The Economics of HIV/AIDS

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Abstract:

Since its revelation some two decades ago, the spread of the epidemic of HIV/AIDS has been exceptionally fast. Infections were concentrated in developed countries in the early years. Low and middle-income countries are its latest victims, with devastating social and economic consequences.

The objectives of the present paper are to make an attempt to analyze the relationship between economic growth and HIV/AIDS; address public health policy issues and suggests modifications.

Studies indicate that with its present mark HIV/AIDS infestation would decimate the economic growth from anywhere from 10% to 70%, over the next 20 years. In the absence of any cure, the containment of spread is the cost-effective option than treatment and care. The survey of existing research indicates that the traditional tools, of mandatory vaccination, subsidization, dissemination of information, etc. used by public health authorities also needs to be comprehensively reviewed and re-oriented.

Introduction:

Public awareness of HIV/AIDS came about only in the early 1980s. However, the earliest recorded and reported cases of HIV/AIDS occurred in 1952, 1959 and 1979 in New York City.[1]

Today, HIV/AIDS is the world's fourth largest cause of death, after heart disease, strokes and lower respiratory infections. The World Health Organization (WHO) estimates that the total number of people who died due to AIDS is almost 20 million and 34 to 46 million are living with the HIV (World Health Report (WHR), 2004).

Unlike the other diseases, mentioned above, which affect people in their old age, HIV/AIDS affects the most productive age group of 15 to 59 years (WHR, 2004).

Infections are concentrated in low and middle-income countries, especially sub-Saharan Africa, where 70% of infected people live. A vast majority of them are unaware of their infected state (Walker, 2003). Next to Africa, the region with the next highest incidence of AIDS is South and South East Asia, with 5.6 million infected people (Whiteside, 2001). However, the spread of the infection is fastest in Asia, followed by Eastern Europe and parts of Latin America (Walker, 2003). India and China are the most vulnerable among developing countries, sharing a population of 2.25 billion between them. Though the national figures of HIV prevalence in both countries are low (0.1% in China and 0.4 to 1.3% in India), a closer look reveals that they have attained severe outbreaks in some provinces. (WHR 2004, UNAIDS Global Report on AIDS 2004).

Economic consequences are largely felt due to the disruptions in the labour and commodity markets. Loss of workers creates an imbalance in labour demand and supply.

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[1] Source: http://uhavax.hartford.edu/bugl/rise.htm.

Reduction in population sinks demand for goods and services and thus the total output. Reduced populations also affect savings, investments and capital formation.

The alarming rate at which the disease is spreading calls for the governments, civil society and other stakeholders (drug manufacturers, research institutions and support organizations) to pool their efforts for a comprehensive and long term approach to the menace.

An understanding of the economic and social consequences is very important. It helps these various institutions (for example governments, UN agencies, international community) to prioritize scarce resources and direct policy to mitigate its affects and meet future development needs.

In this paper an attempt has been made to understand the current and projected economic consequences of HIV/AIDS and the preparedness to deal with them. I have also surveyed the macro economic literature on HIV/AIDS.

The two key questions that I raise and address are: Does HIV/AIDS have an economic impact and if so, to what extent?; And, is public health policy in a position to deal with a pandemic of the nature of HIV/AIDS?

In Part 1, I begin my analysis by describing the key features of HIV/AIDS epidemic that make its study a particularly difficult challenge for researchers.

In Part 2, I present the empirical research done so far on the affects of HIV/AIDS on economic growth. These studies can be divided into calibrated and non-calibrated models.[2] Further, I distinguish between the studies that are entrenched in macro economic theory and those using econometric modeling techniques.

[2] Non calibrated models are those that involve verification of these calibrated models

I attempt to answer my second question relating to governmental intervention in Part 3. I have examined three issues: the behavior of various macro economic variables, like GDP, savings and capital in response to various interventions; the efficacy of public health policy, assuming rational individual behavior; and the problem of resource allocation and HIV/AIDS in the developing world.

Part 4, contains observations and recommendations for the future research on this subject. Here I intend to broaden the perspective by incorporating issues like impact of HIV/AIDS on trade and globalization.

Part 1: Challenges to research in HIV/AIDS

In this section, I discuss the main challenges relating to the data on HIV/AIDS. These challenges are three fold and include long incubation periods, the reliability of prevalence estimates and the scale of the disease (Garnett, Grassly and Gregson, 2001).

Long incubation

The typical incubation period for AIDS is ten years. This allows the spread of the disease across a heterogeneous population. Further, the asymptomatic nature of the disease allows for complacency in the response of governments and civil organizations. This is evident from the increasing prevalence of the disease in rural areas, which was essentially considered an urban phenomenon (Garnett et al 2001).

Reliability of prevalence in the data

The data for the study of HIV/AIDS for developed countries is more easily available and is more reliable as compared to developing countries. For the developing countries, the information is derived using population based surveys or screening of sentinel populations (Garnett et al 2001). This sentinel population largely consists of blood donors and women attending antenatal clinics. This segment is considered the most vulnerable to the disease (UNAIDS 2004, Garnett et al 2001). Therefore using HIV/AIDS data derived from antenatal clinics can be regarded as reliable for developing countries. (Garnett et al, 2001).

Scale of the disease

Garnett et al (2001) argue that it is very difficult to predict the scale to which the disease will spread. They explain that two factors, the risk behavior and susceptibility of the population, determine the spread of the disease.

Risky Behavior:

If the population is divided into low-risk and high-risk individuals, the spread of the disease is determined by the distribution of risky contacts and the probability that transmission will occur through that contact. This could be through sexual contact, needle or blood transfusions. Due to differing risky behaviors of individuals the disease tends to spread first within the at-risk pool. Once the disease spreads through this pool, its growth is constrained.

Susceptibility:

Susceptibility depends on factors such as the concentration of infected cells in the host, the genotypes of the sex partners, the immunology state of the individuals, the presence of other sexually and non-sexually transmitted pathogens and the predicted value of the average rate of partner change (Garnett et al 2001).

While most epidemiological models (Bulatao (1990), Lwanga and Chin (1991)), proceed by assuming random matching in a given population to determine the scale of the disease, Philipson (1999) argues that low risk individuals will match with other low risk individuals and high risk with other high risk individuals.[3] This is called asortative matching. Random matching approach overstates the growth of the disease as against a demographic model using asortative matching (Philipson, 1999).

Part 2: Growth empirics and HIV/AIDS

This section is comprised of a survey of the literature in the field of HIV/AIDS and economics. The empirical research in this area can be divided into calibrated and non-calibrated models. Calibrated models typically simulate the growth trajectory in an "HIV/AIDS" scenario versus a "No-HIV/AIDS" scenario, and forecast growth 15 to 20 years ahead. They use prevalence data from well-established epidemiological models like Chin and Lwanga (1991) and Bulatao (1990). Non-calibrated models typically verify the conclusions of calibrated models.

Calibrated models can further be sub-divided into two categories based on macroeconomic theory and econometric techniques. The former comprises of the neo-classical growth model associated with Solow (1956) and the augmented neo-classical growth model associated with Mankiw (1990). These include Cuddington (1993a and 1993b), Cuddington and Hancock (1994), Robilano, Voetberg, Picazo (2002) and others.

The econometric modeling using techniques like Computable General Equilibrium (CGE) include Kambou, Gerard, et al (1992) and Ardent, Lewis (2001a and 2001b).

All calibrated models conclude that if HIV/AIDS is not dealt with effectively, it would have devastating effect on the economy.

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[3] This is based on the General Theory of Matching Markets in economics. The theory states that given, traders of different quality levels of good, high-quality traders will match/trade within themselves and low-quality traders will match/trade within themselves.

Uncalibrated models were developed in the late 1990s. Studies by Bloom D, Mahal A (1997), Dixon Simon, McDonald, Roberts (2001a and 2001b), McDonald et al (2000 and 2004) are included in this category. The conclusions reached by these economists are mixed. Bloom and Mahal (1997) find that the earlier studies have over estimated the affects of HIV/AIDS on growth. Dixon et al (2001a and 2001b) find that the disease is still in too early a stage to decisively determine its economic affects.

2.1 Models associated with Solow et al (1956)

A bulk of the literature that examines the impact of HIV/AIDS on economic growth is based on the Solow model (1956) and the Augmented Solow Model developed by Mankiw et al (1992). In 1956, Solow argued that it was possible to estimate economic growth by assuming the neo classical production function with decreasing returns to scale (Mankiw et al, 1992). However, empirical analysis did not support Solow's conclusion.

Mankiw et al (1992) argue that the absence of human capital variables such as education and health could lead to a misspecification bias in the Solow model. By adding human capital variables to physical capital, they developed the Augmented Solow model.

For the Solow based models, I will elaborate the mathematical model only for the initial paper published by Cuddington in 1993. This triggered off a chain of research using the neo-classical models. A summary of the remaining mathematical models and the results are available for the reader in Appendix C, C1 to C4

Cuddington (1993a)

Cuddington (1993a) uses the extended version of the classic single sector Solow model for a perfectly competitive economy. He develops two scenarios - "AIDS" and "No-

AIDS", in order to assess the economic impact of AIDS on the Tanzanian economy. He uses Bulatao's (1990) demographic prevalence estimates of HIV/AIDS for Tanzania as an input to the macro model. Simulations are done for the period 1985-2010. Historical data on macro economic variables (GDP, GDP per capita, gross domestic savings, investment and so on) from the World Bank and the Tanzania Bureau of Statistics are used.

The paper begins by identifying morbidity and mortality as the channels through which macroeconomic influences take place. Morbidity and mortality result in a decline of labour productivity and savings, due to an increase in medical expenditure and funeral costs. Greater demand for precautionary savings increases variability in income. The declining savings results in a decline in domestic capital formation. There are detrimental effects on human capital too. The loss of experienced and educated workforce changes the composition of the workforce from a more experienced one to a less experienced one. In addition, there is a shift in expenditure from education to health care. All these factors together contribute to a decline in the existing capital stock and national output.

