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"Time is costly": Modelling the macro-economic impact of scaling up access to antiretroviral treatment for HIV/AIDS in sub-Saharan Africa

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1. Introduction

Macroeconomic policy requirements, including the need to control inflation and avoid large-scale public deficit, may limit the capacity of financial policy-makers at the country level to allocate sufficient resources for scaling up access to HIV prevention, care and treatment. National authorities may have concerns about policies that may lead to increased long term dependence on external donor financing. In addition, international and bilateral donor agencies may themselves have concerns about targeting an increasing share of Official Development Assistance (ODA) toward AIDS programmes rather than to other policies aimed at promoting economic growth, poverty reduction and public health in developing countries.[1]

Since the early years of the HIV pandemic, macroeconomic modelling has been used to assess its potential impact on economic growth in the most affected countries, notably in Sub-Saharan Africa.[2,3,4] New economic models derived from the theory of endogenous growth[5,6,7,8] emphasize the importance of human capital in economic growth and take into account the way by which the HIV pandemic may affect economic agents in the long term (e.g. investment in education or physical capital, savings, etc.).[9,10,11,12]

Here we present an analysis based on the use of such an endogenous growth model aimed at comparing the potential macroeconomic impact of AIDS in six African countries in the presence and in the absence of scaling up access to HIV treatment. Our results provide a macroeconomic rationale to the current efforts of increasing funding for AIDS programmes with the aim of reaching universal access to treatment by 2010.[1] Our analysis should further contribute to the on-going international debate on the extent to which new funds should be devoted to health systems in general and, more specifically, to the response to the HIV epidemic.

2. Material & methods

The endogenous growth CGE-Model

The model used for this research is a Computable General Equilibrium Model (CGE-Model), including an endogenous growth property. Table 1 presents the various channels through which the AIDS pandemic may affect economic growth as well as the list of variables used in the model to capture these effects.

Insert TABLE 1

The model assumes the following macroeconomic production function:

$$Y(\varepsilon) = (K(y,\varepsilon))^{\alpha}.(L.H(y,\varepsilon))^{\beta}.(D(y,\varepsilon))^{\chi}$$

with ε, population's epidemiological status and $\alpha + \beta + \chi = 1$.

This equation will serve to analyse the effect of the epidemic on the macroeconomic income of a country. Any increase in ε represents a deterioration of the population's health status and affects the accumulation process of each production factors (*Y, K, L, H* and *D,* as defined in Table 1). A specificity of the model (its "endogenous growth" property) is that these cumulative factors, and consequently the total growth rate of the economy, are an increasing function of the *per capita* national income level *Y/N* (*=y),* with a critical value threshold y_c

that has to be reached in order to obtain positive growth (growth rate $G > 0$ for $y > y_c$). The exact threshold level and the calculation of the macroeconomic rate of growth are based on microeconomic foundations which take into account agents' behaviours including at the household level. An precise mathematical appendix (available on request) gives more details about the microeconomic hypotheses used about agents' behaviours and also explains the fundamental reasons why the existence of the threshold level y_c might be at the origin of substantial differences between countries in the assessment of the policy response.

The scenarios

The empirical calibration of the model had two aims: to assess the macroeconomic benefits of the policy aimed at scaling-up access to HIV treatment and to help identifying conditions under which such policy will be efficient in the specific context of a country, including its current level of growth. Similarly to previous assessments of the macroeconomic impact of AIDS,[11,12] the model calculates, for each country to which it is applied, the difference between the simulated GDP in a baseline scenario "without AIDS" (that is, prevalence HIV rate set at zero) and in an alternative macroeconomic pathway "GDP with AIDS". However, contrary to previously used models, in our application, we also recalculate this difference when introducing a new scenario including a policy response to the epidemic based on scaling up access to HIV treatment.

