AIDS Crisis and Growth

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UNAIDS 2006 Report on the global AIDS epidemic

- Estimated 38.6 million people living with HIV/AIDS,
- 95 % in developing countries.
- 4.1 million newly infected.
- 2.8 million died of AIDS.
- 12 million orphans in sub-Saharan Africa due to AIDS

Motivation

- What is the effect of the massive AIDS crisis in sub-Saharan Africa on economic growth?
- How useful are the proposed policies (e.g. subsidizing AIDS medications) to mitigate economic effects?
- Why does this matter?

$\hookrightarrow$ even moderate growth effects can have a sizeable impact on future generations

$\hookrightarrow$ no prospects of cure in the near future; treatments are costly.

Empirical literature

- Found small growth effects of the AIDS epidemic
- Example: Bloom and Mahal (1997)

$\hookrightarrow$ regress growth on prevalence of AIDS for 51 countries (1980-1992), controlling for other factors

$\hookrightarrow$ insignificant effects

Model-based literature

- Growth models predict large effects of AIDS on growth
- Kambou et al. (1992): G.E. model of Cameroon

$\hookrightarrow$ can cut the rate of GDP growth by up to 50%

- Cuddington and Hancock (1994): Solow type model for Malawi

$\hookrightarrow$ GDP growth rate lower by 0.25 percentage points

- Arndt and Lewis (2000): similar conclusion for South Africa.

Channels through which AIDS can affect growth

- Shorter life expectancy – less incentive to invest

↪ Ferreira and Pessoa (2003): schooling time can decline by half

- Hard for children of AIDS sufferers to accumulate human capital

↪ orphans have fewer opportunities to obtain human capital

↪ reallocation of resources

↪ children pulled from school (UNAIDS 2000)

- Medical costs – diverts public resources

- Firms reluctant to hire workers and invest in their training

- Impact on return to investment

The Simple Model

- OLG Model: people live for at most 3 periods
- "Youth": divide $\Delta < 1$ units of labour between working and learning
- "Adulthood": supply 1 unit of labour

$$\text{health status} = \begin{cases} \text{healthy} & \text{with probability } \pi_t \\ \text{HIV/AIDS} & \text{with probability } 1 - \pi_t \end{cases}$$

$\hookrightarrow$ make choices for young

- "Old age": if healthy, consume; otherwise dead

Impacts of AIDS in model

- Certain death at end of Adulthood
- Reduction in effective labour of adults, $\psi < 1$
- Value of medicine, m_t
- Reduced productivity in learning, $B^S \leq B^H$

Preferences

- Healthy individual:

$$\alpha_1 \ln c_t + \alpha_2 \ln f_t + \alpha_3 \ln c_{t+1} + \alpha \ln h_{t+1}$$

- HIV/AIDS infected individual:

$$\frac{\alpha_1}{\rho} \ln \left[c_t^{\rho} + \theta m_t^{\rho} \right] + \alpha_2 \ln f_t + \alpha \ln h_{t+1}$$

where θ determines share of expenditure on medicine and $\rho =$ elasticity of substitution

Production

- Aggregate production function:

$$Y_t = AK_t^{\gamma} L_t^{1-\gamma}$$

- Aggregate effective labour supply:

$$L_t = \left\{ \pi_t \left[1 + (1 - n_t^h)\Delta \right] + (1 - \pi_t) \left[\psi + (1 - n_t^h)\Delta \right] \right\} H_t$$

where H_t = stock of human capital

- Capital stock:

$$K_{t+1} = \text{savings of healthy adults}$$

$\hookrightarrow$ 100% depreciation

Competitive factor markets

- Wage per unit of effective labour:

$$w_t = (1-\gamma)AK_t^{\gamma}L_t^{-\gamma}$$

- Rental rate of capital:

$$r_t = \gamma AK_t^{\gamma-1}L_t^{1-\gamma}$$

Human capital accumulation

- Similar to Lucas (1988):

$$h_{t+1} = \begin{cases} B^h n^h H_t & \text{if parent is healthy} \\ B^s n^s H_t & \text{if parent is sick} \end{cases}$$

$\hookrightarrow$ inherit average human capital of previous generation

$\hookrightarrow$ return to investment is <u>not</u> child's wage, but adult's utility

Government's budget

- Government spends an exogenous amount G_t plus subsidizes medicine at rate $1 - \sigma_t$