The model: The extended version of the Solow Model is as follows,

$$Y_t = \alpha\gamma^t E_t^{\beta} K_t^{1-\beta} \qquad (1)$$

Where, t is time. Aggregate output Y_t is assumed to be produced using Cobb-Douglas technology with constant returns to scale. E is the labour inputs in terms of efficiency units. K_t the capital stock. β is the share of labour in national output. γ is the rate of technological change over time. α is a constant scale factor to fit the actual data in 1985. Therefore, labour efficiency is denoted as

$$E_t = \sum_{t=15}^{64} (1 - z\, a_{it})\rho_i\, L_{it} \qquad (2)$$

Where L_i is the number of workers of age i at time t. z is a fraction of work year lost per AIDS stricken worker due to absence or reduced productivity on the job.[4] a_{it} is included as a measure of proportion of population with AIDS. ρ_i is a measure of experience and therefore labour productivity without AIDS. A direct measure of worker experience is unavailable. Thus, Cuddington (1993a) assumes that a worker's experience can be proxied by taking worker age and subtracting 15 years of schooling. Finally, population growth, n_t, is captured as a function of a,

$$n_t = n_t(a_t) \qquad (3)$$

where $$\partial n / \partial a < 0 \qquad (4)$$

Savings Behaviour

The model focuses on the direct effects of increased medical expenditure on savings. If m is the per patient medical cost and x is the annual AIDS related medical costs financed out of savings, then

$$S_t = s_0 Y_t - xm\, a_t L_t \qquad (5)$$

Where, s_0 is the domestic savings rate out of GDP without AIDS.[5] This specification of total domestic savings implies that the saving rate falls with an increase in prevalence of AIDS as a result of increase in health care cost per patient.

Therefore,

$$s = s(a_t) \qquad (6)$$

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[4] In 1993, when the paper was published, there was no empirical estimate of z. The author uses a rough estimate from Pallangoyo and Laing (1990) who finds that the average adult AIDS patient in Tanzania experiences 286 days of illness over the course of the disease . According to Cuddington (1993a), "if adult patients live approximately one and half years but are absent from work 286 days the productivity loss will be easily 50% or z will be 0.5" (Cuddington, 1993a, Page 184 and 186)

[5] Similarly, there were no official estimates of the effect of AIDS on private and public savings. Therefore, Cuddington (1993a) considered a range of values for parameter x.

where

$$\partial s / \partial a < 0 \qquad (7)$$

Moreover, capital accumulation may be financed by foreign capital inflows represented by s^*.

Capital Accumulation

The change in capital to labour ratio is written as in the classic Solow model,

$$\Delta k = \lfloor s(a) + s^* \rfloor f(k, a) - n(a)k - \theta k \qquad (8)$$

f(k, a) is the production per worker, θ is the capital depreciation. The first terms shows that as AIDS prevalence increases, it has a negative impact on labour productivity and national saving. This will tend to reduce the rate of capital formation and the ratio of capital-to-labour. Reflected in the second term, is the negative long-term effect of AIDS on the labour force growth rate, which tends to raise k over time. The optimal k^* is given in equation 9

$$y^* \equiv f(k^*, a^*) = \frac{n(a^*) + \theta}{s(a^*) + s^*} k^* \qquad (9)$$

The above derivation gives the following two outcomes. First, increase in prevalence of AIDS shifts the aggregate production function downward because of the negative effect of deteriorating health on labour productivity and a rise in the younger and less experienced labour force.[6] If considered in isolation, the first outcome reduces output per capita and capital-labour ratio. Second, the AIDS epidemic is shown to ultimately reduce the labour force growth rate, and have a negative effect on both the savings rate and the rate of capital accumulation.

[6] As mentioned earlier, a younger and less experienced labour force which replaces the more experienced labour force (due to death and mortality) lowers productivity (Cuddington 1993a)

Conclusion

Cuddington (1993a) concludes that the Tanzanian economy will grow at anywhere from 2.8% to 3.9 % by 2010 in an "AIDS" scenario. The size of the economy is 15% to 25% smaller in comparison to a "non-AIDS scenario"(Cuddington, 1993a)

Policy implications

This paper was a preliminary an attempt to understand the magnitude of the effect of HIV/AIDS on growth in the future. Policy implications were not in the scope of this paper. However, it inspired a chain of research along the same lines, where more variables and different data sets were exploited.

Discussion and Drawbacks

It has been argued by Maliyamkono et al (1990) that the predictive capabilities of this model may be limited with respect to less developed economies, as they operate at less than full employment and have uncompetitive labour markets. To counter this criticism, Cuddington reworked the paper, to include market failures.

Cuddington 1993b

Cuddington (1993b) argues that it is not the full employment feature of the economy that matters but the extent to which HIV/AIDS causes a change in capacity utilization. Under the full employment assumption, if AIDS reduces unemployment, the total loss in output may be overestimated. If AIDS increased unemployment, the simple full employment framework will underestimate loss in output. He extended the framework further to incorporate underemployment and dual labour markets, in both formal and informal sectors. His study presupposes that formal sector wages are sticky in the short run but they ultimately settle at equilibrium levels with the dualism in the labour market finally disappearing.

He included the effects of HIV/AIDS on both the demand and supply of labour within the dual labour market framework.

On the supply side, the rise in mortality rates reduces the size of the labour force and tilts its composition towards younger, less experienced cohorts and reduces the labour supply.

On the demand side, AIDS related illnesses reduce labour productivity by increasing absenteeism from work and reducing overall strength, stamina and concentration. Thus, reduced per capita productivity reduces the demand for labour.

With an epidemic of AIDS, like in a full employment situation, the demand and supply curve shifts inwards. The output loss is also greater as compared to the full employment economy. However, if the fall in supply is greater than the demand, it will lead to a fall in unemployment. He simulates his model using the same data source as in Cuddington (1993a). (Please refer to Appendix C1 for details on the summary structure of the model)

Conclusion

He concludes that in the "AIDS" scenario, the negative impact on GDP ranges from 11% to 28%. The decline in per capita income ranges from 3.6% to 16.1%. HIV/AIDS reduces the number of jobs. Therefore, a dual labour market economy is characterized by greater underemployment compared to the single labour market economy, which is characterized by greater unemployment. However, he concludes that if the formal labour markets are more flexible as in the case of the informal labour markets, then the loss in productivity due to AIDS is more or less compensated for by productivity improvements, due to efficient allocation of resources.

Policy Implications

If exit and entry barriers to the formal labour markets, such as minimum wage requirements or inflexible exit policies, are removed the losses imposed due to AIDS could be reduced.

Discussion and Drawbacks

One of the main criticisms against the dual economy model is that it downplays the importance of the informal sector as an important contributor to economic growth. Most developing economies are characterized by labour-intensive modes of production, with dual labour market structures with the informal sector significantly contributing to GDP.

Cuddington and Hancock (1994)

Cuddington and Hancock (1994) undertook a similar exercise for Malawi for the period 1985 to 2010[7] and compared "AIDS" versus "no-AIDS" scenarios. They used Bulatao's (1990) AIDS prevalence estimates for the "AIDS" scenario and the data source for the aggregate macro economic variables was the World Bank Reports on Malawi. The difference between this study and the earlier ones was that they further divided the affects of the disease into "low" "medium" and "high" impact groups.[8]

Conclusion

Cuddington and Hancock (1992) conclude that in the AIDS case, the reduction in total output ranges from 3 % to 9% by 2010. The per capita income remains unchanged because of a reduction in population. In addition, capital accumulation will fall because of lower savings in the formal sector. The conclusions relating to the labour market are similar to those in the case of Tanzania. (Please refer to Appendix C2 for detailed discussion of the results).

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[7] The framework of the model remains similar to Cuddington (1993a and b).

[8] The low impact scenario assumes the impact of AIDS will be less the 1.1% by 2010. The medium AIDS scenario assumes that AIDS prevalence rate will rise from 0.01% of the population in 1985 to 1.1% by 2010. The high impact scenario assumes that 6.1% of the population will have active AIDS in the year 2010..

Policy Implications

As in Cuddington (1993b), if policies aimed at reducing the inflexibilities in the formal labour market are implemented, then the productivity loss due to AIDS can be reduced.

Dixon, McDonald, Roberts (2001a)

So far I have described calibrated models. The more recent study by Dixon et al (2001a) attempts to verify the effects of HIV/AIDS, as estimated by the earlier studies. They apply the augmented Solow model for a data set of 41 African countries over a period of 1960 to 1998. They incorporate health and education in a dynamic panel data model, where health capital is determined by health status.

The data set is divided into two sub-samples - Southern and Eastern Africa (SEA) sample consisting of 16 countries (SEA has a mean prevalence of 15.6% and the highest growth rates) and Rest of Africa sample (ROA) consisting of 25 countries (with much lower mean prevalence as compared to SEA).

Estimation is done using seemingly unrelated regression (SUR). They estimate two equations, growth and life expectancy. The effect of HIV/AIDS on growth is derived indirectly through its effect on life expectancy (health capital measure) and population. Macro economic aggregates like GDP, GDP per capita, investment and so on are taken from the World Bank, World Penn Tables and FAOSTAT. (Please refer to Appendix C3 for details on the summary structure of the model)

Conclusions

Dixon et al (2001a) concluded that growth rates in high prevalence countries of SEA were negatively affected. However, for the full Africa sample and the ROA sample, there were no significant deviations from normal economic variables. (Please refer to Appendix C3 for summary of results of the model).

Policy implications

Within the next five to 10 years, governments of developing countries, especially in India and China, where the prevalence levels are still manageable need to invest in prevention policies and health infrastructure, so that they are able to avert a major HIV/AIDS crisis.

Discussion and Drawbacks

One of the merits of the model is that it has attempted to understand the impact of HIV/AIDS on growth indirectly through the effect on life expectancy. The indirect approach ensures that there is no misspecification bias. Moreover, the use of health and education as human capital variables are important inclusions.

Robalino et al (2002)

Through another non-calibrated model, Robalino et al (2002) used a similar approach as Cuddington (1993a and b) to draw conclusions on the effect of HIV/AIDS on economic growth for Kenya.[9] They identify savings as a channel through which HIV/AIDS affects the economy. HIV/AIDS reduces savings due to higher health care expenditure, which in turn reduces investment and capital formation. After specifying the optimal savings path, they capture the effect of HIV/AIDS through its impact on labour productivity and on demographics, that is, reduction in the over all labour force.

The study uses data from World Bank, National AIDS/STDs Control Program (NASCOP) for Kenya. It simulates the typical "HIV/AIDS" scenario vs. a "No-HIV/AIDS" scenario and estimates GDP, GDP per capita and savings for an economy from 2000 to 2020.

[9] Kenya in 1998 had a HIV prevalence of 13%(Dixon et al, 2001). Please refer to Appendix A Table 1 for UNAID estimates for latest prevalence estimate for HIV/AIDS for population between 15-49 years for 2003

Robalino et al (2002) use time series data on GDP, labour and capital stock for 1960-1998. (Please refer to Appendix C4 for details on the summary structure of the model).

