DOCUMENT DE TRAVAIL DT/2002/15

AIDS and Income Distribution in Africa
A Micro-simulation Study for Côte d'Ivoire

Denis COGNEAU
Michael GRIMM

AIDS AND INCOME DISTRIBUTION IN AFRICA
A MICRO-SIMULATION STUDY FOR CÔTE D'IVOIRE*

Denis Cogneau[a] and Michael Grimm[a, b]
(cogneau@dial.prd.fr / grimm@dial.prd.fr)

[a] DIAL – UR CIPRE de l'IRD
[b] Institut d'Etudes Politiques de Paris

Document de travail DIAL / Unité de Recherche CIPRE
Décembre 2002

RESUME

Nous essayons de relier la distribution de l'épidémie du SIDA sur une population africaine avec la distribution des revenus. A cette fin, nous développons un modèle de micro-simulation démo-économique capable de simuler sur une période de quinze ans l'impact du SIDA sur les revenus des ménages et des individus. Le modèle est mise en place en utilisant des enquêtes ivoiriennes variées. Les résultats des simulations sur une période de 15 ans révèlent la complexité des interactions entre les comportements démographiques et la formation des revenus. L'épidémie paraît toucher un peu plus souvent les moins pauvres des pauvres et confronte les survivants d'un ménage affecté à des baisses de revenu limitées. En l'absence des autres effets macro-économiques l'épidémie du SIDA entraînerait une réduction de la taille de l'économie de la Côte d'Ivoire de 6% en 15 ans, mais affecterait peu le revenu moyen par tête, les inégalités de revenu et la pauvreté. Au niveau micro-économique, la prise en compte des baisses d'activité et de productivité dues à la maladie conduirait évidemment à un diagnostic plus pessimiste en matière de pauvreté. Au niveau macro-économique, si la demande de travail était gravement affectée par l'épidémie, le diagnostic serait là encore aggravé. En tout état de cause, le coût des traitements anti-rétroviraux actuellement disponibles est hors de portée de presque toutes les personnes infectées en Côte d'Ivoire.

ABSTRACT

We try to link the distribution of the AIDS epidemic over an African population with the distribution of income. For this purpose, we develop a demo-economic micro-simulation model able to simulate over a fifteen years period the impact of AIDS on household and individual incomes. The model is implemented using a rich set of Ivorian surveys. The results reveal the complexity of the interaction between demographic behavior and the income generating process. The AIDS epidemic seems to hurt more the lower middle class of the Ivorian population, that is the richest of the poor, and confronts survivors of an affected household to downward, although moderate, transitions through the distribution of income. In the absence of other macro-economic impacts, the main effect of AIDS in Côte d'Ivoire is a shrinking of the size of the economy by around 6% after 15 years, leaving average income per capita, income inequality, and income poverty roughly unchanged. If now the impact on private health expenditures was taken into account, then no doubt that AIDS would clearly increase consumption poverty and decrease welfare. Moreover, if the prospects and patterns of labor demand were significantly affected by AIDS, then again both the overall and micro-economic impacts of the epidemic would appear more dramatic. In any case, the annual cost of anti-retroviral treatment remains out of reach for almost all infected persons in Côte d'Ivoire.

* We thank Hania Zlotnik and Joseph Chamie (United Nations, Population Division, Department of Economic and Social Affairs) for providing us with the United Nations' demographic projections for Côte d'Ivoire. This article benefited also from discussions with Nancy Snauwaert and Damien Rwegera from the UNAIDS Inter-country Team for West and Central Africa (Abidjan), with Annabel Desgrées du Loû (IRD Abidjan), and with participants at research seminars at ENSEA, Abidjan, and DELTA, Paris as well as with participants, and especially our discussant Stephen Jenkins, at the 27th General Conference of the International Association for Research in Income and Wealth in Stockholm.

Content

List of tables

List of figures

1 Introduction

Since the eighties HIV/AIDS[1] has spread very rapidly in Sub-saharan Africa. Today there are countries as Botswana, South-Africa and Zimbabwe where more than 20% of the adult population is infected. It is well known that the AIDS epidemic has a significant demographic impact by increasing sharply mortality for young adults and thus modifying significantly the population age structure (e.g. United Nations/World Health Organization (UNAIDS/ WHO) (1991); Brouard (1994); United Nations (1999)). But AIDS has probably also a very strong economic impact. Macroeconomic consequences, such as labor force shortages, destruction of human capital, and resulting reduced growth have already been studied for several countries, either by single/cross-country regressions (e.g. Bloom and Mahal (1995); McPherson, Hoover and Snodgrass (2000); Dixon, McDonald and Roberts (2001)), macro-projections (see e.g. Becker (1990); Cuddington (1993a, 1993b); Cuddington and Hancock (1994); Cuddington, Hancock and Rogers (1994)) or Computable General Equilibrium Models (e.g. Kambou, Devarajan and Over (1994); Arndt and Lewis (2000, 2001); MacFarlan and Sgherri (2001)). Micro-economic studies are, with a few exceptions, restricted to a listing of potential effects on households' welfare or enterprises efficiency (e.g. Philipson and Posner (1995); UNAIDS/WHO (1999); International Labour Office (2000)) or are often based on unrepresentative case studies (e.g. Barnett and Blackie (1989); Tibaijuka (1997); Béchu (1998); Janjaroen (1998); Menon, Wawer, Konde-Lule *et al.* (1998); Kamuzora and Gwalema (1998); Aventin and Huard (2000); Gregson, Waddell and Chandiwana (2001); Booysen and Bachmann (2002)). Macro-micro linkages are hardly explored, while they are probably the main issue at stake. Indeed, increased adult mortality probably has huge macro and micro-consequences, i.e. labor force shortages will not only constrain growth but will also lead to large changes in relative wages and in households' composition. The two latter effects are likely to produce reallocations of labor supply, school dropouts within households and the arousal of new categories of poor through unexpected transitions from the top to the bottom of the distribution of income.

[1] In what follows we will sometimes refer to "HIV/AIDS" only by "AIDS".

The study of these phenomena calls for applied dynamic micro-simulation techniques.

An originality of our study is that we account explicitly for heterogeneity and clustering in the individual probability of getting AIDS. In contrast with Wachter, Knodel and VanLandingham (2003), who couple empirically based region-specific risk multipliers with random household-specific risk multipliers, we exploit a Demographic and Health Survey to construct risk multipliers which are explained by individual socio-economic characteristics. This vector of characteristics will then allow, for the first time, to our knowledge, to link directly the distribution of AIDS to the distribution of income. The epidemiological model underlying the risk multipliers is inspired by that of Anderson and May (1992).

Another strand of literature relevant to our analyses is the literature on household income micro-simulation models used to analyze the impact of macro-economic shocks on income distribution and poverty in developing countries. These models can be separated in those where the underlying household income generating model is estimated in a reduced form (e.g. Bourguignon, Fournier and Gurgand (2001); Grimm (2001)), and those where labor supply, production and consumption choices are jointly modelled in a structural way (Cogneau and Robilliard 2000; Cogneau 2001). A major drawback of all these models is however their static structure in the sense that they do not take explicitly into account the temporal dimension of the macro-economic shocks under analysis. This issue is particularly important when analyzing the impact of demographic shocks, as for instance the AIDS epidemic, that affects the distribution of income rather slowly, compared to a currency devaluation for instance, via changes in the population age structure. Therefore, we embed our (structural) household income micro-simulation model in a dynamic micro-simulation model build in the spirit of the models used in industrialized countries to analyze pension reforms, the distribution of life-cycle incomes, or the accumulation of wealth.[2] Our model simulates the most important demographic events as fertility, mortality, marriage, household formation, and

[2]See e.g. Harding (2000) on dynamic micro-simulation models and policy analysis.

migration. It is based on data from several household income surveys, a Demographic and Health Survey, a migration survey, and a population census, all undertaken during the nineties in Côte d'Ivoire, as well as on demographic projections by the United Nations. It is, to our knowledge the first exercise of this kind for a developing country.

We present an application for Côte d'Ivoire, West-African country the most affected by the AIDS epidemic and one of the 15 most affected countries in the world. The first two AIDS cases in Côte d'Ivoire were declared at the end of 1985 (Garenne *et al.* 1995). Afterwards the epidemic spread very rapidly and end-2001 UNAIDS estimated the adult prevalence rate at 9.7% (10.8% end-1999)[3], the number of adults and children who died of AIDS in that year at 75,000, and the number of current living AIDS-orphans at 420,000 (UNAIDS/WHO 2002). HIV prevalence among sex workers tested in Abidjan is more than three times higher (UNAIDS/WHO 2000). The *Institut National de la Statistique* of Côte d'Ivoire calculated on the basis of the population census of 1998 a life expectancy at birth for men and women of 49.2 and 52.7 years respectively. Today, UNAIDS estimates that these indicators have fallen to 47.7 and 48.1 years. Whereas without AIDS the life expectancy for men and women would have been expected to increase to 61 and 65 years in 2015, they are now expected to be 15% and 18% below (United Nations 2001).

The paper is organized as follows. In Section 2, we describe our micro-simulation model. In Section 3, we present the results of the three counterfactuals that are simulated, i.e. "without AIDS", "with AIDS, but without individual risk heterogeneity", and "with AIDS and with individual risk heterogeneity". First, we discuss them in terms of growth, inequality and poverty changes since the early 1990s up to 2007, then we analyze the impact of AIDS on individual welfare trajectories. Section 4 concludes.

[3]This estimation includes all adults (15 to 49 years), with HIV infection, whether or not they have developed symptoms of AIDS, alive at the end of 1999.

2 Model structure

2.1 Key characteristics of the model

We use a dynamic micro-simulation model designed to simulate at the individual level the most important demographic and economic events through time. The micro-simulation approach allows us to take into account individual heterogeneity, in particular regarding the risk of AIDS infection and the income earning capacity. Furthermore, it permits to analyze the policy outcomes in terms of inequality and poverty, and not only in terms of growth, as does an aggregated model. The dynamic approach is important because the AIDS epidemic, although it strongly modifies the age mortality rates, only has a significant impact on the age structure in the long term. In the meantime the mortality change interacts with other demographic and economic behaviors such as fertility, marriage and labor supply. The basic unit is the individual, but each individual belongs in each period to a specific household. The model is a discrete time model, in which each period corresponds to one year. We assume a fixed order for the different events, which is: marriage, household formation, school enrolment, fertility, mortality, international immigration, reallocation of land, occupational choices, generation of individual earnings and household income. The population of departure is constructed using the *Enquête Prioritaire sur les Dimensions Sociales de l'Ajustement Structurel* (hence: "EP 1993") which was carried out by the *Institut National de la Statistique* of Côte d'Ivoire (INS) and the World Bank in 1992 and 1993. The survey contains information about the socio-demographic characteristics of household members, their housing, health (but not AIDS infection), education, employment, agricultural- and non-agricultural enterprises, earnings, expenditures, and assets. From March to June 1992, 1,680 households in Abidjan (economic capital of Côte d'Ivoire), and from June to November 1993 7,920 households (among them 3,360 in other Ivorian cities) from the rest of the country were interviewed. The total sample covers 58,014 individuals. The sample was calibrated on January 1st 1993. In what follows, we present briefly the modelling of mortality, and in particular mortality due to AIDS infection, and that of earnings which constitute the fundamental part of the model. The modelling of the other behaviors and events is presented in appendix.