- Collects tax revenue from adults only

- Budget constraint:

$$G_t + (1 - \sigma_t) p_t M_t = (\pi_t + (1 - \pi_t)\psi)\tau_t w_t H_t$$

- Price of medicine p_t treated as exogenous

Healthy household's optimization problem

- $$\max_{c_t,\ f_t,\ c_{t+1},\ h_{t+1}} \alpha_1 \ln c_t + \alpha_2 \ln f_t + \alpha_3 \ln c_{t+1} + \alpha \ln h_{t+1}$$

  subject to

  $$\begin{aligned} c_t + f_t + s_t &= (1-\tau_t) w_t H_t + (1-n_t) w_t H_t \Delta \\ c_{t+1} &= (1+r_{t+1}) s_t \\ h_{t+1} &= B^h n_t H_t \end{aligned}$$

- Solution:

  $$\begin{aligned} c_t^h &= c^h(\tau_t, w_t, H_t) = \frac{\alpha_1(1+\Delta-\tau_t)}{\alpha_1+\alpha_2+\alpha_3+\alpha_4} w_t H_t \\ f_t^h &= f^h(\tau_t, w_t, H_t) = \frac{\alpha_2(1+\Delta-\tau_t)}{\alpha_1+\alpha_2+\alpha_3+\alpha_4} w_t H_t \\ s_t &= s(\tau_t, w_t, H_t) = \frac{\alpha_3(1+\Delta-\tau_t)}{\alpha_1+\alpha_2+\alpha_3+\alpha_4} w_t H_t \\ n_t^h &= n^h(\tau_t) = \frac{\alpha_4(1+\Delta-\tau_t)}{\alpha_1+\alpha_2+\alpha_3+\alpha_4} \end{aligned}$$

Sick household's optimization problem

- $$\max_{c_t,\ f_t,\ h_{t+1}} \frac{\alpha_1}{\rho} \ln \left[c_t^{\rho} + \theta m_t^{\rho} \right] + \alpha_2 \ln f_t + \alpha \ln h_{t+1}$$

  subject to

$$\begin{aligned} c_t + f_t + \sigma_t p_t m_t &= (1-\tau_t) w_t H_t \psi + (1-n_t) w_t H_t \Delta \\ h_{t+1} &= B^s n_t H_t \end{aligned}$$

- Solution:

$$\begin{aligned} c_t^s &= \frac{\alpha_1 (\Delta + \psi (1-\tau_t))}{\alpha_1 + \alpha_2 + \alpha_4} \frac{w_t H_t}{1 + \theta^{\frac{1}{1-\rho}} (\sigma_t p_t)^{-\frac{\rho}{1-\rho}}} \\ f_t^s &= \frac{\alpha_2 (\Delta + \psi (1-\tau_t))}{\alpha_1 + \alpha_2 + \alpha_4} w_t H_t \\ m_t^s &= \frac{\alpha_1 (\Delta + \psi (1-\tau_t))}{\alpha_1 + \alpha_2 + \alpha_4} \frac{\theta^{\frac{1}{1-\rho}} (\sigma_t p_t)^{-\frac{1}{1-\rho}} w_t H_t}{1 + \theta^{\frac{1}{1-\rho}} (\sigma_t p_t)^{-\frac{\rho}{1-\rho}}} \\ n_t^s &= n^s (\tau_t) = \frac{\alpha_4 (\Delta + \psi (1-\tau_t))}{\Delta (\alpha_1 + \alpha_2 + \alpha_4)} \end{aligned}$$

Aggregate dynamics

- Human capital:

$$H_{t+1} = \left[\pi_t B^h n^h(\tau_t) + (1-\pi_t) B^s n^s(\tau_t)\right] H_t$$

- Physical capital:

$$K_{t+1} = \pi_t s(\tau_t, w_t, H_t)$$

where

$$\begin{aligned} w_t &= w(\tau_t, K_t, H_t) \\ &= (1-\alpha) A K_t^{\gamma} \begin{pmatrix} \pi_t \left[1 + (1 - n^h(\tau_t))\Delta\right] \\ +(1-\pi_t)\left[\psi + (1 - n^s(\tau_t))\Delta\right] \end{pmatrix}^{-\gamma} H_t^{-\gamma} \end{aligned}$$

Modified model

- Assumes that medicine improves productivity instead of utility

$\hookrightarrow$ replace ψ with $\psi(m_t)$

- Sick adult's optimzation problem

$$\max_{c_t,\ f_t,\ h_{t+1}} \alpha_1 \ln c_t + \alpha_2 \ln f_t + \alpha \ln h_{t+1}$$

subject to

$$\begin{aligned} c_t + f_t + \sigma_t p_t m_t &= (1-\tau_t) w_t H_t \psi(m_t) + (1-n_t) w_t H_t \Delta \\ h_{t+1} &= B^s n_t H_t \end{aligned}$$