As in other researches,[13] we made the choice to "represent" the policy response through a decrease in prices of the healthcare commodities which are needed to deliver an essential package of care for the HIV-infected population, including drugs for antiretroviral treatment. Results are presented below under the hypothesis that the totality of the set of goods contributing to health expenditures for HIV care and treatment has its price reduced by 50% during the 2003-2006 period and remains stable until 2010. We performed however extensive sensitivity analysis testing alternative levels of reductions of the price index of these healthcare goods from only 10 % to 90%.

More specifically, the policy response is represented in the model through the following pathway: a reduction of the healthcare price index has the direct effect of increasing demand for healthcare and facilitating access by reducing households' financial constraints; consequently, the heath-status and the well-being of each HIV-infected individual improve (this effect is expected by households; it is the motivation for their healthcare demand). Two additional effects are also calculated by the model: healthcare consumption has a positive effect on the ratio *active population/total population (L/N)* and consequently implies a direct quantitative increase in the productivity of the population; in addition, increase in healthcare consumption for HIV care and treatment will also improve the future workers' efficiency via an improvement of human capital *H* (this qualitative effect increases the intrinsic productivity of the population).[14] In other words, the model takes into account the fact that more healthy people can

i) participate to the production with a greater likelihood

ii) work better, now and in the future, as their (good) health status facilitates effort and concentration as well as acquisition and transmission of knowledge and savoir-faire to others, including their own children.

The importance of these two effects has already been emphasized in the theoretical literature[15,16] but, to our knowledge, in the case of measuring the potential macroeconomic impact of the Aids epidemic, both effects have not previously been taken into account in a

simultaneous way by a computable macroeconomic model, using an endogenous growth framework. Of course, it must be noted that our scenarios use a simplified assumption according to which "good health" directly translates into improved human capital. Such assumption de facto favours some specific channels through which AIDS affects labour productivity: it insists on the direct effect, through workforce assiduity, capacity or savoir-faire,[2,9] rather than on the indirect effect through intergenerational transfers of education.[11] The transformation of medicines in "good health", and then in human capital, is also conditioned by the effective success in the scaling up of HIV treatments (medical feasibility, efficiency in the supply-chain delivering medicines to the whole territory). The results of the macro model are dependant on these hypothesized scenarios.

The empirical data used

The model was applied to a panel of six African countries: Angola, Benin, Cameroon, Central African Republic and Ivory Coast. The model was calibrated using UNAIDS epidemic projections (by SPECTRUM EPP – Epidemic Projection Package – software) as well as available national data for GDP, population, capital stock, gross domestic investment, fiscal policy, etc., up to 2003 –extracted from World Development Indicators (WDI, from the World Bank). The value "epsilon", rate of prevalence, is forecasted dynamically by the SPECTRUM model, for each year and each country (2000-2010). These prevalence rates and the demographic projections used in the study are imported from U.N. databases and are not endogenous to the macroeconomic model (a weakness that we address in the discussion section). An important unobservable variable is the « human capital », *H*, at the beginning of the period (1985); it has been determined as the best econometric fit of the observed macroeconomic level of GDP growth during the 1985-1995 period,[17] whereas the consecutive variations of *H* have been endogenously determined by the model**.** In addition, parameters such as elasticity of healthcare demand to price and to income, have been obtained from previous surveys about health care demand and expenditures in African countries.[18,19]

3. Results

Figure 1 and Table 2 first show for each country the impact of the epidemic on GDP in the absence of scaling up access to ART (GDP *versus* GDP no AIDS). In spite of the variability of their HIV prevalence rates, the detrimental impact of AIDS on GDP, i.e. the difference in GDP when comparing the scenarios with and without AIDS, is in the same order of magnitude in four countries : Angola, Centre African Republic, Cameroon and Ivory Coast: in these countries, the GDP in 2010 will be respectively 12.8%, 13.9%, 17.0%, and 13.3% lower than it would have been in the absence of the HIV/AIDS epidemic –corresponding approximately to a 1% loss in GDP growth per year through the 2000-2010 period. The two countries with respectively the lowest and highest HIV prevalence rates present a contrasting picture: the impact is a lot more limited in the case of Benin (-4.2% in 2010), whereas on the contrary, Zimbabwe is the most dramatically affected (-25.5%).