2.2 Mortality and the risk of AIDS infection

We shall design two kinds of AIDS simulations. The first one, that we call WAIDSU for with AIDS and Uniform, simply relies on United Nations' mortality projections, where the risk of dying of AIDS in each year only varies with sex and age. The second one, that we call WAIDSH for With AIDS and Heterogenous, accounts for heterogeneity and clustering in the individual probability of getting AIDS, within each sex and age group. The individual risk factors are derived from variables on attitudes regarding AIDS collected for men (15 to 59 years old) and women (15 to 49 years old) in the Ivorian Demographic and Health Survey (DHS) of 1994 (INS 1995a). These risk factors are then calibrated on United Nations' mortality projections. This section briefly describes the construction of our so-called WAIDSH scenario. A more detailed description of this method can be found in Cogneau and Grimm (2002).

We suppose that at the individual level, the probability of infection depends on the number of partners, the frequency of unprotected sexual intercourse with each partner, and the average level of infection of chosen partners. Drawing from the "susceptible-infected" (SI) model of Anderson and May (1992), adopted by Kremer (1996), and omitting the i index, we write:

$$P = \rho\beta Y \tag{1}$$

where P is the probability of becoming infected over a given period, ρ is the number of partners during this period, β the transmission rate, and Y the average prevalence rate of partners. The DHS gives us at least for men a good proxy for ρ that is the declared number of sexual partners in the last two months. For women this variable is not available, therefore we simply use the dichotomous information on whether the woman had a sexual intercourse in the preceding two months. To measure β, we use the information regarding the frequency of condom use, assuming implicitly a constant frequency of sexual intercourse with each partner. Y is approximated by the variable "knowing somebody with AIDS", supposing that this gives a clue about the level of infection of the social network surrounding the individual.

Each of these three variables is regressed, separately for men and women, on a vector of observed variables containing age, education, localization, matrimonial status, household size, and the individual relation to the household head. In the equations of β and Y, we also introduce the declared number of sexual partners in the last two months (having had sexual intercourse in the preceding two months for women) in order to control for the impact of sexual activity on these variables. Then, when using the estimated equations to predict individual risks, we ignore the corresponding parameters to obtain a "per partner" measure. Furthermore, we assume normality and independence of the residuals of these three equations.[4] For the men's ρ, we choose an ordered probit specification. For all other equations, we use a simple binary probit model.

For men, the number of sexual partners is only lower for ages between 15 and 19 years, the coefficients for all other age groups being non-significantly different from each other. Household heads have a slightly higher expected number of sexual partners. Conversely, matrimonial status does not come out as significant, suggesting that we are not confronted with a high "married man" bias on the declared number of partners. Most importantly, the declared number of partners grows with education. Important factors linked to education may be personal autonomy, spatial mobility, and polygamy. The number of sexual partners is slightly inferior in Abidjan, other things being equal. For women we find roughly the same associations between sexual activity and individual socio-economic characteristics. However, in contrast with men but as one can expect, the probability of having had sexual intercourse within the two months period preceding the survey is marked by a strong positive "married woman" effect.

Condom use decreases for both sexes with age and with married status,

[4] Alternatively, we could estimate ρ, β, and Y simultaneously, but then an identifying variable for each equation is necessary which our survey does not provide. A third possibility would be to impose correlation coefficients between the residual terms, but lacking any information regarding their size, we favor the independence hypothesis.

and conversely increases with education. For men, the number of partners comes out as significant, increasing condom use too. Place of dwelling comes out as insignificant, as well as head of household status in the case of men. For both sexes, the strong “marriage effect” on condom use may be a matter of worry. It partially corresponds to a higher confidence in the partner, which theoretically should be reflected in the Y variable rather than in the β variable. Unfortunately again, we can not conclude satisfyingly on the respective weight of the “faithfulness” and “unprotected marital intercourse” factors. In our calibration procedure of the mortality rates, we cancel out this “marriage effect” on condom use by putting to zero the coefficient of marital status.

In the case of men, the probability of knowing somebody who is infected with HIV is lower for youngest (inexperienced) people (15-20 years old) and higher for household heads. It increases with the declared number of partners and the level of education. Of course, this effect of education may reflect an increasing size of the social network and better information rather than a higher probability of matching with infected people. Conversely, living in Abidjan has a significant negative effect on the probability of knowing infected people. The interpretation may be that secrecy is better preserved in large towns than in other dwelling places where social links are more intimate and less anonymous. In the case of women, age effects are almost insignificant, except for the 30-34 years old group. The positive effect of education is maintained. Other things being equal, married women know more often somebody who is infected. By contrast with men, the effect of living in Abidjan disappears. These two latter results may reflect gender differences in social networks—more extended and intimate knowledge of relatives for married women, whatever their localization.

The predicted individual risk factors P are then calibrated on dynamic mortality tables for men and women, supposing implicitly that the risk of infection is proportional to the risk of dying through AIDS. These mortality tables are computed using (i) the Ivorian United Nations' projections (United Nations 2001) for infant mortality, juvenile mortality and life expectancy at birth for the period 1990 to 2010 (see Table 1) and (ii) Ledermann model life tables (Ledermann 1969). In these tables, we fixed the mortality rate beyond 87 years at one, such that there is no survivor at 88 years. The United Nations' projections include a with AIDS and a without AIDS scenario allowing to disaggregate the mortality tables in AIDS deaths and deaths due to other causes. AIDS mortality is introduced in our mortality tables in such a way that it concerns only children up to five years and adults between 20 and 59 years old. The individual AIDS risk factors are, of course, only applied to the mortality due to AIDS. Due to the lack of data for women older than 49 years in the DHS, we introduce no risk heterogeneity for that age group. For children under five, we apply the risk factor of the mother. If the mother cannot be identified, we use that of the father. If neither a mother nor a father can be identified, we set the risk factor to one.[5] In households where an AIDS death occurred, the Y variable is set to one, so as to reflect intra-household transmission of AIDS. It is important to note that the resulting AIDS mortality probabilities for population subgroups are not independent of the population structure.

The described procedure applied to projections of the EP 1993 implies that the risk of dying of AIDS increases continuously with age for men. For women it increases until the age of 35 and then remains more or less constant or even slightly declines. The risk of dying through AIDS is increasing in time. For instance, in 2001, for the male age groups 20 to 45 years and the female age groups 20 to 49 the risk of dying through AIDS is equal or sometimes even higher, especially for women, than that of dying by another cause than AIDS. Thus, AIDS becomes for these age groups by far the major cause of death. The AIDS death probabilities for men are higher in rural areas for the age groups 15 to 39, whereas they are lower for the age groups 40 to 54. For women, they are in the mid-nineties always higher in rural areas. By contrast, after 2000 they are for all age groups older than 25 slightly higher in urban areas. Perhaps the most important result is that the AIDS mortality probabilities increase for each

[5] In the base sample, the intra-household links are only declared with respect to the household head, therefore for children other than those of the household head, we can neither identify the mother nor the father. Another case is, where the mother was already dead in the base sample, but the child was one of the household head's children, then the father but not the mother is known.

Table 1
Estimations and projections of mortality in Côte d'Ivoire with and without AIDS

Indicator	1985-90	1990-95	1995-00	2000-05	2005-10	2010-15
Infant mortality						
with AIDS	0.102	0.094	0.089	0.081	0.072	0.063
without AIDS	0.098	0.086	0.079	0.071	0.064	0.056
census 1988 and 1998	0,097		0,104			
Mortality under five						
with AIDS	0.167	0.159	0.152	0.138	0.121	0.104
without AIDS	0.160	0.142	0.128	0.113	0.099	0.085
Life expectancy at birth						
with AIDS/Men	49.8	48.6	47.4	47.7	49.5	52.0
without AIDS/Men	51.0	52.8	54.9	57.0	59.0	61.1
census 1988 and 1998	53,6		49,2			
with AIDS/Women	52.8	50.8	48.1	48.1	50.1	52.9
without AIDS/Women	54.5	56.7	58.4	60.5	62.5	64.6
census 1988 and 1998	57,2		52,7			

Source: World Population Prospects 2000, version February 2001 (United Nations 2001), Populations census 1988 (INS 1992) and 1998 (INS 2001).

age group with educational attainment, especially for men, and a little less for women in urban areas. This increase is larger the higher the age and maximum for the age group 40 to 44 for men and 44 to 49 for women. Some argue that this excess infection levels seen among more educated groups may disappear as the epidemic progresses, because educated people may adopt new, less risky lifestyles quicker than other groups (Ainsworth and Semali 1998; Gregson, Waddell and Chandiwana 2001; Walque 2002). We checked this hypothesis by running the same regressions on the Demographic and Health Survey (DHS) of 1998/99. We found very similar regression coefficients to 1994, especially the measured associations between risk and education hold.[6]

During the simulation, we actualize in each period the individual risk factors, calibrate them in order to respect the United Nations' projections and then simulate AIDS and non-AIDS deaths using a Monte Carlo lottery.[7]

If the household head dies, the succession is modelled in the following

[6] We based our analysis however on the DHS 1994, because the DHS 1998/99 has a much smaller sample size (3,040 women and 886 men vs. 8,099 and 2,552 respectively) and seems biased toward urban areas (Macro International Inc. 1999).

[7] The principle of Monte Carlo lotteries is given in appendix when the modeling of fertility is explained.

order:[8] spouse of the household head, the oldest son if older than 14 years, the oldest daughter if older than 14 years, another member of the household if older than 14 years, the father or mother of the household head (the youngest of both), the oldest son younger than 15 years, the oldest daughter younger than 14 years, another member younger than 15 years.

2.3 Activity choice and labor income model

2.3.1 Theoretical framework: a weakly competitive labor market model

The labor income model draws from Roy's model (1951) as formalized by Heckman and Sedlacek (1986). It is competitive in the sense that no segmentation or job rationing prevails, but only weakly because labor mobility across sectors does not equalize returns to observed and unobserved individual characteristics. In each period, each individual belongs to a given family or household whose composition and location is exogenously determined. . We assume that each individual older than eleven years and out of school faces three kinds of work opportunities: (i) family work, (ii) self-employment, (ii) wage work. Family work includes all kinds of activities under the supervision of the household head, that is family help in agricultural or informal activities, but also domestic work, non-market labor and various forms of declared "inactivity". Self-employed work corresponds to informal independent activities. In agricultural households (households where some independent agricultural activity is done), the household head may be considered as a self-employed worker bound to the available land or cattle.[9] Wage work includes all other kinds of workers, from agricultural or informal wage workers to civil servants or large firms workers.[10]

To both, non-agricultural self-employed work and wage-work we associate the following potential earnings functions:

$$\ln w_{1i} = \ln p_1 + X_{1i}\beta_1 + t_{1i} \tag{2}$$

[8]Likewise, if the household head leaves the household for marriage.