Conclusion

The authors conclude that in the "AIDS" scenario, GDP will be lower by 15% to 25% by 2010 and 35% to 45% by 2020. Per capita income will reduce by 1% to 13%.

Policy Implications

The Government of Kenya and other concerned institutions need to recognize that HIV/AIDS is a crises and device an effective policy option.

Discussion and Drawbacks

The study has important and interesting conclusions with projections made for 20 years. However a drawback is that that Robalino et al (2002) have not developed an alternate scenario to incorporate the effect of levels of policy interventions on GDP growth. For example ff over the next 10 years the disease is expected to reduce GDP by 15%-25%, then delayed government interventions should be incorporated for the next 10 years.

Several other studies have been conducted using the Solow model. Edwards and Al-Hmoud (2003) have used a cross-country data to show that for poor countries (GDP per capita ≤ US$ 1700), the negative relationship between AIDS mortality and economic growth is statistically significant. Bonnel (2000) has explored the linkages between GDP growth and HIV/AIDS using cross-sectional data for developing countries. The results of the analysis suggest that during the last decade, African countries have lost an average 0.8% of their GDP each year as a consequence of HIV/AIDS, assuming an average prevalence rate of 8%. Similarly, a study by Botswana Institute for Development Policy Analysis (BIDPA, 2000) for Botswana, predicted an 8% fall in national household level income, and an increase of 5% in the poverty head count. Per-capita income of the poorest 25% of households is projected to fall by 13%, with an increase of 25% in the number of dependents per income earner.

2.2 Computable General Equilibrium Models

The next set of papers that I will be reviewing makes use of the Computable General Equilibrium (CGE) Model. CGE models are considered better tools as they provide richer sectoral and distributional economic linkages than time-series-based and aggregate macro econometric models (Dissou, 2004). These models have recently been used to analyze the effect of policy changes in different parts of the economy, for example, trade, oil and so on.

Ardent et al (2000)

Ardent et al (2000) have used CGE methodology to estimate the impact of HIV/AIDS on the South African economy. This model falls in the category of calibrated models. They identify major channels through which HIV/AIDS affects economic activity and add these channels to the CGE framework. The channels include, firms, governments and households, and the economy as a whole.

The effect of HIV/AIDS with respect to firms is felt because of disruption of work, due to increased absenteeism, loss of work experience due to morbidity and mortality, which affects overall productivity. With respect to governments, spending on HIV/AIDS reduces other spending (for example education, infrastructure investment) and may increase deficits. With respect to households, it can lead to changes in expenditure patterns and reduction in savings.

Ardent et al (2000) construct a 14-sector profit maximization CGE model and use a translog production function. Sectoral market distortions are imposed to reflect changes in factor inputs and thus overall productivity.

On the demand side, the assumptions include a competitive market, forced and voluntary savings are used to satisfy investment demand and government-spending rules accommodate a crowding-out mechanism.[10] After making the standard CGE model assumptions, they further incorporate assumptions related to the presence of HIV/AIDS. These relate to labour productivity, total productivity, household spending and government spending. The authors proceed by creating alternate growth scenarios. They use this calibrated model to generate projections from 2001 to 2010 and compare a "No-AIDS" scenario with an "AIDS" scenario. Data on macro economic variables were gathered from the South African Reserve Bank.

Conclusions

They draw seven conclusions from their analysis. First, by 2010 real GDP will be about 17% below the level attained in the "no-AIDS" scenario. Second, (absorption (consumption expenditure + investment expenditure + government expenditure) indicates that) real aggregate spending will be 22% lower in the "AIDS" scenario in 2010. Absorption per capita declines by 13%. Third, real per capita GDP will be 8% lower for "AIDS" scenario as compared to the "no-AIDS" scenario. Fourth, the unemployment rate for unskilled labour will increase, but only marginally. Fifth, with respect to savings, there will be a decline from 17% of GDP in 1997 to 14.2% in 2010. Sixth, the authors predict that HIV/AIDS expenditure will be crowded out by other government expenditures. Seventh, the government deficit

[10] The overall funds available for investment or expenditure at the disposal of the government remain the same; therefore if it wants to increase expenditure in one part of its budget, it will have to decrease spending in another part.

spending will be 45% of GDP and these two effects, that is, decline in savings along with the shift in government expenditure cause the GDP to decline by 79%.

The potential economic impacts are, therefore, much larger then any other study. This is because of higher prevalence rates and the inclusion of a time dimension due to which the cumulative effects of depressed rates of investment and rates of total factor productivity growth emerge.

Moreover, the impact on per capita income is also higher as compared to earlier studies, for example BIDPA (2000), which did not assume a savings effect for Botswana. In contrast, for South Africa, the authors assumed there would be a savings effect and that net foreign capital inflow would remain constant contrary to BIDPA.[11]

Thus, they conclude that the decline in productivity is due to three factors:, a decline in the overall factor productivity, a reduction in savings and an increase in government expenditure on AIDS related services, which drags the economy down.

Ardent et al (2001)

Ardent et al (2001) further explore the interaction between unemployment and AIDS. They use the same methodology as Ardent et al (2000). Here the authors introduce distortions in the model by assuming that wages of unskilled and semi-skilled labour are set institutionally. In the absence of a feedback mechanism, with respect to wage setting, wages are not responsive to changing unemployment levels. They explore this relationship on employment given an AIDS pandemic (Ardent et al, 2001).

Ardent et al (2001) conclude that by 2010 for the "AIDS" scenario, the real GDP is about 20% lower and GDP per capita is 8% lower as compared to no-AIDS scenario. Absorption minus AIDS related public and private expenditure, which is an alternate measure

[11] For Botswana, it was assumed that a decline in savings would be replenished by inflow of foreign investment

of welfare, substantially decreases by 13% in the "AIDS" scenario as against a "no-AIDS" scenario. Demand for unskilled and semi-skilled labour is projected to be weak due to the dual effects of declining economic growth and its composition under an AIDS epidemic, in the coming decade.

This AIDS induced slowdown in demand completely offsets the AIDS induced decline in supply. As a result, the unemployment rates are the same in the "AIDS" and "no-AIDS" scenarios. To solve the unemployment problem, policies to foster more rapid job creation are required.

Policy implications

The conclusions and policy implications reached by Ardent et al (2001) are similar to those reached by Cuddington (1993b) with respect to Tanzania and Cuddington and Hancock (1995) for Malawi. They had proposed that flexibility between formal and informal labour markets would increase economic growth rate and employment.

Discussion and Drawbacks

The use of CGE models is a departure from the earlier studies using Solow theory. The use of this modeling technique in the future will allow for inclusion of other variables like trade and the effects of HIV/AIDS on a country's trading partners.

2.3 Other Studies and Conclusions

Bloom and Mahal (1997) argue that the earlier studies tend to overstate the effects of HIV/AIDS on an economy. They identify four characteristics of developing countries, which mitigate the effect of HIV/AIDS. First, developing economies have surplus labour. This surplus labour mitigates the effect on labour productivity and population demographics. Second, since HIV/AIDS affects the poor, the loss in terms of value will not be so great.

Third, social and economic networks emerge, for example, extended families, which reduce the burden on formal health care systems. Fourth, individuals respond to increasing prevalence by reducing high-risk behavior. This in turn will bring down prevalence, and therefore the actual prevalence will be lower then the projected.

In order to prove their hypothesis, the authors use empirical growth equations to measure the nature and strength of statistical associations between the prevalence of AIDS and the rate of growth of GDP per capita. They use non-linear least square and non-linear two stage least square method for estimating the relationship between HIV and GDP. The period of study is from 1980 to 1992. The cohorts included are adult population in the age group 15-64 in the year 1993. They use cross-country data analysis for 51 countries, which includes estimates from both developed countries and the developing countries. Direct number of AIDS cases is not available for any country besides the US. The HIV estimates for the other countries have been gathered separately. They use the epidemiological model, EPIMODEL developed by Chin and Lwanga (1991) to estimate cumulative AIDS cases. This is then matched to economic, social and demographic data for corresponding countries (Bloom et al, 1997). HIV/AIDS data is from US Bureau of Census and WHO regional offices; macro economic variables are taken from World Bank reports. (Please refer to Appendix C5 for details on the summary structure of the model)

Conclusion

Bloom and Mahal (1997) have included 51 countries in their sample. These represent 69% of the world population. The average AIDS prevalence is 4.9 per 1000 adults (1.1/1000 weighted by adult population) from 1980 to 1992 (for example it ranges from 0/1000 in China, 39.6/1000 in Zambia). Every additional AIDS case per 1000 persons per year is associated with 0.8 % point reduction in the average annual rate of per capita income growth for 1980-1992. Moreover, the linkage between AIDS prevalence and income growth showed that the AIDS coefficients were insignificant in (absolute) value in the two specifications.

Thus they concluded that it was economic growth, which influences AIDS growth and not vice versa. Their final conclusion was that AIDS had no impact on economic growth and there is no evidence of reverse causality (Bloom et al 1997).

Discussion and Drawbacks

Some of the augments on which Bloom et al (1997) base their hypothesis are surprising. Their first two arguments, labour surplus economies and correlation between poverty and HIV/AIDS (death of poor will not result in substantial loss to the economy)), underestimate the contribution of the informal sector to these economies. As in the case of South Africa (Ardent et al 2001), most of these economies experience inflexible, sticky wage structures in the formal sector, due to which they may experience high rates of unemployment. But the informal sector is more market driven, with a flexible wage environment. For example, informal sector contribution to labour force for India (1990-91) was almost 73% as a percentage of non-agricultural employment, for Indonesia (1998) it was 78% and for Philippines (1995) 67% (Charmes, 2000). With respect to GDP, the percentage contribution for India was 32%, for Indonesia 25.2% and for Philippines 25.4% (Charmes, 2000). With such large contributions coming from this part of the economy, an HIV/AIDS epidemic is bound to adversely effect labour productivity and GDP growth in the coming years, as shown by Ardent et al (2001).

With respect to their third argument, they discount the costs of free services given by family members, which they argue reduces the burden on health care systems. However, a reduction in costs on heath care systems due to the presence of extended family network may actually increase costs in other parts of the economy. For example, a wife may have to give up work to support a sick husband or a child may have give up going to school to take care of sick parents.