Insert TABLE 2 AND FIGURE 1

Table 2 and Figure 1 also depict the potential macroeconomic impact of scaling up access to HIV care and treatment. Table 2 and Figure 1 demonstrate that scaling-up access to treatment in the affected population of workers would significantly limit GDP losses due to AIDS from a 24.8% reduction in GDP loss in Central African Republic to a 85.2% reduction of the GDP

loss in Angola, with Cameroon and Ivory Coast respectively presenting 32.9 and 32.1% reductions. Quite interestingly in the case of Benin, the least affected country in our sample, a massive response would allow to re-establish a rate of growth similar to the one which would have been expected in the absence of AIDS. To the contrary, Zimbabwe does not seem to strongly react to scaling up with only a limited 10.3% reduction in GDP loss. Finally, Table 2 shows that for four out of the six countries (Angola, Benin, Cameroon, Ivory Coast), the macroeconomic gains of scaling up would become potentially superior to its associated costs in 2010. At this date, these countries could *de facto* self-finance their program.

When testing alternative levels in the scaling up response, through various hypotheses in the price index for healthcare goods, it appears that in order for Cameroon, Central African Republic, and Ivory Coast to achieve at least a two third reduction in GDP losses (as was already the case for Benin and Angola under the hypothesis of a 50% decrease in the price index) further reductions in price –up to 70%– would be needed. This would remain an unattainable goal for Zimbabwe, even in the hypothesis of a 90% decrease.

4. Discussion

The present study is the first attempt to apply macroeconomic modelling, using an endogenous growth framework that incorporates the long term effects on human capital, to forecast the impact of HIV/AIDS on economic growth in some of the most affected sub-Saharan African countries, as well as the potential mitigating effect of scaling up access to antiretroviral treatment. Early macro-economic estimations forecasted a one-point reduction in the rate of growth of national wealth for countries with HIV prevalence above 5%. [12,13,20,21,22] Our results also point out a 1% loss in GDP growth per year due to AIDS in four of the Sub-Saharan countries studied but better capture the potential detrimental impact of such yearly losses on the long-term growth of these economies. As it seems to be already the case for Zimbabwe, and as it would threaten to be the case in Angola, Cameroon, Central African Republic and Ivory Coast in the absence of an appropriate response, there is a significant risk that the long term impact of AIDS may drive the economy to an "epidemiological trap" that could reverse the development process. Similar long term pessimistic predictions in the absence of response had previously been obtained in the case of South Africa. [10,11,23]

Of course, this study shares some limitations with most available models for evaluating the macroeconomic impacts of shocks. In any case our model should be considered as an evaluation of the impact of current programs, it is rather an attempt to simulate the potential economic gains that may be expected from scaling up to the extent that resources are used in an "ideally" efficient way. Indeed, the model predicts an optimal evolution under the hypothesis that both health programs and production factors in the economy (physical capital, labour and public spending) are used without local shortages and in a fully-efficient way. The no-AIDS baseline scenario therefore neglects the fact that some other impediments for growth could affect African countries (governance problem, civil war, under-employment, structural unbalances due to a post-colonial heritage).[24,25] We also do not take into account other negative or positive shocks (e.g. fluctuation in prices of raw materials) which may explain random deviations of the economy from its long-term growth path, as well as some aspects related to the informal economy (black market) and possible flows of labour between formal and informal sectors. In addition, an emphasis on GDP, which is the focus of macroeconomic modelling, underestimates the whole consequences of the HIV epidemic on the unpaid non-market activities that are of prime importance for human development in the developing world.[26,27,28,29] The introduction of human capital, through the use of an endogenous growth

model, allows, however, taking into account some of these effects, e.g. the transmission of knowledge and savoir-faire.