[9]In 94% of the households involved in independent farm work, the household head is the manager of the farm. Among these cases, he is very rarely involved in another activity than agriculture.

[10]Each category accounting respectively for 6%, 31%, 35% and 28% of the total wage workers sample in 1992/93.

$$\ln w_{2i} = \ln p_2 + X_{2i}\beta_2 + t_{2i} \tag{3}$$

where for each individual i and for each labor market segment $j = 1, 2$, w_{ji} are individual potential earnings, X_{ji} are observable individual characteristics (human capital, place of dwelling, sex, nationality), t_{ji} are sector-specific unobservable individual productive abilities, and p_j the price paid for each efficiency unit of labor.

To family work, we associate an unobserved individual value that depends also on household characteristics, and on other members' labor decisions:

$$\ln \widetilde{w}_{0i} = (X_{0i}, Z_{0h})\,\beta_0 + \widetilde{t}_{0i} \tag{4}$$

where for each each individual i pertaining to household h, Z_{0h} summarizes invariant household characteristics and other members decisions which influence labor market participation.

To farm households, we also associate a reduced farm profit function derived from a Cobb-Douglas technology:

$$\ln \Pi_{0h} = \ln p_0 + \alpha \ln L_h + Z_h\theta + u_{0h} \tag{5}$$

where p_0 is the price of the agricultural good, L_h the total amound of labor available for agricultural activity, Z_h other household characteristics like arable land, and u_{0h} stands for unobservable idiosyncrasic factors' global productivity.

Then, when the household head is a farmer, secondary members may participate in farm work and therefore $\widetilde{w}_{0i}$ is assumed to depend on the "individual's contribution" to farm profits. We evaluate this contribution while holding fixed other members decisions and the global factor productivity of the farm u_{0h}:

$$\ln \Delta\Pi_{0i} = \ln p_0 + \ln\left(L_{h+i}^{\alpha} - L_{h-i}^{\alpha}\right) + Z_h\theta + u_{0h} \tag{6}$$

where $L_{h+i} = L_h$ and $L_{h-i} = L_h - 1$ if i is actually working on the farm in h, and $L_{h+i} = L_h + 1$ and $L_{h-i} = L_h$ alternatively. This means that the labor decision model is hierarchical between the household head and secondary members, and simultaneous "à la Nash" among secondary members (secondary members do not take into account the consequences of their activity choice on that of other secondary members). In the case of agricultural households, we may then rewrite the family work value as follows:

$$\ln \widetilde{w}_{0i} = (X_{0i}, Z_{0h})\, \widetilde{\beta}_0 + \gamma . \left[\ln p_0 + \ln \left(L^{\alpha}_{h+i} - L^{\alpha}_{h-i}\right) + Z_h \theta\right] + \widetilde{t}_{0i} \tag{7}$$

γ stands for the (non-unitary) elasticity of the value of family work in agricultural households to the price of agricultural products.

For non-agricultural household members, $\widetilde{w}_0$ may be seen as a pure reservation wage, where we introduce the household head's earnings and other non-labor income of the household in order to account for an income effect on participation in the labor market.

Comparing the respective values attributed to the three labor opportunities, workers allocate their labor force according to their individual comparative advantage:[11]

$$i \text{ chooses family work iff } \widetilde{w}_{0i} > w_{1i} \text{ and } \widetilde{w}_{0i} > w_{2i} \tag{8}$$

$$i \text{ chooses self} - \text{employment iff } w_{1i} > \widetilde{w}_{0i} \text{ and } w_{1i} > w_{2i} \tag{9}$$

$$i \text{ chooses wage} - \text{work iff } w_{2i} > \widetilde{w}_{0i} \text{ and } w_{2i} > w_{1i} \tag{10}$$

2.3.2 Econometric identification and results

For econometric identification, in line with our "hierarchical-simultaneous" model of labor decisions within the household, we must assume independence for the $\left(\widetilde{t}_0, t_1, t_2\right)$ between individuals, even among members of the same household. In the case of agricultural households, we also assume that u_0 is independent from $\left(\widetilde{t}_0, t_1, t_2\right)$ for all household members.[12] We assume joint normality for the $\left(\widetilde{t}_0, t_1, t_2\right)$ vector:

$$\left(\widetilde{t}_0, t_1, t_2\right) \rightarrow N\left(0, \Sigma\right) \tag{11}$$

[11] Multi-activity in the sense that an individual carries out two activities, either in a seasonal rhythm, or by working in each activity part of the weekly working time, is not considered in our model. Table A1 (appendix) shows that multi-activity is not a very important issue, especially for household members other than the head. This indicates that there is a relatively strong specialization on the individual level, and that income source diversification is managed principally on the household level.

[12] This latter assumption should allow for a direct identification of the $\Delta\Pi_0$ effect in $\widetilde{w}_0$, through the effect of u_{0h}. However, as $\Delta\Pi_0$ is presumably affected by large measurement errors, we exclude "available land" from the variables in $\widetilde{w}_0$, taking it as an instrument for the identification of the effect of $\Delta\Pi_0$.

Under these assumptions, we may adopt the following estimation strategy: (i) For non-agricultural households, we estimate by maximum likelihood techniques the occupational choice/labor income model represented by equations (2)-(4) and the series of selection conditions (8)-(10); we obtain a bivariate tobit, as in Magnac (1991). (ii) For agricultural households, we follow a limited information approach: in a first step, we estimate the reduced form farm profit function (5), then derive an estimate for the individual potential contribution to farm production (6); in a second step, we estimate the reservation wage equation (4) and then include this latter variable as in (7), and retain the wage functions estimated for non-agricultural households.[13]

Maximum likelihood estimation allows for the identification of the parameters of the wage, self-employment profit and family work value equations: $\beta_1, \beta_2, \beta_0$. Only some elements of the underlying covariance structure between unobservables can be identified, because observed wages are measured with errors and include a transient component ε_j $(j = 1, 2)$ which does not enter into labor supply decisions of (risk-neutral) individuals. We then write for estimation:

$$\left(\widetilde{t}_0, t_1, t_2, \varepsilon_1, \varepsilon_2\right) \rightarrow N\left(0, \Sigma^*\right) \tag{12}$$

Now, nine variance or correlation parameters may be identified:
$\rho = corr\left(t_1 - t_0, t_2 - t_0\right)$, $\sigma_j = \sqrt{var\left(t_j + \varepsilon_j\right)}$, $\theta_j = \sqrt{var\left(t_j - t_0\right)}$, $\lambda_j = corr(t_j + \varepsilon_j, t_j - t_0)$, $\mu_j = corr(t_j + \varepsilon_j, t_2 - t_1)$. Given that only the reservation value function is distinct between members of agricultural households and members of non-agricultural households, two series of estimates are computed for β_0, θ_1, θ_2, ρ, λ_1, λ_2,[14] whereas only one series is computed for $\beta_1, \beta_2, \sigma_1, \sigma_2, \mu_1, \mu_2$.

Table A4 (appendix) shows the estimation results for non-agricultural household members, including the head. As for education, returns are ordered as expected: the highest in the wage sector with a 17% increase for each additional year, and the lowest in the informal sector with only 7%. The

[13] This latter option is rather innocuous, as only 425 individuals declare out-of-farm earnings in agricultural households, compared to 6,276 in non-agricultural households.

[14] Even the θ_1, θ_2 and ρ estimates are computed in order to respect a common constraint, $\sigma^2\left(t_2 - t_1\right) = \theta_1^2 + \theta_2^2 - 2\rho\theta_1\theta_2$ being the same in both cases.

impact of education on the reservation wage lies in-between but close to the self-employment coefficient (10%). Returns to age or experience are similar in both, the informal and formal sectors, while the reservation value follows an ever increasing parabola (remember that children older than twelve years and enrolled in school are out of the sample). All three values are higher in towns than in rural areas, wages getting a premium in Abidjan. Non-Ivorians have, as expected, a lower reservation value and are discriminated against Ivorians in the wage sector (other things equal, they get 26% less than Ivorians), but not in self-employment. This is again the case for women for whom, other things being equal, the competitive potential wage appears as 83% lower than for men.[15] The reservation value for women is 22% lower than for men, but the effect of this variable should not be interpreted in isolation from the variables describing the relation to the head. Indeed household heads tend to participate most of the time and more frequently if they are women, far behind followed by spouses. Among household variables which only influence the reservation value, household head's income for secondary members has the expected positive sign, although it is only hardly significant. The number and age structure of children has a small and mixed influence on participation on the labor market. The number of men of working age, but not that of women, tends to decrease participation.

Table A3 (appendix) shows the agricultural profit function, associated to the heads of agricultural households. The number of family workers comes out with a coefficient that is consistent with usual values: a doubling of the work force leads to a roughly 50% increase of agricultural profits. The amount of arable land also comes out with a decreasing marginal productivity. Age and sex of the household head are both significant, whereas education of the household did not come out and was withdrawn from the set of explanatory variables. All regions come out with a negative sign with respect to the Savannah region (North), which reflects the low relative prices for cocoa and coffee

[15]Given that we analyze monthly wages, this large difference in the wage rate can be explained by differences in the hours worked. Furthermore, imposing a competitive structure for the labor market leads to an integration of some elements of non-monetary tastes for jobs or of entry costs in the potential wage equations.

in contrast to cotton (grown in the north) in the year of estimation 1992/93.

Table A4 (appendix) shows the estimation results for secondary members of agricultural households. As noted before, self-employment benefit and wage functions have been constrained to be the same as for non-agricultural households. Not surprisingly, people living in towns tend to work more often outside the family. This is also the case for women and immigrants, whatever their relation to the household head. The presence of children has no effect, while the number of working age men in the household still increases the reservation value of an individual. The above defined potential individual contribution to the agricultural profit increases the propensity to work on the farm with a reasonable elasticity of +0.3.