Dixon et al (2001) point out that the use of cross-section data used by Bloom et al (1997) may have certain drawbacks. For example, the use of cross section data requires the assumption that all countries included in the sample have started with a common initial technologies, common rates of technical progress and common preferences with respect to choice of technologies . They also point out that there may be loss of important information due to the collapse of dynamics (Dixon et al 2001). They further point out that the data that Bloom and Mahal (1997) use is for the 1980s and early 1990s when prevalence estimates were limited, which could have caused such poor results. Furthermore, Bloom and Mahal (1997) did not include South Africa, Botswana, Rwanda, Namibia and Swaziland, which have very high prevalence rates (Dixon et al, 2001).[12] Dixon et al (2001) also question the growth equations, which according to them, use ad hoc explanatory variables and are not entrenched in any theory.

2.4 Summary and Discussion[13]

Majority of the papers discussed, conclude that the effect of HIV/AIDS will be significant in the long run. The papers based on the Solow type models have concluded that HIV/AIDS will decrease GDP by 10% to 40% for the period of the simulation, in a typical "AIDS" versus "No-AIDS" scenario. Savings growth will decline substantially. However, the effect on GDP per capita will not be so significant, which is attributed to declining demographics caused by the disease.

[12] Please refer to Appendix A Table 1 for current prevalence levels in these countries.
[13] A summary of the broad results of the different studies mentioned in this section are attached in the Appendix A, Table 2, of this paper

Growth models have been criticized on several counts. Dixon et al (2001) make two objections – one is the use of aggregate data, which may not reflect all the non-monetary affects of the disease. Two, all labour is not perfectly substitutable. Accordingly, labour-intensive sectors are bound to feel deeper effect of the disease.

I agree with Dixon et al (2001), GDP though a good starting point, is only a crude measure of welfare because it does not include the cost of those items that may not have a price tag. In case of HIV/AIDS, the efforts that extended families may put in for those suffering with HIV/AIDS (voluntary services) may not be included as a cost. Instead of using GDP alone, an alternate measure similar to the human development index or physical quality of life index needs to be constructed. These indices would take into account a fall in the quality of life of its victims and society in general and GDP should be used as an input.

CGE models, however, go a step further and conclude that the there is not only a substantial decline in GDP over the period but a substantial decline in GDP per capita coupled with a decline in savings rate.

The main policy prescription that emerges from the studies using both approaches is that more flexible labour markets will help to counter the loss in output due to HIV/AIDS.

The non-calibrated models have had mixed findings. Bloom et al (1997) have called the conclusions of the above models as over estimations. Dixon et al (2000) found that there was some evidence of affects of HIV/AIDS on economic growth. But they concluded that it was too early to make definite statements. Bonnel (2000) found that sub-Saharan African economies were loosing GDP at the rate of 0.8% per year due to AIDS.[14]

Thus, in conclusion, we have not been able to establish the full impact of the disease. But it is clear that early action needs to be taken to prevent its spread. Only such a policy

[14] Impact of AIDS, UNDESA, 2004

will prevent a substantial reduction in the gains in development made by these economies over the last four decades.

With this I conclude this section, which throws light on my first question, that is, whether the spread of HIV/AIDS has an economic impact on the economy and if so, to what extent? Next while addressing my second question, I will be assessing the role of public health policy and its effectiveness.

Part 3: Economics of Intervention:

In this section I will address the second key question as mentioned in my introduction, that is, "is the traditional health policy in a position to deal with a pandemic of the nature of HIV/AIDS?". I attempt to answer this question by raising three key issues.

First, given that the disease will reduce economic growth and alter the structure of the economy in terms of labour productivity, savings and investment, what will be the effect of a policy intervention on the growth trajectory of that economy? Given the resource constraint, which of the two policies, that is, prevention or coping, is a better choice?

Second, if intervention is a "*commodity/good*", should it be a public or private good. From an economist's perspective, if an individual is rational and must bear the cost of intervention, the demand for intervention will be elastic to prevalence. Given this, how effective would public health policy be if it were responsible for providing intervention?

Third, it is established, that less developed countries are most effected by HIV/AIDS, therefore, what are the barriers they face in controlling the disease?

3.1 Intervention, Growth and HIV/AIDS

Cuddington et al (1994) and Robalino et al (2002) have considered intervention from a theoretical perspective.

Cuddington et al (1994)

Cuddington et al (1994) extend the single sector Solow model (Cuddington 1993 a and 1993b and Cuddington and Hancocke 1994a and 1994b), to include the consequences of alternative health sector policy actions such as preventive and coping. They add a simple demographic, epidemic equation and policy parameters to the aggregate macroeconomic framework and describe the effect on steady state equilibrium. (Please refer to Appendix C6 for details on the summary structure of the model).

Given a "no AIDS scenario", the relationship between birthrate, income and capital per unit of effective labour (*k*) can be drawn with different steady states. Please refer to Appendix B for Figure 1.

Due to the dependence of income on birthrate, there can be three situations with respect to *k*. The three states represent the rate at which birthrates and income rise. k* is called Nelson's Development Trap, that is, birthrates rise faster then income and therefore, result in a lower *k*. k** and k*** are stable *k's* such that as income rises, birthrates fall. Given HIV/AIDS, the effect of two policy interventions, preventive and coping, are incorporated and affects on original *k* are examined.

Preventive expenditure policy, increases medical expenditure, (assuming that probability of contracting HIV is a function of expenditure) and reduces the rate of HIV transmission. The second is the coping expenditure policy to help HIV patients cope with the disease. Figure 2 (Please refer to Figure 2, Appendix B) shows that if the economy starts at a high k say, a point C. With a given percentage of population with HIV and k, increase in medical expenditure leads to fall in k and fall in birth rate of the population and therefore, fall in percentage of population with HIV. The economy moves to point D, which has a lower k and lower percentage of population with HIV then at C. If birth rate of the population does not fall, then the economy moves to a point E. This point has a higher percentage of population with HIV compared to D, but the same k as point D. Moreover, increase in medical expenditure, can drive the economy into Nelson's low level development trap (k^*) depending on cost-effectiveness of the intervention strategy just as it can reduce or eliminate AIDS.

Next they consider the effect of an increase in medical expenditure, as part of a coping expenditure policy. This reduces the number of AIDS patients for a given k, but increases the percentage of HIV patients. Further, it shifts the growth curve depending on where the economy is and can drive the economy to a "no-AIDS" steady state.

Finally, the authors evaluate the use of one particular intervention strategy, long-run distribution of condoms. They simulate and compare the results of three situations - "No-AIDS", "AIDS without condoms" and "AIDS with condoms". They assume a typical sub-Saharan country.

Conclusion

The results are as follows: First, HIV/AIDS has a greater effect on capital-labour ratio if savings are affected rather then labour productivity. Second, for a given level of savings and labour productivity an increase in transmission rates leads to a significant increase in the capital-labour ratio.[15] This implies that policies should be aimed at reducing transmission rates. Third, in a "no AIDS" scenario, the capital-labour ratio is significantly lower than in the

[15] For a 57% increase in transmission rate, infection rate rises 530% and capital labour ratio rises 144%.

"AIDS scenario", with or without condom use. Fourth, the authors introduce condoms in their fictitious economy and study the effect on transmission, prevalence, birthrate and per capita income with interesting results. "An increase in condom use affects the birth rate immediately but affects the infection rate and thus the mortality rate only gradually over time." (Cuddington 1994, page 493). Therefore, in an "AIDS-with-condoms" situation, the population growth falls faster than prevalence and mortality, and the infection continues to have negative impact on savings and k, in the short run.

The authors therefore, conclude that increased prevention expenditure is more effective then coping expenditure, in reducing prevalence. They advocate a policy of condom distribution coupled with education, which will bring down prevalence and increase income, as a result of reduced birthrates and therefore, an increase the per capita income.

Discussion Drawbacks

This paper is a milestone since it is the only one, which attempts to examine the effect of HIV/AIDS on the growth trajectory, given that its effect on economic output is established. Even though it is theoretical in nature it raises some important questions and provides a direction to the course of future research. The next step would be to incorporate resource constraints and examine the actual growth trajectory for countries with high levels of prevalence.

The paper considers an intervention policy empirically and it's consequences and makes recommendations. Unfortunately it is very limited in its approach since it does not consider other methods of intervention or the trade-off with other interventions. For example, once prevalence levels engulf large populations, use of condom education and distribution will largely become ineffective. Therefore, coping expenditures will have to be enhanced. Thus the effect on growth trajectory needs to be tested empirically.

Robilano et al (2002)

Next, Robilano et al (2002) made an attempt to estimate the rate at which the Kenyan society should reduce prevalence in order to maximize its social welfare. They use similar variables as Cuddington (1994) to incorporate prevention and coping expenditures.

Conclusion

The authors conclude that similar levels of welfare can be achieved using different intervention procedures. However, they argue that a policy that is aimed at sharp reductions today (a sound prevention policy) tends to be more effective because in the long run it reduces the costs on coping expenditures. However, if a prevention policy is very lax, then the marginal benefits of the policy are nullified, due to lost labour productivity. It will also result in high marginal costs of coping as a result of higher prevalence.

The authors stress that even a lax prevention policy and high marginal costs of coping expenditure will increase welfare in terms of increased per capita consumption by almost 12% to 20%.

Policy Implication

With respect to Kenya they therefore suggest that first the policy should be aimed at stabilizing the prevalence and then aim at reducing it.

Discussion and Drawbacks

In conclusion, both papers have advocated a prevention policy as compared to a coping policy. With respect to effect of an intervention on the economy, the trajectory of economic growth will depend on the level of k in the economy. Both preventive and coping policies increase medical expenditure. However, the more cost effective policy will move the economy to a "no AIDS scenario". The strategy suggested by Cuddington et al (1994) and Robilano et al (2002) is preventive rather than a coping.

The practical relevance of this theory can especially be appreciated in the context of developing countries with resource constraints and poorly developed health care systems. The cost of High Active Anti-retroviral Therapy (HAART) is prohibitive, at almost $20,000 per patient per annum, and so is the cost of creating healthcare infrastructure. The spread of education and encouraging other preventive strategies appears to be a more immediate solution to the crisis situation. Either way, in the long run, investment in healthcare will have to be put in place.

3.2 Rational behavior, infectious diseases and effective intervention

The second issue that I will be addressing is the effectiveness of intervention (public heath policy) to eradicate infectious diseases in the presence of rational behaviour. Philipson (1999) has explored this at great length. The arguments and evidence presented by him have very dramatic consequences for public health policy. These include, effectiveness of public health policy to eradicate an infectious disease and the optimality of such a solution. He also deals with the welfare affects of eradication, the effectiveness of subsidized and mandatory treatments and the timing of an intervention and the role of communication/education of the disease.