Another set of limitations relates to the possible shortcomings of the empirical data used. Whereas the main parameters used to calibrate the model are available in existing macroeconomic databases from the World Bank, some specific values used in the microeconomic component of the model were available for one country alone and extrapolated to the others. Two specific limitations of our research should further be recognized. First, our simulations of the impact of scaling up treatment do not take into account how the increased availability of treatment may modify the dynamics of HIV transmission in the long run. It can be argued that combining treatment with effective prevention efforts could reduce the resource needs for treatment dramatically in the long term.[30,31] Mathematical epidemiologic models indicate however that the decreased infectiveness of treated patients is likely to be counterbalanced by the increase in life expectancy of the patients that will predictably translate into an increased probability of sexual encounters between sero-different partners.[32,33] A recent epidemiological modelling even concluded that antiretroviral treatment cannot be seen as a direct transmission prevention measure, regardless of the degree of coverage.[34] Thus, the overall impact of scaling up access to treatment on HIV incidence will further depend on the extent to which availability of treatment will affect individual and group HIV-related risk behaviours,[35,36,37] as well as behaviours toward seeking HIV screening and care in the subpopulation who is already infected.[38,39]

Second, as in previous macroeconomic exercises,[13] we introduced the policy option of scaling up treatment in our model based on the hypothesis of a decrease in price of the health care commodities that are part of an efficient HIV package of care. The extent to which such an assumption may be realistic remains a matter of debate. A 50% or more reduction in prices for the HIV package of care may be obtained through the implementation of differential pricing[40,41] and subsidies from international ODA (which would limit the direct contribution of both public funds from national budgets and out-of-pocket payments from affected households). Prices remain high for second line antiretroviral drugs and other components of care such as tests, diagnostic kits and laboratory monitoring tools. There are thus still windows of opportunity for further decreases in prices of goods and services related to the HIV package of care. However, if the goal of universal access to treatment is to be achieved in 2010, the global production capacity of antiretroviral drugs and other commodities for efficient HIV care delivery will need to be multiplied by a factor of ten over the next five years, which raises a number of challenges for brand-name and generic pharmaceutical manufacturers and for health care systems that may limit decreases in prices.

Our approach explicitly focuses attention on the importance of timing in the policy response. Delays may have irreversible effects. If the AIDS-shock has already driven the economy close to a no-development trap, the policy response, including access to treatment, may be efficient in restoring the dynamics of growth, *if and only if* its implementation is carried out at a rapid and massive scale. Then, our results not only confirm that the long term effects of the HIV epidemiologic shock have been underestimated, notably its deferred impact on the productivity of the future generations through the deterioration of the human capital. The study also points out that a country's proximity to a threshold level –which, if it is not attained, could reverse the whole development process– is a key parameter for the potential impact of the epidemic on growth. In spite of the methodological limitations discussed above, our approach strongly suggests that a massive investment in scaling-up access to HIV

treatment may efficiently counter-act the detrimental long term impact of the HIV pandemic for growth in Sub-Saharan Africa, and that potential macroeconomic benefits of scaling up may even compensate for its associated costs in some of the most affected countries at the 2010 horizon. For such a success to be achieved, knowing that all countries have an adjustment period lasting a minimum of 5 years, a massive external aid should enter the country in the very beginning of the period, not only in order to help buying treatments but also in order to reinforce the capacity of the national health systems and to avoid possible local shortages in delivery of HIV services.