2.3.3 Calibration and simulation procedure

For simulation purposes, we need to recover the whole covariance structure Σ^*. Therefore we proceed to a calibration. We may first reasonably assume that the measurement error/transient component of wages is low, that is: $\varepsilon_{2i} = 0$ for all i. Second, we may assume that the unobservable of the reservation value is not correlated with ε_1, the measurement error/transient component of self-employment benefit, that is: $corr\,(t_0, \varepsilon_1) = 0$. The two assumptions allow for a straightforward recovery of the Σ matrix and of $\sigma\,(\varepsilon_1)\,, corr\,(t_1, \varepsilon_1)\,, corr\,(t_2, \varepsilon_1)$. Under these assumptions and given the estimated coefficients, we obtain rather sensible estimates:

-fairly close standard errors for the permanent components of individual task unobservables, i.e. $\sigma\,(t_1) \approx \sigma\,(t_2) \approx 0.8$;

- almost no correlation between the two: $corr\,(t_2, t_1) \approx 0.0$;

- positive and fairly close correlations between these unobservables and the unobservable in the reservation value, i.e. $corr\,(t_1, t_0) \approx corr\,(t_2, t_0) \approx 0.5$;

- a fairly large measurement error/transient component for self-employment benefits: $\sigma\,(\varepsilon_1) = 1.4 * \sigma\,(t_1)$;

- itself being negatively correlated with t_1 and notably t_2: which may reflect that under-declaration of benefits is more frequent at the top of the distribution of income.

Once the calibration is done, the weakly competitive occupational choice and labor income model is ready for simulation. In each period, the relative task prices p_1/p_0 and p_2/p_0 should ideally be determined by the general equilibrium of goods and labor markets, confronting the aggregate number of efficiency units of labor supplied by individuals to the aggregate demand for each task derived from consumption choices and production processes. We leave this for future work, and assume stability of relative prices, i.e. perfect adequacy between labor supply and demand evolutions. The occupational structure and the income distribution of the economy is then purely supply driven, and depends only on fertility, mortality, household composition, migration and educational investment. Some consequences of this modelling choice can easily be foreseen: as the working age population gets younger and as the average size of households decreases, work outside the family becomes more frequent. And as the average level of education increases, wage work increases more than self-employment.

Land is of course a key variable in the generation of agricultural income. The quantity of land owned by households is only declared in classes in the EP 1993. To simplify the reallocation of land, this variable was transformed in a continuous one by simulating residuals using a method proposed by Gourieroux *et al.* (1987). We attribute the land in each household to the current household head. If the household head leaves the household, for marriage for instance, land is attributed to the new household head. If the first-born boy of a household leaves for marriage, he receives 50% of the household's land. The land of households which disappear, due to deaths of all the members, is reallocated within each strata among the households without land in equal parts, such that the proportions of households owning land remain constant with respect to 1992/93. At the end of each period the quantity of land is increased for each household by 3%, which is the approximate natural population growth rate in the model.

In our simulation model, households switch to the agricultural sector—i.e. become an agricultural household—if the land they own exceeds a certain threshold level $L >= \bar{L}$ which we fixed at 0.1 ha, and in the opposite, they exit the agricultural sector—i.e. become a non-agricultural household—if land size falls under this threshold, $L < \bar{L}$.[16]

3 Simulation results

Drawing from the hypotheses summarized in Section 2.2, three demo-economic simulations are implemented: (i) a no-AIDS scenario (NOAIDS), (ii) an AIDS scenario in which risks of infection only depend on sex and age (WAIDSU, for With AIDS Uniform), and (iii) an AIDS scenario in which risks of infection vary within each sex and age group with education, location, marital status, position in the household and the size of the household (WAIDSH, the "H" standing for "Heterogenous"). As noted before, each of these three scenarios respects the United Nations' prospects and estimations for the impact of AIDS on life expectancy at birth.

The simulations are affected by two kinds of hazard: (i) by sampling errors which are linked to the size of the sub-samples used as starting point for the simulations, and (ii) by Monte-Carlo draws used for the simulation of individual demo-economic events. Ideally one would like to use the full sample of the 1992/93 survey and to perform 30 or more simulations for each scenario, deriving from them average results and confidence intervals. Unfortunately, the computation of micro-demographic projections is highly time consuming, with computation time varying more than proportionally with the size of the starting sample because of the exponential nature of demographic growth which increases the population size by more than 50% over 15 years. Up to now, Tables 2 to 6 and Figures 1 to 2 present results obtained as the mean of three simulations for each scenario on the same 10% sub-sample.

3.1 Aggregate results

In this section, we describe the impact of AIDS on economic growth, income inequality, poverty, and demographic variables.

Table 2 shows that, according to our simulations, AIDS has a more important impact on the size of the population and economy than it has on the level

[16] In the base sample 45.6% of the households are involved in independent agricultural activity (18.3% urban and 81.7% rural) and 54.4% are not (86.9% urban and 13.1% rural).

Table 2
Simulation results in terms of population, growth, inequality, and poverty
(income in 1 000 CFA F 1998–Abidjan, end of each year)

	1992	1998	2002	2007	growth p.a.
No. of individuals					
NOAIDS	5336	6646	7704	9375	0.038
WAIDSU	5331	6474	7379	8785	0.034
WAIDSH	5334	6493	7375	8739	0.033
No. of households					
NOAIDS	929	1168	1384	1716	0.042
WAIDSU	926	1168	1389	1729	0.043
WAIDSH	936	1171	1400	1740	0.042
Cum. no. of AIDS deaths					
NOAIDS	0	0	0	0	
WAIDSU	1	142	296	544	
WAIDSH	2	154	323	576	
Mean hh. income					
NOAIDS	1238	1461	1595	1725	0.022
WAIDSU	1244	1404	1510	1584	0.016
WAIDSH	1213	1416	1490	1596	0.018
Mean hh. size					
NOAIDS	5.742	5.691	5.566	5.466	-0.003
WAIDSU	5.759	5.543	5.315	5.082	-0.008
WAIDSH	5.692	5.583	5.263	5.002	-0.009
Mean hh. income per capita					
NOAIDS	252	345	392	442	0.038
WAIDSU	256	335	390	436	0.036
WAIDSH	248	341	407	459	0.042
Mean hh. income per adult equivalent[a]					
NOAIDS	523	651	724	800	0.029
WAIDSU	528	631	706	767	0.025
WAIDSH	512	636	703	781	0.029
Dependency ratio					
NOAIDS	1.710	1.486	1.384	1.363	-0.015
WAIDSU	1.721	1.534	1.416	1.371	-0.015
WAIDSH	1.700	1.508	1.338	1.321	-0.017
Gini hh. income (hh)					
NOAIDS	0.573	0.593	0.614	0.633	0.007
WAIDSU	0.568	0.598	0.611	0.636	0.008
WAIDSH	0.577	0.605	0.624	0.643	0.007
Gini hh. income per capita (hh)					
NOAIDS	0.554	0.606	0.621	0.644	0.010
WAIDSU	0.553	0.604	0.611	0.636	0.009
WAIDSH	0.556	0.611	0.642	0.653	0.011
Gini hh. income adult equivalent[a] (hh)					
NOAIDS	0.536	0.568	0.589	0.612	0.009
WAIDSU	0.533	0.571	0.588	0.618	0.010
WAIDSH	0.540	0.579	0.605	0.626	0.010
P0 US$1 hh. income per capita (hh.)					
NOAIDS	0.376	0.36	0.347	0.339	-0.007
WAIDSU	0.373	0.358	0.344	0.345	-0.005
WAIDSH	0.384	0.359	0,343	0,332	-0,010

Notes: [a] Adult equivalent income, AEY, is here computed by the formula $AEY = Y/S^e$, where Y is total household income, S household size, and e is an economics of scale parameter which we gave the value 0.5. For total household income e is equal to zero. For total household income per capita e is equal to 1. *Source:* Simulations by the authors.

and on the distribution of individual incomes. Demographic growth decreases by around 0.5 percent per year due to AIDS. This estimation is consistent with the observed growth of 3.3% p.a. between the two population censuses of

1988 and 1998. The slowdown of the population growth means that by the end of 2007, the population of Côte d'Ivoire is smaller by around one and a half million people, taking into account not only the deaths of infected persons, but also the births which will not occur. The growth of the number of households remains unchanged. It is the average size of households which decreases due to AIDS by around 0.45 persons.

Although AIDS primarily kills adults of working age, the dependency ratio does not increase, but instead decreases and even more in the WAIDSH scenario. This effect will be commented upon in detail in the next section, because it strongly determines the evolution of the distribution of income.

At a first glance, it seems that the economy tends to shrink at approximately the same rate than population. Therefore income per capita growth does not change much. Rates of growth are even closer for income per adult equivalent where we replace the number of people living in the household by its square root in order to account for economies of scale. However, it should be noted that the current version of the model does not introduce any of the factors which macro-studies have pointed out to influence per capita growth. An increase of private and public health expenditures may lead to a decrease of savings and investment and result in a lower demand for domestic goods and for wage labor. Second, labor productivity of infected people is lower, and people get inactive long before they die. Third, workers deaths generate turnover costs.

While inequality strongly increases with time in the three scenarios, the evolution of the income distribution seems unaffected by AIDS, and that whatever the equivalence scale that is considered. In consequence, as income per capita increases with a rate around 4% p.a., poverty is reduced in the same way in the three scenarios.

Table 3 recapitulates changes in the employment structure and in enrolment rates. Again, the changes over time in the employment structure are not strongly modified by the AIDS epidemic. Each of the three scenarios preserves the same trend that we forecasted given the *supply driven* nature of the occupational choice model. Over the fifteen years period, the inactivity

Table 3
Simulation results in terms of
employment and school enrolment
(employment of pop. > 11 years old,
not enrolled in school)

	1992	1998	2002	2007	growth p.a.
Inactive					
NOAIDS	0.206	0.192	0.184	0.172	-0.012
WAIDSU	0.204	0.198	0.183	0.161	-0.016
WAIDSH	0.207	0.196	0.177	0.157	-0.018
Wage earner					
NOAIDS	0.093	0.109	0.117	0.126	0.020
WAIDSU	0.093	0.111	0.117	0.124	0.019
WAIDSH	0.092	0.107	0.116	0.129	0.023
Non-farm self-employ.					
NOAIDS	0.101	0.118	0.129	0.137	0.021
WAIDSU	0.103	0.120	0.128	0.138	0.020
WAIDSH	0.101	0.118	0.130	0.139	0.022
Indep. farmer					
NOAIDS	0.184	0.164	0.162	0.172	-0.004
WAIDSU	0.185	0.169	0.170	0.195	0.004
WAIDSH	0.184	0.169	0.174	0.192	0.003
Fam. help on farm					
NOAIDS	0.416	0.416	0.408	0.392	-0.004
WAIDSU	0.416	0.402	0.401	0.382	-0.006
WAIDSH	0.416	0.410	0.403	0.382	-0.006
Enrol. childr. 5 to 11 years old					
NOAIDS	0.369	0.437	0.497	0.543	0.026
WAIDSU	0.370	0.432	0.489	0.547	0.026
WAIDSH	0.369	0.433	0.493	0.537	0.025
Enrol. childr. 12 to 18 years old					
NOAIDS	0.420	0.379	0.367	0.385	-0.006
WAIDSU	0.420	0.376	0.361	0.385	-0.006
WAIDSH	0.420	0.376	0.369	0.388	-0.005

Source: Simulations by the authors.

rate declines by around 4 percentage points, the weight of agricultural workers declines by 2 percentage points, whereas both the weights of wage earners and of self-employed increase by around 3 percentage points each. The main differences introduced by the AIDS scenarios lie in an accelerated decrease of the inactivity rate and a lesser decline of the weight of agricultural workers. These contrasting features are easily explained by the head's income effect in non-agricultural households and the labor productivity effect in agricultural households which influence labor supply decisions. Among agricultural workers, the increase of the relative weights of independent farmers comes from automatic replacements of dead household heads.