At the heart of his argument is the rational behaviour of individuals. He argues that as prevalence of an infectious disease increases, the demand by individuals for prevention also increases. Thus he argues that, demand for prevention is prevalence elastic. This simply means that beyond a certain threshold prevalence of the disease, an individual will engage in protective behaviour and increase his demand for protection (for example with an increase in HIV/AIDS, the demand for protective behaviour will increase). [16]

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[16] Below that threshold he will engage in transmissive behavior

Initially, this limits the growth of the disease, but eventually, the decline of the disease below that threshold results in a fall in demand for protection. This is one of the differences in conclusions between epidemiology and economics.

Epidemiologists argue that, as more infected people meet uninfected people, the disease increases, however, economists argue that with the increase in prevalence the demand for protection also increases, causing eventual fall in the incidence of the disease. A fall in demand for protection makes it unprofitable for drug companies to continue production of such protection (e.g. vaccines). This in turn allows the disease to return, as lesser and lesser people get vaccinated and the population gets susceptible to the infection. This limits the ability of public health policy to eradicate an infectious disease.[17]

Moreover, he argues that eradication is not Parato Optimal, especially for the present generation if the benefits of eradication are lower then its costs. It is the future generation that benefits the most from eradication but does not pay for it. It thus makes it unprofitable for drug-manufacturers to eradicate the disease in the present. To solve this dilemma, he suggests a lower present discount rate, which will increase the value of future prevention over the current costs of the eradication program. Therefore, he suggests that such programs should be financed through deficit financing, which will allow transferring the costs to future generations.

Next he addresses the efficacy of public health interventions given the prevalence elastic demand for intervention. First, he addresses three issues of effectiveness of public price subsidies and mandatory vaccination. He questions the efficacy of Pigovian subsidies to solve the problem of under provisioning.[18] This is because in the presence of prevalence elastic-demand for intervention, the price elasticity of demand for vaccines is reduced. How?

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[17] The only infectious disease successfully eradicated as per WHO is small pox

[18] Pigovian taxes and subsidies are enacted in order to correct the effects of negative and positive externalities

Price has both a negative and positive effect on demand. The negative effect leads to reduced demand and consequently an increase in prevalence. Beyond the threshold prevalence, demand becomes price inelastic. An increase in prevalence raises the level of subsidy under a pro-cyclical policy and therefore results in a fall in price. A decrease in prevalence reduces the subsidy under a counter-cyclical policy and leads to an increase in price.[19]

In a competitive market, the market eradicates the disease only if the subsidy covers the minimum average cost of production. In a monopoly, the monopolist would prefer to keep the infection alive. If the monopolist's price is equal to the subsidy, the vaccine is free to consumers who demand it universally. However, there is no universal demand as long as the price of the monopolist is greater then the subsidy. A monopolist facing inelastic demand will never find it profitable to eradicate because the short-term increase in quantity offered by eradication will not be large enough to compensate for the zero future profits offered by eradication. Therefore, subsidized eradication is not profitable under this market structure.

With respect to mandatory vaccination or policy Philipson (1999) conclude that the higher the prevalence elasticity the less effective are mandatory vaccination programs due to raising demand for protection. This is because all mandatory vaccination programs are partial since they do not cover the entire population. Partial mandatory programs crowd out private demand for vaccination for those outside the program, i.e. some individuals will vaccinate in the absence of a program but not in the presence of it[20]. This indirect negative effect on private demand not covered by the public programs, increases in the prevalence response of demand and as a consequence the author's conclusion.

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[19] The increase in prevalence due to a high price is the positive indirect effect between prevalence and price (Philipson, 1999)

[20] Philipson (1999) explains crowding out with the following example. He argues that there is evidence of low levels of vaccination of children who are in pre-schools in the US. People wait till the children enter school since it becomes mandatory (and is covered by health policy) to vaccinate once in school.

Next, he addresses the importance of timing of an intervention. Here he argues that if a subsidy is introduced at a point in time when prevalence is beyond the threshold, then the individuals would have already engaged in protective behaviour, deeming the subsidy ineffective. Therefore, for a government program to be effective it must be undertaken at lower prevalence levels.

Finally, the author questions the policy of health/disease information disseminated by public health authorities. The author concludes that such a policy becomes ineffective because of the choice of the target group to alter behaviour. For example, with HIV/AIDS, this is the low-risk positive and the high-risk negatives.[21] The reason is that once high-risk individuals have access to their health status they by virtue of their nature take more risks then they would have if they did not have the information, for example, they may take on more partners and would be at a higher risk of contracting the disease. Low risk positive individuals by their inherent nature will not spread the disease. Thus providing them with information will be ineffective. Philpson (1999) quotes a study known as the San Francisco Home Health Study, which provides empirical evidence to support his conclusions. . The study found that there was an increase in sexual contact by 16% in high-risk negatives, after they were tested for HIV and were found to be negative. However, I do not agree with the author. In Thailand targeting the high-risk HIV negatives and low-risk HIV positives paid off substantially (Anisworth, Teokul , 2000).

Thus in conclusion, for public heath policy to be effective we cannot take a mere a myopic epidemiological consideration. Public health authorities need to take into

[21] Low-risk positives have a lower probability of spreading the disease, though they have contracted the disease. High-risk negatives have a high probability of contracting and spreading the disease, though they have not contracted the disease. Examples of high-risk individuals are sex workers.

consideration the effect of prevalence elasticity of demand for prevention on individual behavior.

3.3 Debate on resource allocation and third world priorities

The third issue that I will be addressing is the debate with respect to allocation of scarce resources, which have competing options. Even though today prevention is the most recommended strategy to protect populations from HIV/AIDS, it cannot be ignored that a large number of people are infected with HIV/AIDS and 95% of them live in low and middle income countries (Anisworth, Teokul, 2000). It is important to provide treatment to improve their quality of life.

Low and middle-income countries have special characteristics that make them vulnerable to a HIV/AIDS pandemic. First, is the high levels of poverty and illiteracy that make them vulnerable to the disease. Second, is the lack of well-developed health care delivery systems. Uganda has only 5 physicians for every 100,000 population and the average public health expenditure per capita is less then US$ 14 annually (Anisworth, Teokul, 2000). Less then 10% of its population has access to any decent health care system (Bloom et al, 2000). These characteristics fit most low-income countries, like India, Peru, Columbia and many others. Third, the immune system may be compromised because of insufficient nutrition and exposure to opportunistic illnesses like TB, malaria and hepatitis, to name a few (Bloom et al, 2000). Fourth, competing development and health priorities like reducing malnutrition and fighting TB are bigger immediate problems compared to AIDS (Bloom et al, 2000). Fifth, many of these countries have competing social and national priorities. For example, South Africa spends US$ 279 million on drugs annually and US$ 4.19 billion on defense (Bloom et al, 2000).

Bloom et al (2000) argue that it is not just the characteristics of the less developed countries, which are barriers to fight the disease, but characteristics inherent in the global trading order. The patenting regime, which compensates companies for the risk they take and the expenses they incur in research and development, result in prices that are 80% to 90% of the cost of generic drugs produced and in some cases 200 to 300 times, in developing countries.[22] The cost of HAART can be as high as US$ 20,000 per capita, which is beyond the budget of any developing country and are generally recommended to the wealthiest rather then to the most needy. In 1999, access to drugs and treatment was fiercely contested among the key stakeholders. For example, the US almost imposed sanction against South Africa for allowing generic drugs (the cost of which was many times lower then the drugs sold by US drug companies) to fight AIDS under its own sovereign policy on drug patent reimbursement. However, due to political pressure, this was changed and in 2000 the Clinton administration announced that under the TRIPS agreement of WTO, drugs to fight an emergency crises would be provided at reasonable prices (Bloom et al, 2000).[23] However, Bloom et al (2000) argue that the priority should be continued research and development in the treatment of the disease. Therefore the debate on price needs to be extended where national governments of both developed and developing nations are greater participants, so that the burden of research for a cure does not fall wholly on the drug companies.

Anisworth et al (2000) argue that national governments need to have a set of core priorities rather then trying to address the entire gamut of the issue. "This will help them first tackle the immediate problems at hand then the address larger issues" (Anisworth et al (2000),

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[22] http://news.bbc.co.uk/1/hi/health/3900597.stm: Karen Allen, 16the July, 2004. What has the AIDS conference Achieved

[23] Trade Related Intellectual Property Rights (TRIPS)

Page 58). They also point out that there is a need to integrate poverty alleviation programs with HIV/AIDS reduction programs.

Bloom et al (2000) call for a set up of an impartial global forum in line with WTO or other Brettenwood organizations, with an independent bureaucracy and an independent secretariat. All signatory countries need to be obliged to take its recommendations seriously. It would be more of a co-ordination body, which would also play an important role in fostering trust between the different stakeholders, for example, drug companies and governments.

However, I don't agree with Bloom et al (2000) with respect to creation of another institution in line with the Brettonwood organizations. Experience with similar organizations has shown that they act largely in the interest of the largest shareholder, rather than the interest of the member nations (Chossudovsky, 2003). If any such recommendation needs to be implemented it should be under the framework of the existing bodies of United Nations, which was created for a similar purpose.

3.4 Summary and Discussion

At the beginning of this section I had set out to focus and expand on several objectives. First, was to identify the most effective public health policy choice to fight HIV/AIDS. Based on theoretical and empirical research it was argued that a health policy that would focus more on prevention rather then coping would be more effective.

Second, the objective was to evaluate the efficacy of public health policy in the context of infectious diseases and rational behavior. Given the nature of HIV/AIDS and the resource constraints, policy makers need to address some of the challenges that may arise due to what Philipson (1999) calls the prevalence elastic demand for intervention. They need to review the effectiveness and the timing of their health policies such as mandatory vaccination, dissemination of information and health subsidies.

Third, the objective was to address the debate on constraints and challenges in the developing world and HIV/AIDS. Here it was argued that developing countries do face a Herculean challenge. On the one hand, poverty, illiteracy and lack of health infrastructure make them most vulnerable to a pandemic. On the other hand, they have limited resources, which have immediate requirements. Thus, there is a need for public health authorities to understand these challenges and deal with the problem more creatively rather then adopting a traditional approach.

Part 4: Conclusion and Discussion

At the onset of this paper I had attempted to answer two key questions. The first, concerning the efficacy of the claims that HIV/AIDS will significantly reduce economic growth. The second, concerned the ability and effectiveness of public health policy to deal with a pandemic the size of HIV/AIDS.

