackwell Publishing Ltd

**Notes**

1. Some empirical cross-country evidence for this claim can be found in Fylkesnes et al. (2001) and Hargreaves, et al. (2002).
2. The choice by sick individuals to consume $m$ is positively related to their productivity, however, this assumption can be easily relaxed in this paper without changing the results.
3. In this paper $\sigma = 1$ for all $t$, that is, the government does not subsidize treatment as this is not the focus of the current exercise.
4. The equilibrium is stable and unique. That is, for any initial level of the capital stock, it converges to the same steady state. The only exception is if initial physical capital is zero. Also, in equilibrium, the fraction of the infected population relative to the uninfected is constant and only depends on the HIV incidence, which in turn is chosen exogenously.
5. Solutions are omitted for the purposes of space.
6. The list of countries used was: Ethiopia, Botswana, Ghana, Guinea, Kenya, Lesotho, Madagascar, Mauritius, Namibia, Nigeria, Rwanda, South Africa, Tanzania, Uganda, and Zambia.
7. HIV prevalence data from the World Development Indicators is available for the following countries: Ethiopia, Botswana, Ghana, Guinea, Kenya, Lesotho, Namibia, Nigeria, Rwanda, South Africa, Tanzania, Uganda, and Zambia.
8. Each probability combination is referred to similarly as under scenario 1; that is, case 2a to case 2e.
9. Each probability combination is referred to similarly as under scenario 3; that is, case 4a to case 4e.
10. For the purposes of space, the sensitivity tables are omitted, however they can be made available at the reader’s request.
11. $\Psi^1$ has been restricted to 0.54 so as to guarantee that $n_{1,h} > n_{1,s}$ always happens.
12. The skill premium $w^1/w^2$ can be expressed as: $\frac{1-\eta}{\eta} \frac{L^2}{Q_\phi} \left( \frac{Q}{L^2} \right)^{\phi - \delta}$. Hence, whenever $Q < L^2$, as $\mu$ increases, the skill premium decreases.