Enrolment rates increase through time but are not much modified by the AIDS epidemic. The micro-economic model of schooling decisions may underestimate the impact of AIDS on school attendance and school dropouts, because it does not introduce any direct income effect.

3.2 Behind averages: the impact of AIDS on individual welfare

Here we analyze the main behavioral changes implied by the occurrence of an AIDS death which explain the intricate phenomena hidden behind the averages considered in the preceding section. First we describe the frequency and the profile of AIDS deaths in each AIDS scenario. A first difference can be pointed out with respect to the propagation of AIDS. One important feature of the so-called heterogenous epidemic (WAIDSH) is the introduction of an intra-household correlation between risk factors concerning AIDS infection. Children under five years have the risk of their mother. And for men between 20 and 59 and women between 20 and 49 years old, remember that the mechanism is the following: when a first death occurs in a given household, then everybody in the household "knows somebody who got AIDS" with probability one, which, according to our modelling of risk factors, increases all household members risks factors through the "matching component" (see section 2.2). As Table 4 shows, this mechanism generates a higher concentration of AIDS-deaths. Among individuals present in 1992 and in 2007, about two thirds have not experienced an AIDS death in one of their households of passage, 19% have experienced an unique AIDS-death, and the remaining 15% have experienced two or more AIDS deaths.

Table 4
Total number of AIDS deaths
known by individuals in households of passage
(statistics only for individuals present in 1992 and 2007)

No. of AIDS deaths known	WAIDSU	WAIDSH
0	0.595	0.655
1	0.290	0.194
2	0.094	0.100
3	0.020	0.029
4	0.001	0.013
> 5	0.000	0.009

Source: Simulations by the authors.

Table 5 illustrates the mortality differentials introduced by AIDS with respect to education and occupation. Among 15 to 60 years old people, a heterogenous AIDS epidemic (WAIDSH) induces an over-mortality for educated groups, which is in contrast with the mortality pattern for an uniform epidemic (WAIDSU) and with the No-AIDS scenario. As it can be seen in Table 5, the weight of people having ever attended school among the AIDS-related deaths is 15 percentage points higher (in 2007) in the WAIDSH scenario relatively to the WAIDSU scenario. The distribution of AIDS deaths by occupation (population older than eleven years and not enrolled in school) reveals a rather different picture. Now, the heterogenous AIDS epidemic kills a little more often farmers and a little less often wage-earners, self-employed people and inactive people.

Figure 2 draws the concentration curve of AIDS deaths inside the distribution of income per capita. It reveals that in both AIDS scenarios the epidemic kills more often people in the bottom-half of the income distribution. For instance, the 50% poorest people cumulate 60% of the AIDS-deaths over the 15 years period. However, the two epidemics seem to be more concentrated on the richest of the poor, just above and just under the poverty line, as the maximum concavity of the concentration curves is reached around the second quintile of the distribution.[17] The heterogenous epidemic is only a little more regressive than the uniform epidemic, as indicated by the stronger concavity of the corresponding concentration curve. In sum, AIDS kills more the poor, but rather the richest of the poor.[18]

Having described the differences in the AIDS deaths profiles between the two scenarios, we now turn to the micro-economic explanation of the aggregate results. A first striking feature of the results, which has to be explained, is the evolution of the dependency ratio, which seems to determine strongly welfare and poverty outcomes. Recall first that dependency ratios are computed as the number of inactive over the number of active individuals in each household, and that every individual in agricultural households older than eleven

[17]If individuals are taken as accounting units and a poverty line of US$1 household income per capita is assumed, the head count index, P0, is about 0.43 in 2007.

[18]In the case of the uniform epidemic, this effect is principally due to the age distribution of the epidemic: individuals in the intermediate age groups are over-represented in the "lower-middle class" of the distribution of income per capita.

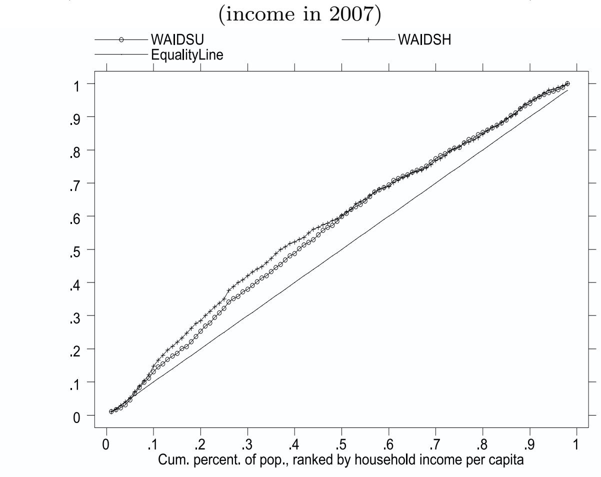
Table 5
Simulation results in terms of AIDS mortality differentials
(over-mortality with respect to share in t)

	1992	1998	2002	2007
BY EDUCATIONAL LEVEL (population > 14 and < 60 years old)				
Share of cum. AIDS deaths–no schooling				
WAIDSU	0,675	0,659	0,605	0,623
WAIDSH	0,554	0,545	0,503	0,479
Over-mortality–no schooling				
WAIDSU	0,085	0,056	-0,008	0,005
WAIDSH	-0,036	-0,055	-0,102	-0,126
Share cum. AIDS deaths–at least some primary schooling				
WAIDSU	0,241	0,229	0,283	0,267
WAIDSH	0,247	0,286	0,339	0,362
Over-mortality–at least some primary schooling				
WAIDSU	-0,073	-0,057	0,005	-0,004
WAIDSH	-0,067	-0,005	0,051	0,086
Share of cum. AIDS deaths–at least some secondary schooling				
WAIDSU	0,085	0,111	0,112	0,110
WAIDSH	0,199	0,169	0,159	0,159
Over-mortality–at least some secondary schooling				
WAIDSU	-0,012	0,001	0,003	-0,001
WAIDSH	0,103	0,060	0,051	0,040
BY OCCUPATION (population > 11 years old. not enrolled in school)				
Share of cum. AIDS deaths–inactive				
WAIDSU	0.206	0.226	0.202	0.193
WAIDSH	0.169	0.154	0.168	0.170
Over-mortality–inactive				
WAIDSU	0.002	0.029	0.019	0.031
WAIDSH	-0.036	-0.039	-0.007	0.012
Share of cum. AIDS deaths–wage earner				
WAIDSU	0.071	0.137	0.154	0.144
WAIDSH	0.137	0.149	0.137	0.136
Over-mortality–wage earner				
WAIDSU	-0.031	0.027	0.037	0.022
WAIDSH	0.034	0.041	0.021	0.010
Share of cum. AIDS deaths–non-farm self-employ.				
WAIDSU	0.108	0.137	0.165	0.154
WAIDSH	0.100	0.102	0.121	0.135
Over-mortality of individ.–non-farm self.-employ.				
WAIDSU	0.005	0.018	0.038	0.019
WAIDSH	-0.004	-0.014	-0.006	0.000
Share of cum. AIDS deaths–indep. farmer				
WAIDSU	0.265	0.173	0.156	0.161
WAIDSH	0.169	0.235	0.218	0.214
Over-mortality of individ.–indep farmer				
WAIDSU	0.077	-0.009	-0.028	-0.051
WAIDSH	-0.013	0.053	0.026	0.001
Share of cum. AIDS deaths–family help on farm				
WAIDSU	0.349	0.328	0.323	0.347
WAIDSH	0.426	0.360	0.357	0.345
Over-mortality of individ.–family help on farm				
WAIDSU	-0.053	-0.066	-0.066	-0.023
WAIDSH	0.019	-0.041	-0.034	-0.023

Notes: A positive sign of “over-mortality” means that the corresponding group was more than proportionally affected by AIDS deaths. *Source:* Simulations by the authors.

years, out of school, and not active outside the household is treated as family help. As already noted, each scenario shows a decreasing trend of the dependency ratio over time. Moreover, second order differences emerge between the

Figure 1
AIDS deaths concentration curve
(vertical axis: cum. percentage of AIDS deaths)
(income in 2007)



Source: Simulations by the authors.

three scenarios, but the two AIDS scenarios come out as lower and higher bound—the WAIDSU scenario being the more pessimistic and the WAIDSH scenario the more optimistic. A similar result has been found by Booysen and Bachmann (2002) for the South-African case. They state that the dependency ratio in AIDS affected and non-affected households is not significantly different. However, one drawback of their study is the small size of the used sample comprising only 406 households and being not representative on the national level.

A number of factors contribute to the decrease of the dependency ratio. First, AIDS also kills inactive people. They represent around 40% of all AIDS deaths over the period under study: prime age children, students, inactive, and unemployed people in urban areas. The heterogenous epidemic kills slightly more often inactive people than the uniform epidemic, because of the modelling of intra-household transmission, and because of the correlation of risks with education. Second, the death of a fertile woman in a household decreases total fertility of the household. This latter effect is only partially compensated in our fertility equation, where the decrease of the number of fertile women in the household has a positive impact on the fertility of other women. The fall in household fertility is again more pronounced in the WAIDSH scenario where married women are more affected by AIDS, because of more frequent sexual intercourse. Third, the death of a household head makes exits from inactivity in urban areas more likely, especially in the WAIDSH scenario, which kills household heads more often.