In its report to the G8 Gleneagles Summit of July 2005, the Commission for Africa, a group of seventeen prominent experts in the field, advocated an immediate doubling of current ODA targeted to Sub-Saharan Africa for the 2006-10 period.[42] In the more realistic estimates, an implementation of the Commission's recommendation would imply 10 billion US $ of extra-annual aid for health and HIV/AIDS. This alone would cover about half of the total direct costs of the scaling up policy that was assessed in our macroeconomic simulation, if we extrapolate our scenario in the six studied countries to the whole Sub-Saharan African region. Strong uncertainties however remain on the amounts of international aid that will be targeted to scaling up access to HIV treatment in the coming years, including the future prospects of funding of the Global Fund against AIDS, Tuberculosis & Malaria. Our estimation of the positive macroeconomic potential impact of scaling up access to HIV treatment provides a strong indication that massive efforts to scale up these programs is a rational investment for both national governments and the international donor community.

References

[1] UNAIDS. *Resource needs for an expanded response to AIDS in low- and middle-income countries.* Geneva, August 2005.
[2] Ainsworth M, Over M. AIDS and African development. *World Bank – Research Observer* 1994; **9(2)**.
[3] Cuddington JT, Hancock J. The Macroeconomic Impact of AIDS in Malawi: a dualistic, Labour Surplus Economy. *Journal of African Economies* 1995; **4(1)**: 12-33.
[4] Kambou G, Devarajan S, Over M. The Economic Impact of AIDS in an African Country: Simulations with a Computable General Equilibrium Model of Cameroon. *Journal of African Economies* 1992; **1(1)**.
[5] Lucas R. On the mechanics of economic development. *Journal of monetary economics* 1988; **22**: 3-42.
[6] Azariadis C, Drazen A. Threshold Externalities in Economic Development. in *Quarterly Journal of Economics* 1990; **105(2)**: 501-26.
[7] Evans GW, Honkapohja S, Romer P. Growth Cycles. *American Economic Review* 1998; **88(3)**: 495-515.
[8] Cooper R. Coordination Games: Complementarities and Macroeconomics. *New York:Cambridge University Press* 1999.
[9] Haacker M. Modeling the Macroeconomic Impact of HIV/AIDS. *IMF Working Paper* 2002, 02/195.
[10] Haacker M. The Macroeconomics of HIV/AIDS, *IMF* 2004.
[11] Bell C, Devarajan S, Gersbach H. Thinking about the Long-Run Economic Costs of AIDS. in Haacker, M. (ed.) *The Macroeconomics of HIV/AIDS* (2004), IMF.
[12] McDonald S, Roberts J. AIDS and economic growth: A human capital approach. *Journal of Development Economics* 2005; *In Press,* Corrected Proof, Available online 10 August 2005.
[13] Corrigan P, Glomm G, Mendez F. AIDS crisis and growth. *Journal of Development Econo*mics 2005; **77(1)**: 107-24.
[14] Grossman M. On the Concept of Health Capital and the Demand for Health. *Journal of Political Economy* 1972; **80**: 1275-1294.
[15] Strauss J, Duncan T. Health Nutrition and Economic Development. *Journal of Economic Literature* 1998; **36**.
[16] WHO (Sachs JD, Ed.). *Macroeconomics and health: investing in health for economic development.* Report of the Commission on Macroeconomics and Health (CMH) of the World Health Organization Geneva, 2001.
[17] Hansen Lars P, Heckman JJ. The Empirical Foundations of Calibration. *Journal of Economic Perspectives* 1996; **10(1)**: 87-104.
[18] Cisse B. Etude de l'accès aux soins et l'utilisation des services de santé: une analyse comparative entre quatre capitales ouest-africaines. Unicef 2003.
[19] Cissé B, Luchini S, Moatti JP. Progressivity and horizontal equity in health care finance and delivery: What about Africa? *Health Policy* 2006; *Available online 3 April*.
[20] Arndt C, Lewis J. The Macro Implications of HIV/AIDS in South Africa: A Preliminary Assessment. *South African Journal of Economics* 2000; **68(5)**: 856-87.
[21] Bonnel R. HIV/AIDS: Does it Increase or Decrease Growth in Africa?. *South African Journal of Economics* 2000; **68(5)**: 820-55.
[22] Couderc N, Ventelou B. AIDS, economic growth and epidemic trap in Africa. *Oxford Development Studies* 2005; **33(3)**: 1-10.
[23] Chakraborty S, Papageorgiou C, Perez-Sebastian F. Diseases and Development, mimeo, *University of Oregon* 2005.
[24] Acemoglu D., Johnson S., Robinson J.A. The Colonial Origins of Comparative Development: an Empirical Investigation, *The American Economic Review* 2001; **91(5)**: 1369-1401.
[25] Bloom, D., Mahal, A., "Does the AIDS epidemic threaten economic growth?", *Journal of Econometrics* 1997; **77(1)**: 105-24.
[26] Wehrwein P. The economic impact of AIDS in Africa, *Harvard AIDS Review* 2000; Winter Issue: 12-14.
[27] Sen A. *Development as freedom.* Albert Knopf Inc, New-York, 1999.
[28] Becker G, Philipson T, Soares R. The Quantity and Quality of Life and the Evolution of World Inequality. *American Economic Review* 2005; **95(1)**: 277-91.
[29] Barnett T, Whiteside A. AIDS in the twenty-first century: disease and globalization. Palgrave Macmillan, New-York, 2002.
[30] Moatti J P, N'Doye I, Hammer S M, Hale P, Kazatchkine, M Antiretroviral treatment for HIV infection in developing countries: an attainable new paradigm. *Nature Medicine* 2003; **9(12)**: 1449-52.
[31] Salomon, Joshua A, Hogan Daniel R, Stover John, Stanecki Karen A, Walker Neff, Ghys Peter D, Schwartländer Bernhard. Integrating HIV prevention and treatment: from slogans to impact. *PLoS Medicine* 2005; **2(1)**: 16.