- Complication: n^s depends on $H_t \Rightarrow$ non-linear dynamics

Calibration and Simulations

- Want to study the impact of AIDS under different scenarios, starting from balanced growth path with no AIDS ($\pi = 1$)
- Parameters chosen to match various estimates and 2% growth (Table 1)
- Four scenarios (Figures 1 and 2):

(1) $\pi = 0.8$ for one generation

(2) $\pi = 0.8$ permanently

(3) $\pi = 0.8$ for two generations

(4) gradual decline in π over 4 generations, then back to $\pi = 1$

Table 1
Parameter values for calibration

Preference parameters	Taxes
$\alpha_1=1$	$\tau=0.2$
$\alpha_2=0.4$	
$\alpha_3=1$	
$\alpha_4=0.2$	
$\rho=-0.5$	
$\theta=0.05$	
Technology parameters	Health productivity parameters
$A=1$	$\beta=5$
$\alpha=0.3$	$\Psi_1=1$
$B^{H}=2.73$	$\Psi_0=0.5$
$B^{S}=2.73$	
Relative productivity parameters	
$\Psi=0.5$	
$\Delta=0.15$	

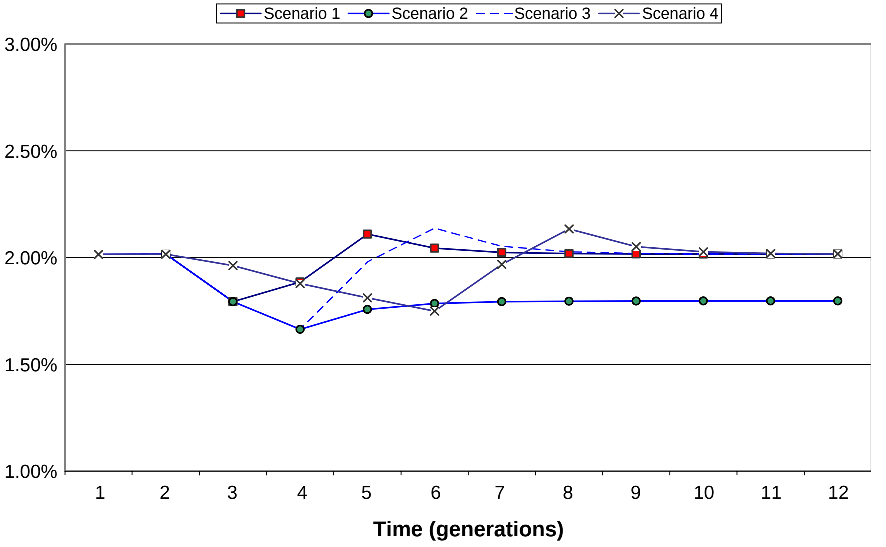

Fig. 1. Annualized rate of growth.

related health care expenditures are no more than 20% of the income of the sick individuals.

Our parameter value for capital's share of income is standard (see Gollin, 2002). The choices of parameters A, B^{H} and B^{S} ensure a pre-AIDS annual growth rate of real per capita income of 2%. According to Lebergott (1964) wage income from child labor

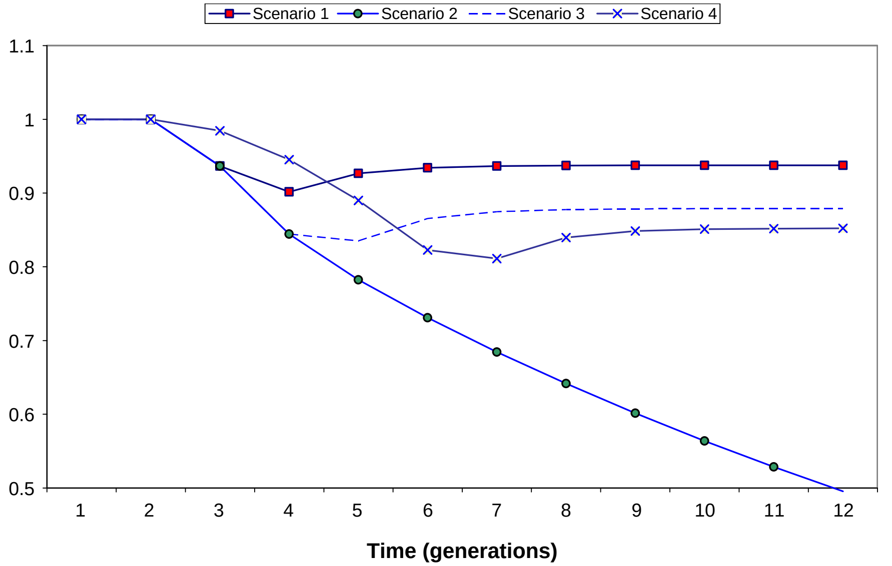

Fig. 2. Current income/potential AIDS-free income.