All these factors explain why in AIDS affected households the dependency ratio may not necessarily increase, and may even decrease. This does however not mean that AIDS deaths have no significant effect on the welfare of households. In Table 6, we look again at the sample of individuals present in the 1992/93 survey and having survived to 2007. We then formulate a simple panel regression model which writes for each period after 1994:

$$y_{i,t+1} = \lambda y_{i,t-1} + \alpha.ad_{i,t} + \beta.od_{i,t} + u_i + \varepsilon_{i,t+1} \tag{13}$$

where $y_{i,t}$ stands for the (log) of income per capita, $ad_{i,t}$ for the occurrence of an AIDS death in the household of passage in year t, and $od_{i,t}$ for the occurrence of an other death in the household of passage in year t.[19] We give our preference to this two lags specification because in our model, a death takes two years to be fully taken into account by the occupational choice model at the household level.[20] Given the presence of an individual fixed effect, this model is better estimated in differences:

$$y_{i,t+1} - y_{i,t-1} =$$

$$\lambda(y_{i,t-1} - y_{i,t-3}) + \alpha.(ad_{i,t} - ad_{i,t-2}) + \beta.(od_{i,t} - od_{i,t-2}) + \varepsilon_{i,t+1} - \varepsilon_{i,t-1} \tag{14}$$

The estimation of λ is here again potentially biased by the correlation between $y_{i,t-1}$ and $\varepsilon_{i,t-1}$.[21]

As Table 6 shows, having experienced an AIDS death in the household of passage in year t does have on average a negative effect on the income per capita reached in $t+1$, with a fall of income by roughly 3%. In contrast,

[19] Individuals may change the household during their life-course, therefore we call the individual's household in a given year "household of passage".

[20] Because of the simultaneous "à la Nash" structure of decisions, household members make a first occupational choice in year t, notwithstanding the choices of others, but then they may reconsider it in year $t+1$, once they observe the consequences of the decisions of the other members.

[21] A slight correlation may even subsist between $ad_{i,t}$ or $od_{i,t}$ and $\varepsilon_{i,t+1} - \varepsilon_{i,t-1}$, due to non-linear age effects or, in the case of heterogenous AIDS, due to changes in the risk differentials. A more scrupulous model of the income process would be necessary, as well as the use of instrumental variables techniques in the spirit of Arellano and Bond (1991) who propose estimators for dynamic panel data.

having experienced a death from another cause has on average a positive effect by roughly 1.5%. The difference between the two kinds of deaths is principally linked to the difference in the age-mortality pattern. AIDS kills more often active workers, while other causes of mortality more often kill prime age children and older persons, lowering the dependency ratio.

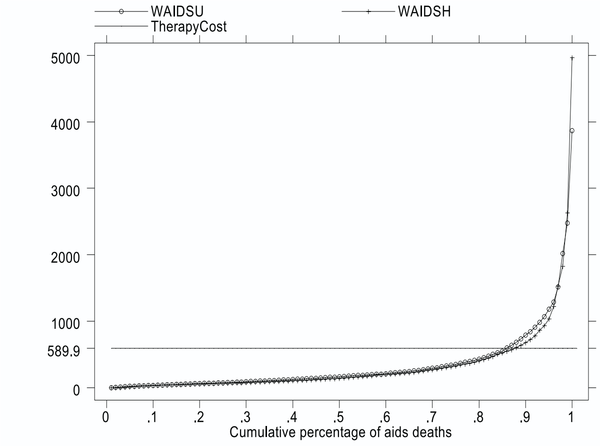
Table 6
Regressions of log household income per capita on having known a death in household of passage controlling for log household income per capita in 2007
(estimations only on individuals present in 1992 and 2007)

	Coeff.	Std. Err.
Income in $t+1$ regressed on death in t and income in $t-1$		
WAIDSU (50245 obs.)		
AIDS death	-0,035 *	0,006
other death	0,027 *	0,004
WAIDSH (50111 obs.)		
AIDS death	-0,052 *	0,006
other death	0,033 *	0,004
Diff. in inc. betw. $t+1$ and $t-1$ regressed on diff. in inc. betw. $t-1$ and $t-3$		
WAIDSU (49803 obs.)		
AIDS death	-0,029 *	0,005
other death	0,014 *	0,003
WAIDSH (49696 obs.)		
AIDS death	-0,029 *	0,005
other death	0,014 *	0,003

Source: Simulations by the authors.

We can now tell a satisfying story for the aggregate results obtained in the preceding section. We have seen that AIDS kills more often the richest of the poor and make survivors a little poorer in terms of income. In other words, AIDS kills more often people around the poverty line and make some survivors crossing the poverty line downwards. The combination of these two elements may explain why the overall effect of AIDS on income poverty seems ambiguous when poverty is measured at the individual level. At the household level, the household formation and income generating process increase again this ambiguity. Of course, as already mentioned, our simulations do not take into account the decrease of productivity and the increase in health expenditures incurred by households affected by AIDS. While leaving this for future research, we may easily deduce that these effects will clearly increase poverty by moving surviving individuals downward in the distribution of welfare.

Figure 2
Pen's Parade and approx. therapy cost per person per year[a]
(vertical axis: household income per capita
in 1 000 CFA F 1998 in the year preceding the AIDS death)



Notes: [a] In Senegal, the cost of anti-retroviral drugs for one year was reported as about US$ 1 000 per patient in year 2001 (Frankfurter Allgemeine Zeitung 2001).

Source: Simulations by the authors.

4 Conclusion

To our knowledge, the present work is the first attempt to link the distribution of the AIDS epidemic over an African population and the distribution of income and poverty. It reveals the complexity of the interaction between demographic behavior and the income formation process. It seems that the AIDS epidemic hurts more the lower middle class of the Ivorian society, that is the richest of the poor, and confronts survivors of an affected household to downward, although moderate, transitions through the distribution of income. In the absence of other macro-economic impacts, the main effect of AIDS in Côte d'Ivoire is a shrinking of the size of the economy by around 6% after 15 years, leaving average income per capita, income inequality, and income poverty roughly unchanged. If we took into account the increase of private expenditures, then, no doubt, AIDS would clearly increase consumption poverty and decrease welfare. Moreover, if the prospects and patterns of labor demand would be significantly affected by AIDS, then again both the overall and micro-economic impact of the epidemic would appear more dramatic. In any case, as Figure 2 clearly shows, the annual cost of an anti-retroviral treatment is out of reach for almost all infected persons in Côte d'Ivoire, even choosing a lower bound of 1,000 US$ (at 1998 prices).[22]

Further work should first explore the sensitivity of our demo-economic model to sampling errors and Monte Carlo draws, by running a large number of simulations for each scenario. In a second step, it would be important to analyze the impact of mortality risk heterogeneity, not only for AIDS deaths but also for other causes of death.

We should also assess the impact of private health expenditures and analyze labor demand issues by introducing a simple micro-economic consumption module,[23] and by making endogenous relative labor prices through a general equilibrium model of labor and goods markets.

[22]Koné *et al.* (1998) estimate the total annual treatment cost per person in Côte d'Ivoire (in 1995), i.e. anti-retroviral drugs plus hospital days, generalist consultations, other medications, lab and x-ray and so on as being more than US$ 5,500.

[23]The 1992/93 provides disaggregated data on consumption expenditures.

Appendix

Descriptive statistics and estimation results of the occupational choice and earnings model

Table A1
Description of the sample used for parameter estimation

	Non-agricultural hh.		Agricultural hh.	
	HH head	Other memb.	HH head	Other memb.
Age structure				
12-24	0.030	0.473	0.027	0.479
25-34	0.258	0.300	0.172	0.207
35-44	0.350	0.139	0.203	0.131
45 and older	0.362	0.088	0.599	0.184
Years of schooling (mean)	4.086	2.789	1.099	1.284
Female (=1)	0.171	0.786	0.121	0.716
Non-Ivorian (=1)	0.361	0.287	0.167	0.178
Relation to household head				
Spouse		0.376		0.326
Child		0.269		0.397
Other		0.355		0.277
Localization				
Abidjan	0.316	0.349	0.005	0.007
Other urban	0.553	0.550	0.176	0.202
East Forest	0.060	0.048	0.250	0.263
West Forest	0.030	0.027	0.253	0.224
Savannah	0.042	0.027	0.316	0.304
Occupation (main activity)[a]				
Inactive/Family help[b]	0.142	0.681		0.918
Wage earner	0.484	0.100		0.019
Non-farm self-employ.	0.374	0.219		0.063
Self-employed in agricult.			1.000	
More than one activity dur. year	0.128	0.009	0.129	0.011
HH memb. involv. in farm (mean)			3.160	
Land available				
No land			0.007	
Land: from 0 to 1 ha			0.162	
Land: from 1 to 2 ha			0.196	
Land: from 2 to 5 ha			0.308	
Land: from 5 to 10 ha			0.199	
Land: more than 10 ha			0.127	

Notes: [a] For agricultural households we coded systematically the household head as chief of the farm, which is in 94.4% of the agricultural households indeed the case.
[b] The inactive population does not include enrolled children or individuals in professional trainee programs. *Source:* EP 1992/93; computations by the authors.

.

Table A2
Mean earnings in the sample used for parameter estimation

	Non-cens. obs.	Cens. obs.[a]	Arithm. mean[b]	S.D.
NON-AGRICULTURAL HOUSEHOLDS				
Household head				
log monthly wage	2 507	8	11.500	1.025
log monthly non-farm profit	1 940	4	10.911	1.115
Other household members				
log monthly wage	377	539	11.229	1.104
log monthly non-farm profit	1 452	558	10.185	1.023
AGRICULTURAL HOUSEHOLDS				
Household head				
log yearly agricultural profit	4 204		13.144	1.002
Other household members				
log monthly wage	48	138	10.252	1.306
log monthly non-farm profit	377	243	9.868	1.129

Notes: [a] In the EP 1992/93 individual earnings from dependent wage work and non-farm self-employment were only collected from the first and second decision maker in the household. The estimations take this into account. During the simulations, we imputed earnings for the other active household members, by using the estimated equations and by drawing residuals according to the estimated residual variance. Furthermore, we dropped 153 households from the sample because of implausible high or missing agricultural profits. For individuals occupying several activities, we aggregated all earnings and attributed them to the main activity.
[b] Earnings are in 1998 CFA F-Abidjan.
Source: EP 1992/93; computations by the authors.

Table A3
Agriculture profit function

Dependent variable *log profit last 12 month*	Coeff.	Std. Err.
Log of no. of household members involved in farm work	0.531 *	(0.026)
Land: no land or less than 1 ha (Ref.)		
Land: from 1 to 2 ha	0.349 *	(0.043)
Land: from 2 to 5 ha	0.553 *	(0.042)
Land: from 5 to 10 ha	0.897 *	(0.047)
Land: more than 10 ha	0.964 *	(0.052)
Experience	0.012 *	(0.004)
Experience^2/100	-0.022 *	(0.005)
Woman	-0.136 *	(0.042)
Savannah (Ref.)		
Urban	-0.554 *	(0.038)
East Forest	-0.329 *	(0.035)
West Forest	-0.230 *	(0.035)
Intercept	12.304 *	(0.089)
No. of observations	4 204	
Adj. R^2	0.319	

Notes: * coefficient significant at the 5% level.
Source: EP 1992/93; estimations by the authors.

.