[32] Law MG, Prestage G, Grulich A, Van de Ven P, Kippax S. Modelling the effect of combination antiretroviral treatments on HIV incidence. *AIDS* 2001; **15**:1287-1294.
[33] Katz MH, Schwarcz SK, Kellogg TA et al. Impact of highly active antiretroviral treatment on HIV seroincidence among men who have sex with men: San Francisco. *Am J Publ Hlth* 2002; **92**: 388-39.
[34] Baggaley Rebecca F, Garnett Geoff P, Ferguson Neil M. Modelling the impact of antiretroviral use in resource-poor settings. *PLoS Medicine* 2006; **3(4)**: 124.
[35] Mills S, Saidel T, Magnani R, Brown T. Surveillance and modelling of HIV, STI, and risk behaviours in concentrated HIV epidemics. *Sexually Transmitted Infections* 2004; **80(2)**: ii57-ii62.
[36] Crepaz N, Hart T, Marks G. Highly active antiretroviral therapy and sexual risk behavior: a meta-analytic review. *JAMA: The Journal Of The American Medical Association* 2004; **292(2)**: 224-36.
[37] Diaz T, De Cock K, Brown T, Ghys Peter D, Boerma J T. New strategies for HIV surveillance in resource-constrained settings: an overview**.** *AIDS* 2005; **19(2)**: S1-S8.
[38] De Cock K M, Bunnell R, Mermin J. Unfinished business--expanding HIV testing in developing countries. *The New England Journal Of Medicine* 2006; **354(5)**: 440-2.
[39] Kevin M, De Cock K, Marum E, Mbori-Ngacha D. A serostatus-based approach to HIV/AIDS prevention and care in Africa. *The Lancet* 2003; **362(9398)**: 1847-9.
[40] Danzon PM, Towse A. Differential pricing for pharmaceuticals: reconciling access, R&D and patents. *International Journal of Health Care Finance and Economics* 2003; **3(3**): 183-205.
[41] Henry D, Lexchin J. The pharmaceutical industry as a medicines provider. *The Lancet* 2002; **360(9345)**: 1590-5.
[42] Stern and al. for the G8 Commission, 2005, Report, www.commissionforafrica.org.