Table 2

Income levels relative to no-AIDS scenario (in %) with varying relative efficiency of orphan education

	0	1	2	3	4	5	20
No AIDS	100	100	100	100	100	100	100
$B^{S}=B^{H}$	100	93.66	90.15	92.65	93.42	93.65	93.75
$B^{S}=0.95\ B^{H}$	100	93.66	89.69	92.04	92.75	92.97	93.06
$B^{S}=0.90B^{H}$	100	93.66	89.22	91.42	92.09	92.29	92.37
$B^{S}=0.75B^{H}$	100	93.66	87.82	89.56	90.09	90.24	90.31

Table 3
Varying relative productivity of AIDS infected workers

	0	1	2	3	4	5	20
No AIDS	100	100	100	100	100	100	100
Ψ=0.3	100	91.18	87.74	89.14	89.57	89.70	89.75
Ψ=0.4	100	92.43	88.95	90.90	91.49	91.67	91.75
Ψ=0.5	100	93.66	90.15	92.65	93.42	93.65	93.75
Ψ=0.6	100	94.89	91.34	94.40	95.35	95.63	95.75
Ψ=0.8	100	97.33	93.69	97.89	99.19	99.58	99.75

Table 4
Varying relative productivity of child labor

	0	1	2	3	4	5	20
No AIDS	100	100	100	100	100	100	100
Δ=0.05	100	83.36	81.03	83.02	83.62	83.81	83.88
Δ=0.1	100	93.39	89.81	92.17	92.88	93.10	93.19
Δ=0.15	100	93.66	90.15	92.65	93.42	93.65	93.75
Δ=0.2	100	93.91	90.45	93.09	93.90	94.15	94.25
Δ=0.3	100	94.35	90.98	93.85	94.73	95.00	95.11

Modified Model

- Assumed functional form:

$$\psi(m_t) = \psi_1 - (\psi_1 - \psi_0)\frac{\beta}{m_t + \beta}$$

- Results are significantly different

- Macroeconomic effects are much bigger (Table 5)

$\hookrightarrow$ seems to be due to persistence effect: children of parents with low human capital spend less time learning

Table 5
Aggregate effects when AIDS decreases labor productivity

	0	1	2	3	4	5	20
No AIDS	100	100	100	100	100	100	100
Model 1, One-Period AIDS	100	93.66	90.15	92.65	93.42	93.65	93.75
Model 2, One-Period AIDS	100	72.85	95.55	96.76	97.12	97.23	97.28
Model 1, Two-Period AIDS	100	93.66	84.44	83.53	86.56	87.49	87.89
Model 2, Two-Period AIDS	100	72.85	45.34	98.45	96.51	95.94	95.69

Policy Analysis (in modified model)

- Variation in price of medicine has small effects (Table 6)

$\hookrightarrow$ note: lower prices reduce income in short run but increase them in long run

- Variation in share of revenue spent on medicine has small effects (Table 7)

Table 6
Varying the price of AIDS medications

	Fraction of income allocated to health care	0	1	2	3	4	5	20
No AIDS	0	100	100	100	100	100	100	100
p=0.5	34.54	100	71.99	96.87	98.35	98.79	98.93	98.99
p=0.75	25.68	100	72.46	96.12	97.44	97.84	97.96	98.01
p=1	20.50	100	72.85	95.55	96.76	97.12	97.23	97.28
p=1.5	14.71	100	73.51	94.72	95.77	96.09	96.19	96.23
p=2	11.28	100	74.04	94.14	95.11	95.40	95.49	95.52

Table 7
Varying the fraction of government revenue allocated to health care subsidies

	Fraction of income allocated to health care	0	1	2	3	4	5	20
No AIDS	0	100	100	100	100	100	100	100
γ=1%	16.13	100	73.32	94.94	96.03	96.36	96.46	96.50
γ=2.5%	17.85	100	73.13	95.19	96.33	96.67	96.77	96.82
γ=5%	20.50	100	72.85	95.55	96.76	97.12	97.23	97.28
γ=7.5%	23.26	100	72.63	95.86	97.13	97.52	97.63	97.68
γ=10%	25.89	100	72.45	96.14	97.47	97.87	97.99	98.04

Main Conclusions

- The consequences of AIDS on per capita income are large
- Subsidizing AIDS-related medical care have small growth effects

Some comments

- Motivation for investment in human capital seems weird
- Model designed to avoid heterogeneity, but misses important effects as a result
- Real unclear what is going on in modified model
- Assumes no minimum cost for medicines — matters for policy conclusion