Table A4
Occupational choice and labor income
Bivariate Tobit Model

Dependent variable	Non-farm self.		Wage earner		Reserv. w.	
log monthly earnings	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
NON-AGRICULTURAL HOUSEHOLDS						
Schooling	0.069 *	(0.004)	0.171 *	(0.004)	0.101 *	(0.005)
Experience	0.078 *	(0.005)	0.080 *	(0.005)	-0.011 *	(0.006)
Experience^2/100	-0.074 *	(0.007)	-0.094 *	(0.008)	0.059 *	(0.008)
Abidjan	0.348 *	(0.047)	0.529 *	(0.042)	0.358 *	(0.056)
Other urban	0.300 *	(0.043)	0.257 *	(0.038)	0.100 *	(0.052)
Woman	0.042	(0.038)	-0.830 *	(0.035)	-0.217 *	(0.045)
Non-Ivorian	-0.030	(0.032)	-0.261 *	(0.030)	-0.215 *	(0.036)
# childr. 0-1 years old in hh.					0.038	(0.024)
# childr. 1-3 y. old in hh.					-0.018	(0.018)
# childr. 3-9 y. old in hh.					-0.035 *	(0.017)
# childr. 9-12 y. old in hh.					0.028 *	(0.013)
# men > 11 y. old in hh.[a]					0.026 *	(0.007)
# women > 11 y. old in hh.[a]					-0.002	(0.007)
Household head					-1.177 *	(0.040)
Spouse of h. head.					-0.168 *	(0.033)
Child of h. head.					0.189 *	(0.036)
Other hh. Member (Ref.)						
Income of h. head./1000000					0.009	(0.006)
Intercept	8.472 *	(0.109)	8.600 *	(0.100)	10.586 *	(0.115)
σ_1, σ_2	1.210 *	(0.018)	0.799 *	(0.014)		
$\lambda_1 = \rho(u_1, v)$, $\lambda_2 = \rho(u_2, u)$	-0.185 *	(0.035)	0.416 *	(0.043)		
$\mu_1 = \rho(u_1, u-v)$, $\mu_2 = \rho(u_2, u-v)$	-0.557 *	(0.027)	0.561 *	(0.043)		
θ_1, θ_2	1.000	(—)	1.000	(—)		
$\rho = \rho(u, v)$	0		(—)			
No. of obs.			14 369			
Mean log-lik.			-6.116			
AGRICULTURAL HOUSEHOLDS						
Schooling	0.069	(—)	0.171	(—)	0.026	(0.020)
Experience	0.078	(—)	0.080	(—)	-0.005	(0.016)
Experience^2/100	-0.074	(—)	-0.094	(—)	0.033	(0.022)
Abidjan	0.348	(—)	0.529	(—)	-0.241	(0.259)
Other urban	0.300	(—)	0.257	(—)	-0.576 *	(0.155)
Woman	0.042	(—)	-0.830	(—)	-0.764 *	(0.108)
Non-Ivorian	-0.030	(—)	-0.261	(—)	-0.513 *	(0.095)
# childr. 0-1 years old in hh.					0.067	(0.056)
# childr. 1-3 y. old in hh.					-0.050	(0.040)
# childr. 3-9 y. old in hh.					-0.003	(0.047)
# childr. 9-12 y. old in hh.					0.036	(0.037)
# men > 11 y. old in hh.[a]					0.056 *	(0.022)
# women > 11 y. old in hh.[a]					-0.018	(0.018)
Spouse of h. head.					-0.002	(0.074)
Child of h. head.					0.022	(0.077)
Other hh. Member (Ref.)						
$\ln \Delta\Pi_{0i}$					0.316 *	(0.095)
Intercept	8.472	(—)	8.600	(—)	9.095 *	(0.905)
σ_1, σ_2	1.210	(—)	0.799	(—)		
$\lambda_1 = \rho(u_1, v)$, $\lambda_2 = \rho(u_2, u)$	-0.242 *	(0.031)	0.050	(0.051)		
$\mu_1 = \rho(u_1, u-v)$, $\mu_2 = \rho(u_2, u-v)$	-0.557	(—)	0.561	(—)		
θ_1, θ_2	1.372 *	(0.195)	1.389 *	(0.216)		
No. of observations			9 884			
Mean log-lik.			-0.775			

Notes: * coefficient significant at the 5% level. [a] without accounting for the individual itself.
Source: EP 1992/93; estimations by the authors.

Modelling of fertility, marriage, immigration and school enrolment

Fertility

We use the Ivorian Demographic and Health Survey (DHS) of 1994 (INS 1995a) to model births. The weighted sample is representative on the national level and covers 5935 households, comprising 8099 women between 15 and 49 years old. The survey contains questions concerning the socio-demographic structure of households, fertility, health, education, employment and some assets owned by households. Fertility is estimated by a reduced form probit equation. The dependant latent variable measures the probability that woman i had a birth the twelve months preceding the survey. The observed dependant variable is whether the woman had a birth or not during this period. Among the exogenous variables are matrimonial status, region of residence, both interacted with age and age squared, and education. To control for polygamy, we also introduce the number of other women between 15 and 49 years old in the household. The main characteristics of the estimated model are, that the birth probability increases with marriage, rural residence, and age (at a decreasing rate). In contrast, it decreases with education, the number of other women in the household, and residence in Abidjan. Using the estimated equation and a Monte Carlo lottery, it is determined if a women gives birth in a specific period or not. Monte-Carlo lotteries within a micro-simulation model consist of assigning to each individual i in the current period a certain probability for the occurrence of a given event, say a birth. This probability is drawn from an uniform law comprised between zero and one. The empirical probability that a woman experiences a birth during this period is calculated using a formerly estimated (here econometrically) function, where her individual characteristics enter as arguments. If the randomly drawn number is lower than the empirical probability, then a birth is simulated. If the number of women is sufficiently high the aggregated number of births should be equal or very close to the sum of the individual empirical probabilities. The sex of a child is coded with a probability of 48.8% female in the model.

Marriage

Only first marriage is modelled. All single men between 18 and 49 years old and all single women between 13 and 43 years old are considered as at risk to marry. Those who "search" are selected among them using a Monte Carlo lottery and marriage rates stratified by age, sex, and residence (urban, rural) estimated by the INS (1992) using census data. To arrange marriages, we first stock the chosen men and women for each stratum (Abidjan, other cities, West Forest, East Forest, Savannah) in a matrix representing the different marriage markets. Then each matrix is sorted by education in descending order. We assume that men chose women. A parameter $0 <= \rho = 1$ defines the degree of "assortive mating" Becker (1991). If ρ is equal to one, the most educated man chooses the most educated woman in the corresponding stratum, under the condition that the man is not younger than the woman, and that the woman does not live in the same household as the man, otherwise he chooses the second most educated woman and so on. The second most educated man chooses then the next "available" most educated women and so on. For $\rho = 0.5$, 50% of men choose their wife conditioning on education and 50% choose randomly. For $\rho = 0$ all men choose randomly. The "homogamous" men are selected randomly and independently of their education. However, the selection process always runs in descending order, with the most educated man choosing first. This modelling is coherent with matching models in the sense that it is assumed that individuals act in an environment where information is perfect. There are no search costs. Matches are influenced by the conditions on the marriage markets, i.e. the dispersion of potential spouses and the ratio between potential spouses and competitors. For the simulations ρ was calibrated at 0.8. The marriage is concluded by an exchange of identification codes. Individuals who find no partner remain single and have a chance to be selected in the next period. For married couples there are three modes of cohabitation: (i) the couple forms its own new household, (ii) the couple lives with the parents of the man, and (iii) the couple lives with the parents of the woman. The probabilities for these three possibilities are calibrated at 70%, 15%, and 15% respectively. In new households, the man is coded household head.

Immigration

To model net immigration into Côte d'Ivoire, we use immigration matrices stratified by age and sex based on the *Enquête Ivoirienne sur les Migrations et l'Urbanisation* of 1993 (EIMU) (INS 1995b). This survey covers 16125 households (58378 individuals) and is considered to be representative on the national level. The number of immigrants is determined in each period by applying the net immigration rate by age group and sex on the number of resident individuals of the same age group and sex. The entrants are created by duplicating already resident immigrants (only matrimonial status is systematically coded as not married). Then the immigrant is affected with a probability of 70% to a randomly chosen resident, but former immigrated, family (of course not that of his/her double) and with a probability of 30%, he creates its own single household. The affectation to an immigrant family translates the idea of migration networks, particularly important in Côte d'Ivoire.

School enrolment

We use the information about current enrolment and enrolment in the previous year in the EP 1993 and the *Enquête de Niveau de Vie* of 1998[24] to estimate transition rates into and out of schooling. The models are estimated separately for boys and girls five to 25 years old using age, household composition, Ivorian citizenship, educational level already attained, matrimonial status, relation to the household head, land owned by the household, region of residence, and educational attainment of the father and the mother as explicative variables. The estimated coefficients of the corresponding probit models show that the probability of school entry depends, as one can expect, strongly on age. It is higher for children with educated parents (notably for girls), and is smaller for children in Non-Ivorian households. Furthermore, the probability of entry is higher if the child has already acquired some education in the past. The

[24]The *Enquête de Niveau de Vie* of 1998 is very similar to the EP 1993, but the sample size is smaller by 50%.

probability of staying in school depends positively on the educational level already attained, negatively on marriage and the quantity of land owned by the household, and is higher in urban areas, especially Abidjan. During the simulation, enrolment status is updated in each period for all children from five to 25 years old using the estimated coefficients and a Monte Carlo lottery. Repetition of classes is very frequent in Côte d'Ivoire, especially before the entry into junior secondary school. To account for this phenomenon, we fixed the repetition rates at 20% for the fifth year of primary school, at 50% for the sixth year of primary school and at 10% for all other classes.

References

Ainsworth M. and I. Semali (1998), Who is most likely to die of AIDS? Socioeconomic correlates of adult deaths in Kagera Region, Tanzania. In M. Ainsworth, L. Fransen, and M. Over (eds.), *Confronting AIDS: Evidence from the developing world. Selected background papers for the World Bank Policy Research Report, Confronting AIDS: Public priorities in a global epidemic.* (pp. 95-109), the European Commission, Brussels and the World Bank, Washington, D.C.

Anderson R.M. and R.M. May (1992), *Infectious diseases of humans: dynamics and control*. Oxford: Oxford University Press.

Arellano M. and S. Bond (1991), Some test of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies*, 58: 277-297.

Arndt C. and J.D. Lewis (2000), The macro implications of HIV/AIDS in South Africa: A preliminary assessment. *South African Journal of Economics*, 68 (5): 1-32.

Arndt C. and J.D. Lewis (2001), The HIV/AIDS pandemic in South Africa: Sectoral impacts and unemployment. *Journal of International Development*, 13: 427-449.

Aventin L. and P. Huard (2000), Le coût du SIDA dans trois entreprises manufacturières en Côte d'Ivoire. *Revue d'économie du développement*, 3: 55-82.