The calibrated models based on Solow's (1956) neo-classical theory and the CGE models have reached a common conclusion, though to varying degrees. Both approaches have concluded that there will be a significant reduction in GDP within the next 10 to 15 years if warnings are not taken seriously. The non-calibrated models have mixed results. Though they are largely inconclusive, they have found evidence of early eaffects of the disease on growth in countries with very high prevalence rates.

The broad recommendation in this section is that, to counter the affects of HIV/AIDS, which will largely be felt through its effects on labour markets, these markets need to be made more flexible and competitive.

The second part addressed various issues concerning the most effective health policy. Research on this is a limited one from an economic perspective. The two papers analyzed in this section, recommended prevention as the best strategy. The other issue addressed was the effectiveness of a health policy, given the demand for prevention was prevalence elastic. A review of health measures was recommended.

The third issue addressed the resource constraints faced by developing countries in their fight against HIV/AIDS. The recommendation here was that developing countries must recognize the reality that their economies are the most vulnerable to the HIV/AIDS pandemic. Next, they need to prioritize the use of their resources. Finally, the international community needs to recognize that it is not a problem of just the developing countries but a global crisis. It needs to play a more effective role in resolving the conflicts of motives of the various stakeholders so that the victims of HIV/AIDS do not become the victims of redtape and nepotism.

I have found that the research undertaken in this field by economists are miniscule when compared to those undertaken by the epidemiologists, even though the disease threatens to rise to alarming proportions in many parts of the world. Economists have just begun to explore the tip of the iceberg.

There is a lack of a holistic approach in the current research. Given today's global trading environment where different economies are closely intertwined and national borders more or less invisible, changes in one part of the global system, cascade across the global trading order, as a whole. Capital in the developed world today is dependent on labour in the developing world to realize the gains of capacity utilization. Given these linkages, an epidemic of the nature of HIV/AIDS will not only slice the gains of growth, for a country affected by the pandemic but also will have devastating consequences for the world trading order.

The research today appears to be sporadic and perfunctory, covering only a handful of countries with the highest prevalence levels. Though an attempt has been made to replicate the theoretical framework across a few countries, the studies need to broaden their dimension to analyze the linkages across sectors and consequently, the affects of the disease on the world trading systems and thus, on global productivity.

In recent years, the efforts to fight AIDS have been doubled. Though there is no cure, there is hope. For example, the success of antiretroviral therapy has doubled the life span of individuals suffering with HIV/AIDS in the western countries and the prices have been brought down substantially. In December of 2003, the Clinton Foundation negotiated a deal with the Indian drug companies to provide generic antiretroviral drugs at US $140 per person.[24]

The other positive development is that the global community has realized that HIV/AIDS is a threat to global security and this has led to the creation of a global fund to fight AIDS, TB and malaria.[25]

Economists can play a very important role to assist the global community in its fight against HIV/AIDS. First, economists need to analyze the existing development already achieved by developing countries and identify their future development needs. Based on their analysis they should make recommendations on how to best utilize their limited resources.

Second, economists need to analyze the efficacy of the existing efforts made by different stakeholders. They can play an important role in identifying the most beneficial strategy that would reduce the conflicts between different stakeholders. For example, they can

[24] AIDS 2004, Light at the end of the Tunnel, Lancet Infectious Diseases, Vol. 4, July 2004
[25] Ibid

make recommendations on the best patenting regime that would ensure that drug companies get a fair price for the research they invest in and at the same time majority of the victims of HIV/AIDS are not marginalized due to high drug costs.

Third, economists can use their knowledge on resource optimization and its welfare effects to design effective and efficient health policies. For example, research on intervention policies by economists has been very limited. It has either adopted a focused approach on the direct costs of different intervention strategies (Kumarnyake L et al, 2001, Walker D, 2003, Bertozzi, Gutierrez et al 2004) or an indirect approach that focuses only on one or two policy instruments. For example the studies (Cuddington 1994, Robilano et al 2002) mainly focused on which would be a more effective, intervention in terms of prevention strategy versus a coping strategy; and within that only condom use as a policy intervention was analyzed. Given that epidemiologists have already listed the various interventions with their direct cost implications, economists need to further the analysis and look at the long-term effects of all interventions on the growth trajectory. As more and more people get infected, coping with the disease will eventually gain precedence over prevention. This is where heath care delivery systems will need to be strengthened. Economists can play an important role in recommending alternate health care systems, which optimize the resource constraints and have far reaching welfare affects.

The fight against AIDS has only just begun and in the words of Robert Frost, "we have miles to go before we sleep".

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Appendix

A. Tables

Table 1: Estimated Number of People Living with HIV/AIDS, 2003

Country	Prevalence Percentage in adult population (15-49)
Swaziland	38.80%
Botswana	37.30%
Lesotho	28.90%
South Africa	21.50%
Namibia	21.30%
Malawi	14.20%
Tanzania	8.80%
Cameroon	6.90%
Kenya	6.70%
Uganda	4.10%
Thailand	1.50%
India	0.90%
China	0.10%

Source: UNAIDS,2004, Page 196-197

Table 2: Summary Of The Conclusions of the Studies of Macroeconomic effect of HIV/AIDS

Table 3.1 Summary of the over all results of the Macroeconomic Affects of HIV/AIDS

Author	Country (ies)	Period of Most recently used HIV/AIDS data	Methodology used	Conclusion
Cuddintong 1993a	Tanzania	Early 1990s	Single Sector Solow Model for a competitive economy	For Tanzania in a single sector framework, Cuddington concludes that the growth rate of GDP in the 'No-AIDS' scenario is 3.90% in 2010 vs. 2.80% in an extreme AIDS, which is a 25% decline. He estimates that the growth rate will decline between 15% to 25% by 2010 in different AIDS scenario. In the worst-case scenario, per capita GDP will decline by 11% and will actually rise in a best-case scenario. The savings rate falls quite significantly by almost 64% in the worst-case scenario.
Cuddintong 1993b	Tanzania	Early 1990s	Dual Sector Solow Model for an uncompetitive economy	For Tanzania, in a dual sector framework, Cuddington(1993b) concludes that the growth rate of GDP in the 'No-AIDS' scenario is 4.6% in 2010 vs. 3.2% in an extreme AIDS, which is a 30% decline. He estimates that the growth rate will decline in the range of 11 % to 28% by 2010 in different AIDS scenario. In the worst-case scenario, decline in per capita GDP will be in the range of 3.6% to 16.1% The savings rate falls quite significantly by almost 40% in the worst-case scenario. In a dual economy framework there is greater underemployment then unemployment.
Cuddington and Hancock (1994)	Malawi	Early 1990s	Dual Sector Solow Model for an uncompetitive economy	For Malawi, in a dual sector framework, Cuddington and Hancock (1992) conclude that the growth rate of GDP in the 'No-AIDS' scenario is 4.4% in 2010 vs. 1.6% in an extreme AIDS, which is a 64% decline. He estimtes that the growth rate will decline in the range of 18 % to 64% by 2010 in different AIDS scenario. In the worst-case scenario, per capita GDP will fall by 32.3% but in a best-case scenario will rise. The savings rate is negative in the worst-case scenario. In a dual economy framework there is greater underemployment then unemployment.
Dixon et al (2001)	41 countries in Afr	Late 1990s	Augmented Solow Model, using health and education as human capital measures. They use growth and life expectancy eqations to asses the effect of HIV/AIDS on	For South Eastern Africa (SEA) and Rest of Africa (ROA), Dixon et al estimate the impact on GDP. They find that growth is effected by the life expectancy (proxy for health capital) and is negative and close to significant and life expectancy is also effected by HIV which is negative and significant for SEA sample where prevalence in high.
Robalino et al (20	Kenya	Late 1990s	Slow Modle. Set up an inter-temporal optimization to assess the effects of HIV/AIDS on the economy.	For, Kenya, using a single sector framework, Robalino et al conclude that the growth rate of GDP in the 'No-AIDS' scenario is vs. in an extreme AIDS shows a 25% decline by 2010. He estimates that the growth rate will decline in the range of 15% to 25% by 2010 in different AIDS scenarios. In the worst-case scenario, per capita GDP will fall by 13% but in a best case scenario it will fall by only 1% The savings rate is will fall by 45% and best-case scenario by 32%
Edwards and Al-Hroud (2003)	Cross section data	Late 1990s	Slow Modle.	Countries with GDP per capita less than USD 1700, have a negative relationship between AIDS mortality and economic growth.
Bonnel (2001)*	Cross section data for developing countries, 50 countries	Mid-1990	Solow Modle	Rate of growth of GDP per capita in Africa will be reduced by 0.7% per year in te 1990s (1.2% for a country with HIV prevalence of 20%)
BIDPA (2000)*	Botswana	Late 1990s	Solow Modle	Average rate of GDP growth in 2000-2010 reduced by 1.5% per year
Arndt et al (2000)	South Africa	Late 1990s	Computable General Equilibrium Model	They conclude that by 2010 the real GDP is about 17% lower then in the no AIDS case. Per capita income is also 8% lower. Savings as a percentage of GDP falls by 18% in the AIDS scenario. Total GDP affect is 79%
Arndt et al (2001)		Late 1990s	Computable General Equilibrium Model	Similar results to the above, but have concluded that if sectors that are more labor intensive are likely to be more affected. They suggest an employment policy that is more wage flexible for the formal sector.
Bloom and Mahal (1997)	Cross Section Data, 51 countries (1980-1992)	Early 1990s	Non Linear and Non-Linear two stage least square	They found a weak relationship between income and HIV/AIDS.
Word Bank (2001b)*	Swaziland	Early 1990	NA	Average annual Growth rate of GDP during 1991-2015 will be 1.3% lower. Average annual growth rate of GDP per capita during 1991-2015 will be 0.2% higher
Word Bank (2001a)*	Namibia	Early 1990	NA	Average annual Growth rate of GDP during 1991-2015 will be 0.8% lower. Average annual growth rate of GDP per capita during 1991-2015 will be 0.2% higher
Word Bank (2000)*	Lesotho	Early 1991	NA	Average annual Growth rate of GDP during 1991-2015 will be 1.4% lower. Average annual growth rate of GDP per capita during 1991-2015 will be 0.3% lower
Quattek and Fourie (2000)*	South Africa	Mid 1990s	NA	Average rate of GDP growth over the next 15 years will be 0.3 - 0.4% lower per year
Greener, Jefferis and Siffambe (2001)*	Botswana	Late 1990s	NA	During 1996-2010, annual growth rate of GDP was reduced by 1.1-2.1% Very little effect on GDP per captia
Kambou, Devrajan and	Cameroon	Early 1990s	CGE- 11 sector model	GDP growth rate over 1986-1991, reduced by 1.9% per year.
Over (1992)*	30 Subsaharn countries	Early 1990s	NA	Average annual growth rate of GDP during 1990-2025 reduced by 0.9% on average (up to 1.5% in 10 worst affected countries). Average annual growth rate of GDP per capital reduced by 0.15% per year (up to 0.6% in 10 worst affected

Source: * UNDESA, Population Division, Impact on Economic Growth in Impact of AIDS, New York 2004, Page 85

Appendix B. Graphs

Figure 1: Multiple steady-state k for given $\phi = 0$

AIDS EPIDEMIC

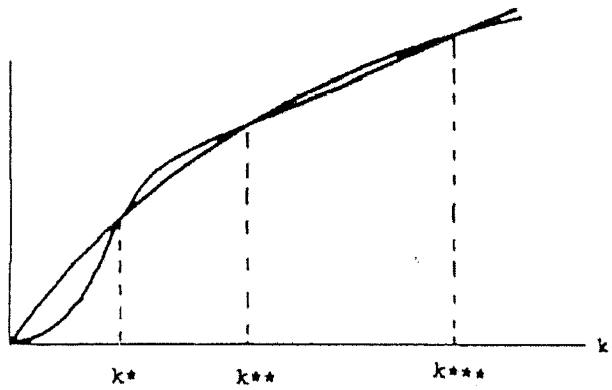

Figure 2. Multiple steady-state k for given $\phi = 0$.