Barnett T. and P. Blackie (1989), AIDS and food production in East and Central Africa: A research outline. *Food Policy*, 14 (1), 2-6.

Béchu N. (1998), The impact of AIDS on the economy of families in Côte d'Ivoire: Changes in consumption among AIDS-affected households. In M. Ainsworth, L. Fransen and M. Over (eds.), *Confronting AIDS: Evidence from the developing world. Selected background papers for the World Bank Policy Research Report, Confronting AIDS: Public priorities in a global epidemic.* (pp. 340-348), the European Commission, Brussels and the World Bank, Washington, D.C.

Becker C.M. (1990), The demo-economic impact of the AIDS pandemic in Subsaharan Africa. *World Development*, 18 (12): 1599-1619.

Becker G.S. (1991), *A treatise on the family. A theory of social interactions* (enlarged edition). Cambridge, MA: Harvard University Press.

Bloom D.E. and A.S. Mahal (1995), Does the AIDS epidemic really threaten economic growth? *NBER Working Paper* No. 5148, NBER, Cambridge MA.

Bourguignon F., M. Fournier and M. Gurgand (2001), Fast development with a stable income distribution: Taiwan, 1979-1994. *Review of Income and Wealth*, 47 (2): 139-164.

Booysen F. and M. Bachmann (2002), HIV/AIDS, poverty and growth: Evidence from a household impact study conducted in the Free State Province, South Africa. Paper presented at the Annual Conference of the Centre for the Study of African Economies (CSAE), 18-19 March, Oxford.

Brouard N. (1994), Aspects démographiques et conséquences de l'épidémie de SIDA en Afrique. In B. Auvert, N. Brouard, F. Chièze, J.-P. Dozon and A. Guillaume (eds.), *Populations africaines et sida* (pp. 119-178), Paris: Editions La Découverte.

Cogneau D. (1999), Formation du revenu, segmentation et discrimination sur le marché du travail d'une ville en développement: Antananarivo fin de siècle *DIAL Working Paper* 2001/18, DIAL, Paris.

item []Cogneau D. and M. Grimm (2002), The distribution of AIDS over the population in Africa. Hypothesis building from individual answers to a Demographic and Health Survey with an application to Côte d'Ivoire. *DIAL Working Paper* 2002/02, DIAL, Paris.

Cogneau D. and A.-S. Robilliard (2000), Growth, distribution and poverty in Madagascar: Learning from a microsimulation model in a general equilibrium framework. *IFPRI TMD Discussion Paper* No. 61, IFPRI, Washington DC.

Cuddington J.T. (1993a), Modelling the macroeconomic effects of AIDS with an application to Tanzania. *World Bank Economic Review*, 7 (2): 172-189.

Cuddington J.T. (1993b), Further results on the macroeconomic effects of AIDS: the dualistic, labour-surplus economy. *World Bank Economic Review*, 7 (3): 403-417.

Cuddington J.T. and J.D. Hancock (1994), Assessing the impact of AIDS on the growth path of the Malawian economy. *Journal of Development Economics*, 43: 363-368.

Cuddington J.T., J.D. Hancock and C.A. Rogers (1994), A dynamic aggregative model of the AIDS epidemic with possible policy interventions. *Journal of Policy Modeling*, 16 (5): 473-496.

Dixon S., S. McDonald et J. Roberts (2001), AIDS and economic growth in Africa: A panel data analysis. *Journal of International Development*, 13: 411-426.

Frankfurter Allgemeine Zeitung (2001), *Nigeria importiert Aids-Medikamente. Erster Versuch mit Billigprodukten*, December 11, no. 288, p. 9.

Garenne M., M. Madison, D. Tarantola, B. Zanou, J. Aka and R. Dogoré (1995), *Conséquences démographiques du SIDA en Abidjan, 1986-1992*. Les études du CEPED 10, CEPED, Paris.

Gregson S., H. Waddell and S. Chandiwana (2001), School education and HIV control in sub-saharan Africa: from discord to harmony? *Journal of International Development*, 13 : 467-485.

Grimm M. (2001), A Decomposition of inequality and poverty changes in the context of macroeconomic adjustment. A microsimulation study for Côte d'Ivoire. *United Nations University/WIDER Discussion Paper* No. 2001/91, UNU/WIDER, Helsinki (forthcoming in A.F. Shorrocks and R. Van der Hoeven (ed.), *Growth, inequality and poverty*, Oxford: Oxford University Press).

Gourieroux C., A. Monfort, E. Renault and A. Trognon (1987), Simulated residuals. *Journal of Econometrics*, 34: 201-252.

Harding A. (2000), Dynamic microsimulation: Recent trends and future prospects. In A. Gupta and V. Kapur (eds.), *Microsimulation in government policy and forecasting* (pp.297-312), Amsterdam: North Holland.

Heckman J. and G. Sedlacek (1985), Heterogeneity, aggregation, and market wages functions: An empirical model of self-selection in the labor market. *Journal of Political Economy*, 93: 1077-1125.

International Labour Office (2000), HIV/AIDS in Africa: The impact on the world of work. African Development Forum 2000. AIDS: The Greatest Leadership Challenge, 3-7 December, Addis Ababa, Ethopia.

Institut National de la Statistique (INS) (1992), *Recensement général de la population et de l'habitat 1988. Tome 1: Structure, état matrimonial, fécondité et mortalité*. Institut National de la Statistique, République de Côte d'Ivoire.

Institut National de la Statistique (INS) (1995a), *Enquête Démographique et de Santé 1994*, Institut National de la Statistique, République de Côte d'Ivoire.

Institut National de la Statistique (INS) (1995b), *Enquête ivoirienne sur les migrations et l'urbanisation (EIMU). Rapport national descriptf*, Institut National de la Statistique, République de Côte d'Ivoire.

Institut National de la Statistique (INS) (2001), *Récensement Général de la Population et de l'Habitation de 1998. Rapport d'analyse. Thème 4 : La Mortalité.* Institut National de la Statistique, République de Côte d'Ivoire.

Janjaroen W.S. (1998), The impact of AIDS on household composition and consumption in Thailand. In M. Ainsworth, L. Fransen and M. Over (eds.), *Confronting AIDS: Evidence from the developing world. Selected background papers for the World Bank Policy Research Report, Confronting AIDS: Public priorities in a global epidemic.* (pp. 349-354), the European Commission, Brussels and the World Bank, Washington, D.C.

Kambou G., S. Devarajan and M. Over (1994), The economic impact of AIDS in an African country: Simulations with a Computable General Equilibrium Model of Cameroon. *Journal of African Economies*, 1 (1): 109-130.

Kamuzora C. and S. Gwalema (1998), Labour constraints, population dynamics and the aids epidemic: the case of rural Bukoba district, Tanzania. *Research Report* No. 98.4, Research on Poverty Alleviation (REPOA), Dar es Salaam.

Koné T., A. Silué, J. Agness-Soumahoro, R.N. Bail and D.S. Shepard (1998), Expenditures on AIDS in Côte d'Ivoire. In M. Ainsworth, L. Fransen and M. Over (eds.), *Confronting AIDS: Evidence from the developing world. Selected background papers for the World Bank Policy Research Report, Confronting AIDS: Public priorities in a global epidemic.* (pp. 255-262), European Commission, Brussels and World Bank, Washington, D.C.

Kremer M. (1996), Integrating behavioral choice into epidemiological models of the AIDS epidemic. *Quarterly Journal of Economics*, 151 (2): 549-573.

Ledermann S. (1969), *Nouvelles tables-types de mortalité*. Travaux et documents, cahier n. 53, Paris: INED and PUF.

Magnac T. (1991), Segmented or competitive labor markets? *Econometrica*, 59 (1): 165-187.

MacFarlan M. and S. Sgherri (2001), The macroeconomic impact of HIV/AIDS in Botswana. *IMF Working Paper WP/01/80*, IMF, Washington D.C.

Macro International Inc. (1999), *Enquête Démographique et de Santé Côte d'Ivoire 1998/99. Rapport Préliminaire*, Demographic and Health Surveys, Macro International Inc., Calverton, Maryland.

McPherson MF., D. Hoover and D.R. Snodgrass (2000), The impact on economic growth in Africa of rising costs and labor productivity losses associated with HIV/AIDS. *CAER II Discussion Paper* No. 79, Harvard Institute for International Development, Cabmridge, MA.

Menon R., M.J. Wawer, J.K. Konde-Lule, N.K. Sewankambo and C. Li (1998), The economic impact of adult mortality on households in Rakai district, Uganda. In M. Ainsworth, L. Fransen and M. Over (eds.), *Confronting AIDS: Evidence from the developing world. Selected background papers for the World Bank Policy Research Report, Confronting AIDS: Public priorities in a global epidemic.* (pp. 325-339), the European Commission, Brussels and the World Bank, Washington, D.C.

Orcutt G., S. Caldwell and R. Wertheimer (1976), *Policy exploration through microanalytic simulation.* Washington D.C.: Urban Institute Press.

Phlilipson T. and R.A. Posner (1995), The microeconomics of the AIDS epidemic in Africa. *Population and Development Review*, 4 (21): 835-848.

Roy A. (1951), Some thoughts on the distribution of earnings. *Oxford Economic Papers*, 3: 135-146.

Tibaijuka A.K. (1997), AIDS and economic welfare in peasant agriculture: case studies from Kagabiro Village, Kagera Region, Tanzania. *World Development*, 25 (6), 963-975.

United Nations (1999), *The demographic impact of HIV/AIDS.* Report on the technical meeting, New York, November 10 1998, Population Division, Department of Economic and Social Affairs, United Nations, New York.

United Nations (2001), *World population prospects: The 2000 revision, version February 2001* (data files). Population Division, Department of Economic and Social Affairs, United Nations, New York.

United Nations/World Health Organization (1991), *The AIDS epidemic and its demographic consequences.* Proceedings of the UN/WHO Workshop on Modelling the Demographic Impact of the AIDS Epidemic in Pattern II Countries: Progress to Date and Policies for the Future, United Nations, New York.

United Nations/World Health Organization (1999), *A review of household and community responses to the HIV/AIDS epidemic in the rural areas of sub-Saharan Africa.* UNAIDS Best Practice Collection–Key Material, UNAIDS/WHO, Geneva.

United Nations/World Health Organization (2002), *Epidemiological fact sheets on HIV/AIDS and sexually transmitted infections, 2002 Update.* UNAIDS/WHO, Geneva.

Wachter K.W., J.E. Knodel and M. VanLandingham (2003), Parental bereavement: heterogenous impacts of AIDS in Thailand. *Journal of Econometrics*, 112: 193-206.

Walque D. (2002), "How does educational attainment affect the risk of being infected by HIV/AIDS? Evidence from Uganda and Zambia". *Mimeo*, University of Chicago, Chicago.