Source: Cuddington et al (1994), Page 481

Figure 2: Effects of preventive medical expenditures: on the High- k and low –k steady states

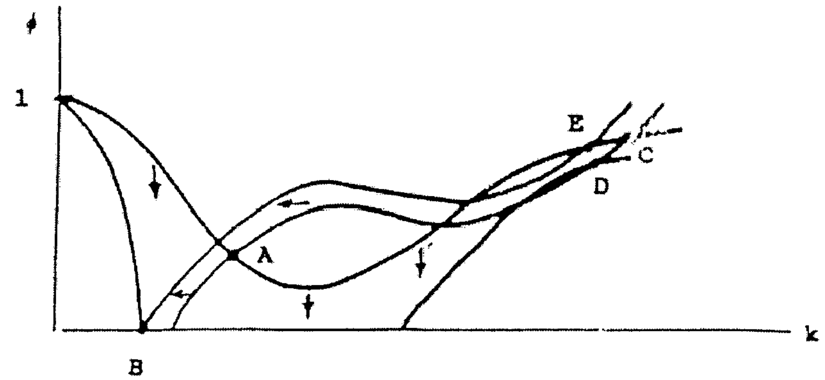

Figure 5. Effect of preventive medical expenditures: On the high-k and low-k steady states.

Source: Cuddington et al (1994) page 484

Appendix C. Summary of Models and results

C1. Cuddington (1993b)

The model: The production function is structured to reflect the adverse impact of active AIDS cases,

$$Y = \alpha\gamma^{t}\left[(1-za)E\right]^{\beta}K^{1-\beta} \tag{10}$$

Where, Y is GDP. E is effective labour demand. K is capital stock. a is the proportion of the work force with active AIDS. z is the fraction of worker productivity lost because of AIDS related illness. γ^{t} is an exogenous time trend capturing technical progress. β is labour's share of total output. α is a constant chosen to ensure that the equality in equation 10 holds for the initial values of Y, E and K (Cuddington 1993b)

Here Cuddington (1993b) distinguishes between effective labour supply and labour demand

$$E^{s} = \sum_{t=15}^{64} \rho_i L_{it} \tag{11}$$

$$E^{d} = \phi K \tag{12}$$

$$\phi \equiv \left[\alpha\gamma^{t}\beta(1-za)^{\beta}/w\right]^{1/(1-\beta)} \tag{13}$$

Where ρ_i is productivity coefficient for worker of age i. L_{it} is the number of workers of age *i*. The physical supply of labour E^{s} is adjusted for the non-AIDS-related, age specific productivity. The impact of AIDS on average productivity is captured separately as show in equation 10.[26] Effective labour demand is a function of the prevailing real wages w (equation 11 and 12), AIDS prevalence a and the capital stock K.

[26] It is an assumption that the author makes based on data availability that is a and z do not vary across age cohorts which enables the specification in equation 10.

The above theoretical model is then extended to distinguish between the two sectors, the formal and the informal. Formal and informal capital formation is given by the following equations:

$$\Delta K_F = s_F Y_F + s^* (Y_F + Y_I) - x_F (H_F + \omega H_I) - \delta_F K_F (t-1) \quad (14)$$

$$\Delta K_I = s_I Y_I - x_I (1-\omega) H_I - \delta_I K_I (t-1) \quad (15)$$

Where, s is the saving rate. Y is sectoral output. H is the AIDS related health care costs. δ is the depreciation rate on capital. Subscripts F and I denote formal and informal sector households. ω is the reduced savings of the formal sector while subsidizing the medical expenses of the informal sector.[27]

Similar to Cuddington (1993a), the manner in which AIDS affects domestic capital accumulation is captured by specifying x, which is the AIDS related medical expenditure financed by national savings. Formal sector savings and foreign funds are allocated to investment in the relatively capital intensive formal sector. The informal sector is unable to generate savings at the same rate as the formal sector and thus its contributions to capital formation are limited.

Results of the simulation

In the "no-AIDS" case Tanzania's real GDP growth rate accelerates from roughly 3.4 % in 1990 to 4.6% by 2010. The share of labour force employed in the formal sector rises continuously from 20% in 1985 to almost 60% by 2010 as a result of capital accumulation. The formal sector sticky wages also settle at their long run equilibrium level.

[27] The author argues that given the high costs associated with AIDS patient care and the worker wages in the informal sector, the formal sector workers subsidize the informal sector patients through the health care system which is reflected in the reduced savings of the formal sector (Cuddington 1993b)

C2.Cuddington and Hancock (1994)

Cuddinton and Hancok's methodology parallel Cuddinton (1993a and 1993b) for Malawi with an "AIDS" and "NO AIDS" scenario.

Results of the simulation

The study concludes that in the "no-AIDS" scenario the real GDP growth rate accelerates from 3.6% per annum from 1985 to 1990 to 5.2 % for the period 2005 to 2010. The real per capita GDP also increases from 0.2% in 1990 to 2% in 2010. The share of labour force employed in the formal sector rises from 16 % in 1985 to almost 35% by 2010 as a result of capital accumulation and the gradual fall in the sticky formal sector wage toward a long run equilibrium level. The long-run equilibrium wage remains very steady over the simulation period. The formal sector employment increases more rapidly compared to the informal sector. The increase is more rapid compared to capital accumulation, which causes the capital-labour ratio in the formal sector to fall significantly.[28]

Now I would like to compare the "no-AIDS" scenario to the "AIDS" scenario using the "medium-impact" AIDS prevalence estimate as an example to demonstrate the effect of AIDS on the economy of Malawi.[29] With $(x, z)= 0.5$, the total output is lower in the "AIDS" case by 4.8% by 2010. However the per capita income is virtually the same in both the sectors (formal and informal) and in both the scenarios ("AIDS and "no-AIDS") since population is also 4% smaller. Changing parameter assumptions for (x,z), show that the negative impact of AIDS on GDP in the year 2010 ranges from 3 % to 9%.[30]

[28] The capital labour ratio falls by 60% 1985 to 2010 for the formal sector

[29] In the medium term the demographic projection Bulatao (1990) reports a rise of AIDS prevalence from 0.01% of the population in 1985 to 1.1% by 2010 Malawi. The population growth rate is three tenth of a per cent lower in the medium AIDS scenario compared with the no-AIDS scenario by the year 2010. (Cuddington et al 1992).

[30] This decrease is much smaller then in the case of Tanzania, this is largely because of the AIDS prevalence assumptions for Malawi (Cuddington et al 1992)

C3.Dixon, McDonald, Roberts (2001a)

The Model: The aggregate production function is Cobb-Douglas with constant returns to scale and labour augmenting technical progress, with an addition of health capital.

$$Y_{it} = [A_{it} L_{it}]^{1-\alpha-\beta-\varphi} K_{it}^{\alpha} E_{it}^{\beta} H_{it}^{\varphi} \quad (16)$$

Where E is education capital. H is Health Capital. Y is output. A is technology. L is stock of labour. α, β, φ are estimates of output with respect to various capital terms, i is country, t is time. The intensive form of the equation can be written as:

$$y_{it} = k_{it}^{\alpha} e_{it}^{\beta} h_{it}^{\varphi} \quad (17)$$

Where y_{it} is output per effective labour, $k_{it}^{\alpha}, e_{it}^{\beta}$ *and* h_{it} are physical, educational and health capital per unit of effective labour. Following methods the standard methods in growth literature (Mankiw et al, 1992), the expression for the steady state output level of income per unit of effective labour y_{it} produces the econometric model given as:

$$g_{it} = -\phi z_{i0}^{*} \sum_{j=1}^{4} \theta_j x^j{}_{it} + n_i + \mu_i + \nu_{it} \quad (18)$$

where,

$$g_{it} = \ln y_{it}^{*} - \ln y_{10}^{*} \quad (19) \qquad \theta_3 = \frac{\phi\beta}{(1-\alpha)} \quad (25)$$

$$\phi = \left(1 - e^{it}\right) \quad (20) \qquad x_{i3}^{3} = \ln e_{it}^{*} \quad (26)$$

$$z_{i0}^{*} = \ln y_{i0}^{*} \quad (21) \qquad \theta_4 = \frac{\phi\varphi}{(1-\alpha)} \quad (27)$$

$$\theta_1 = \theta_2 = \frac{\phi\alpha}{(1-\alpha)} \quad (22) \qquad x_{it}^{4} = \ln h_{it}^{*} \quad (28)$$

$$x_{it}^{1} = \ln(n_i + g + \delta) \quad (23) \qquad \eta = g_{it} \quad (29)$$

$$x_{it}^{2} = \ln s_i^{k} \quad (24) \qquad \mu = \phi \ln A_{i0} \quad (30)$$

Where, η_i constant country specific growth rates, A_{i0} is country specific initial states of technology, g_{it} is cross time variations constant rates of growth of technology, δ is constant rates of depreciation in physical, education and human capital. Savings rate is devoted to physical education and human capital accumulation.

Health capital is the consequence of material standard of living, health care expenditures and the incidence of contagious disease and can be represented by:

$$h_{it} = f(w_{it}, m_{it}, d_{it}) \qquad (31)$$

Where w_{it} is a measure of material standard. m_{it} is health care provision per capital. d_{it} is incidence of disease. The authors use life expectancy as a proxy for health capital, that is, a short fall in life expectancy relative to normal benchmark[31]. Income per capita is used as a proxy for health care expenditure. Estimates of calorie and protein supply per capita, is used for material standards. Prevalence was estimated using epidemiological model of Lwanga and Chin (1991).

Results of Simulation

Dixon et al (2001a) conclude that with respect to growth equation (equation 19) investment and lagged income are both significant and as per theory. Investment and lagged income have the "expected signs and are strongly significant…." that is "negative sign on lagged income indicating conditional convergence and positive sign for the coefficient of investment". (Dixon et al, 2001a page 420). Investment is positively related to growth and lagged income is negatively related to growth. What was surprising that the coefficient for education is not significant for any of the samples![32] The health capital measure, life

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[31] This proxy is criticized for making no allowance for quality of health beyond survival but has been defended by Sen (1998) in the context of developing countries (Dixon et al 2001a)

[32] The authors conducted the regression using education and health, but found that coefficient for education is not significant if health is included as a variable but becomes significant and positive if health capital is dropped

expectancy, is positive and significant only in ROA sample. For SEA sample, it is negative and close-to significant.[33] R^2 is the highest in case of SEA at 62%.

For life expectancy equations, HIV is significant and negative for all three if the interaction term between HIV and income is not included but is significant and negative only for Africa and SEA when it is.[34]

C4. ***Robilano et al (2002)***

Model: The authors set up the inter-temporal optimization problem to capture the effects of HIV/AIDS (for example on consumption, consumer's risk aversion, capital stock and labour productivity and other variables similar to typical Solow model). The labour productivity effects of HIV/AIDS can be captured by through A,

$$A_t^* = \left(\frac{1 - b^{1 - b_2 \mu_t} \left(\beta_t N_t \mu_t / Y_t \right)}{1 + d_0 \left(\beta_t - \beta_{t-1} \right)} \right)^{1/1-\theta} A_t \qquad (32)$$

β is HIV/AIDS prevalence rate at time t, b_1 is the cost of avoiding an additional HIV/AIDS case, b_2 is the cost of reducing an additional HIV case which increases as the targeted reduction in the HIV/AIDS prevalence rate increases.[35] d_0 is the percentage reduction in GDP due to a one percentage point increase in the HIV/AIDS prevalence rate. μ is a policy variable that determines the targeted reduction in the HIV/AIDS prevalence rate. b_1, b_2 *and* d_0 are parameters to be estimated. Y_t is the output at time t. Hence equation 32 captures the

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from the equation. The authors rule out multicoliniarity between health and education but do not explain any further.

[33] The authors explain this anomaly due to the inclusion of Swaziland and South Africa in the SEA sample, though for the period of study, 1980-1990s, they had high prevalence rates, but the effects on life expectancy was not evident as yet. However what is surprising is why the authors did not drop these two countries form their sub-sample alternatively to see if the coefficients turned significant, or even if they did they have not reported the same.

[34] For the other variables of the equation, income is positive and significant for both ROA and SEA but not the entire sample put together. Education is significant and positive only for SEA. Malaria is significant and negative. Finally the coefficient for calorie which is a proxy for over all well being is significant and positive.

[35] b_2 implies that to reduce prevalence beyond a maximum threshold will be cost ineffective

negative affects of HIV/AIDS on labour productivity (denominator) as well as the negative affects resulting from government interventions in order to reduce the prevalence rate (numerator). Therefore the total cost of achieving a reduction in the prevalence rate of μ percent is given by $b_1\beta_1\mu_t N_t$. The authors further make assumptions to capture the affects of HIV/AIDS on the population growth. Their model assumes that, higher is the share of the population infected with HIV/AIDS the faster the speed at which the epidemic propagates.[36]

Results of the simulation

The authors go on to estimate the parameters of the model, which they categorize into macroeconomic, cost function and demographic. The authors simulate two scenarios an "HIV/AIDS" scenario and a "No-HIV/AIDS" scenario. The "AIDS" scenario is further segmented into low, medium and high prevalence of the disease and the affects on GDP, GDP per capita and savings are estimated for the economy.[37] They estimate that by 2010, in a low impact case, AIDS will reduce GDP by 15%, in medium impact case by 20% and in a high impact case by 25%. By 2020, GDP in the three scenarios will be 35%, 40% and 45% lower. With respect to GDP per capita, the reduction is not as dramatic; by 2010 in a low impact case the fall is approximately 1%, 7% and 13% in a medium and high impact scenario.[38] In 2020, the fall will respectively be 3%, 12%, 25% in the three scenarios. With respect to savings, for 2010 the fall is by 32%, 40% and 46% and for 2020, 40%, 50%, 60%. Thus we see that the effect of HIV/AIDS will be quite dramatic on the Kenyan society.

[36] Philipson (1999) has argued that since the demand for prevention is prevalence elastic the above assumption can be questioned. As mentioned earlier this is called the hazard rate and defined diametrically opposite in epidemiology and in economics and has implications on the growth estimates of the disease. This is could one of the criticisms of the model leading to an upward bias on GDP estimates of HIV/AIDS affects.

[37] A) Low impact is defined as one percentage point increase in the prevalence rate reduces GDP by 0.1%, medium impact by 0.5% and high impact by 1%.

B) The authors use National AIDS/STD Control Program forecast for prevalence rate.

[38] The paper projects a fall in population by 15% by 2010 and 33% by 2020.

C5. ***Bloom and Mahal (1997)***

The Model:

$$GDP_i = \beta_0 + \beta_1 AIDS_i^* + X_i \Pi + \varepsilon_i \qquad (33)$$

$$AIDS_i = E(\alpha_k, HIV_{it}, FHIV_i, PHIV_i) \qquad (34)$$

$$HIV_i = \delta_o + Z_{1i}(GDP_i)\delta + Z_2 \delta_2 + \mu_i \qquad (35)$$

Where, GDP is real per capita GDP. $AIDS^*$ is the average annual increase in cumulative prevalence of AIDS. X is a vector of variables that influence growth. Z_i, Z_2 are vectors that may influence HIV transmission patterns. $AIDS$ is cumulative number of AIDS cases in the pd of the study. HIV_t is estimates of the number of HIV cases in a particular year t. $FHIV$ is number of years between when HIV first established itself in a country and the year t. $PHIV$

is number of years between when HIV first established itself in a country and when the peak number of new HIV are projected to occur. E is EPIMODEL map from HIV_t, $FHIV$, $PHIV$ to AIDS. ε_i and μ_i are errors with zero mean, β_0, β_1, Π α , and α_k are parameters to be estimated. i is country. k_1 is industrial country group, k_2 is developing country group.

Equation 33 introduces the average annual increase in the cumulative prevalence of AIDS into a standard reduced form specification that relates the growth rate of real per capita GDP to a number of variables whose relationship to this growth rate is well established in empirical literature on growth (Bloom et al 1997). The AIDS variable is expected to capture the effect on growth of a smaller work force and the diversion of social resources to people with AIDS and the prevention of HIV transmission. The vector of control variables includes the initial level of GDP/capita, the lagged growth rate of real GDP/capita and measures the degree of openness of the economy, the stock of human capital and the share of GDP devoted to public investment (Bloom et al 1997).

In separate specifications they include rate of population and replace it by average crude birth rate and average crude death rate both adjusted for AIDS mortality to avoid the effect of AIDS on economic growth operating through those variables (Bloom et al 1997).

Equation 34 allows for the possibility that the growth rate of GDP per capita influences the transmission of HIV. This could have both negative and positive influences. Increased income may lead to reduced transmission because of improvement in general health and education. Negatively, a reduction in income may lead to increase in commercial sex (Bloom et al 1997).

The authors use Non-Linear Least Squares (NLS) because of a non-linear relationship between GDP and HIV to get the estimates of the parameters of equation 33 and α. Substituting equation 34 into equation 33, they get

$$GDP_i = \beta_0 + \beta_1 E^*\left(\alpha_{k,} HIV_{i,} FHIV_{i,} PHIV_i\right) + X_i \Pi + \varepsilon_i \qquad (36)$$

E^* is E in per capita terms. They then account for simultaneity by using Non-Linear Two Stage (NLTS) and test it by using the speciation by Ruud (1984).

C6. Cuddington et al (1994)

The authors derive an epidemic and growth equations to assess the progress of the epidemic and its effect on capital accumulation.

Epidemic equations[39]:

$$\phi_{t+1} = \phi_t \left[\frac{(1 - \Pi - p) + \mu(1 - \phi_t)(1 - \Pi)}{1 + n - p\phi_t \Pi} \right] \qquad (37)$$

[39] The authors have based the progress of AIDS on the theory of epidemic in which the spread of the disease is based on the theory of random matching when infected and non-infected populations come in contact. However, Philipson's (1999) objection to the above must be kept in mind, that random matching may lead to over estimated prevalence figures.

with two steady states

$$\phi = 0 \qquad \text{"No-AIDS"} \qquad (38)$$

$$\phi = [\mu(1-\Pi) - p - n] \big/ [\mu(1-\Pi) - p] \qquad \text{"AIDS"} \qquad (39)$$

subject to the condition $\left| \dfrac{d\,\phi_{t+1}}{d\,\phi_t} \right| < 1$ (40)

Where, N is the population. ϕ is the percentage of N infected with HIV. μ is the probability that a contact will result in transmission. p is the proportion of population that develops AIDS and dies. n is the birth rate of the population. Π is the probability of death from other causes.

As in the earlier papers (Cuddington 1993 a and b and Cuddington and Hancock 1992 a and b) the authors define a Cobb- Douglas production function and capital accumulation, k, which is capital per unit of effective labour. Within this framework they incorporate the effect of AIDS on labour efficiency by defining z, which is lost labour per AIDS stricken worker and derive the relationship between k and ϕ which is given as:

$$\phi = \frac{\mu(1-\Pi) - p - n(\phi k)}{\mu(1-\Pi) - p} \qquad (41)$$

Growth equation:

The authors then go on to derive relationship between k and ϕ in the steady state using the Solow type of growth equations. This is given by:

$$s\alpha(1 - zp\phi)^{\beta} k^{1\beta} - xmp\phi = (n(\phi k) - p\phi - \Pi k) \qquad (42)$$

Where, s is the is the per capita savings, α is the discount rate as in Cuddington (1993b), m is the medical expenditure on AIDS patients. The left hand side is the per capita savings and the right hand side is the amount of per capita savings required to sustain k for the next generation.