AIDS and income distribution in Africa. A micro-simulation study for Côte d'Ivoire[1]

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Abstract. 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. When focusing on the labor supply effects of over-mortality, 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 poverty roughly unchanged. The dependency ratio is not much modified by the epidemic. These conclusions do not seem to depend on the degree of heterogeneity and clustering of the HIV/AIDS-infections over the population.

JEL Classification: C15, D31, J10

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1 Introduction

Since the eighties HIV/AIDS[2] 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. Côte d'Ivoire is the West-African country 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, Madison, Tarantola *et al.* 1995). Afterwards the epidemic spread very rapidly and end-2001 UNAIDS estimated the adult prevalence rate at 9.7 percent,[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). 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).

AIDS epidemic has a significant demographic impact by increasing sharply mortality for young adults and thus modifying significantly the population age structure (e.g. UNAIDS/WHO 1991; Brouard 1994; United Nations 1999). But AIDS has probably also a strong economic impact. Up to now, micro-economic studies are, with a few exceptions, restricted to a listing of

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

[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. In 1998, HIV1 seroprevalence ranged from 8 to 13 percent among pregnant women in ten cities, while HIV2 infection remained low at 1 percent or below (International Program Center 2000).

potential effects on households' welfare or enterprises efficiency[4] or are often based on unrepresentative case studies.[5] Macroeconomic consequences on growth have already been studied for several countries, either by single/cross-country regressions,[6] macro-projections[7] or Computable General Equilibrium Models.[8] Five main channels have been often cited by which the AIDS epidemic may affect the growth and the distribution of income: (i) the changes in the level and in the composition of labor supply including the destruction of accumulated human capital (education, work experience), (ii) the slow-down in the accumulation of new human capital (iii) the negative impact of illness on the productivity of labor, (iv) the negative impact of increased private and public health expenditures on savings and investment and on the long-term demand for labor, (v) the disorganisation of enterprises and administrations. We focus here on the first channel, i.e. labor supply and human capital destruction issues, by studying the counterfactual consequences of the over-mortality caused by the AIDS epidemics on the micro-economic distribution of income.

For this purpose, we apply a dynamic demo-economic micro-simulation model able to simulate over a fifteen years period the impact of AIDS on the demographic structure of the population and on household and invidual incomes. This model is implemented using a rich set of micro-demographic and micro-economic surveys on Côte d'Ivoire. More precisely, we embed a

[4]See e.g. Philipson and Posner (1995), UNAIDS/WHO (1999), ILO (2000).

[5]See 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).

[6]See e.g. Bloom and Mahal (1995), Bonnel (2000), McPherson, Hoover and Snodgrass (2000), Dixon, McDonald and Roberts (2001).

[7]See e.g. Becker (1990); Cuddington (1993a, 1993b), Cuddington and Hancock (1994), Cuddington, Hancock and Rogers (1994), Haacker (2002), Bell, Devarajan and Gersbach (2003).

[8]See e.g. Kambou, Devarajan and Over (1994), Arndt and Lewis (2000, 2001), MacFarlan and Sgherri (2001).

structural micro-economic household income model in a demographic dynamic micro-simulation model built 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 (see e.g. Harding 2000). The demographic part of our model simulates the most important demographic events as fertility, mortality, marriage, household formation, and 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. Our study is the first which applies such techniques to an African country. Another 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 draw from a Demographic and Health Survey to construct risk multipliers which are explained by individual socio-economic characteristics. This allows us to link directly the probability of dying from AIDS to the main observable correlates of individual incomes. Finally, our study is the first attempt to link the distribution of AIDS over the population to the distribution of income.

Not much is known about the distribution of the AIDS epidemic in African countries. Again today, prevalence rates of the HIV virus and mortality attributable to AIDS illness are only roughly estimated at the national/regional level.[9] The hypothetical approach followed here can not replace direct information that could be collected on the field through representative surveys

[9]For Uganda, the extent of the decline of the prevalence rate was recently put into question (see Parkhurst 2002 and *The Economist*, August 17th-23rd 2002, pp. 32-33).

with seroprevalence testing.[10] It can not replace either epidemiological modeling or micro-analysis of risky behaviors. But we think it is the best suited solution to derive from the existing epidemiological information a prospective image of the distribution of the AIDS epidemic, and to confront this distribution with the distribution of income. In the context of poverty reduction strategies, it may help to identify more precisely the socioeconomic characteristics of target groups (orphans, young mothers etc.) and shed light on some policy dilemmas (prevention vs. care, large coverage care vs. extension of Highly Active Anti-Retroviral Therapies (HAART)).

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, a "without AIDS" scenario and two "with AIDS" scenarios. We first discuss them in terms of growth, inequality and poverty changes since the early 1990s up to 2007, and then analyze the impact of AIDS on individual welfare trajectories. Section 4 draws some policy implications and concludes.

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

[10]The first survey of this kind has just been conducted in South Africa (HSRC 2002).

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 model and simulate the following events: marriage, household formation, school enrolment, fertility, mortality, international immigration, occupational choices, generation of individual earnings and household income. The starting population is constructed using the *Enquête Prioritaire* (called "EP 1993"hereafter) 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 adjusted such that the common starting point for all households is January 1st 1993. In what follows, we briefly present the modelling of mortality, and in particular mortality due to AIDS infection, and that of earnings which constitute the fundamental parts of our model. The modelling of the other behaviors and events is presented shortly in the Appendix.[11]

[11]It should be emphasized that in lack of longitudinal data, most regressions used are based on information derived from cross-section data. When using these regressions to simulate dynamic behaviour, we must of course make the strong assumption that individuals behave over time as individuals of different ages observed in the base year. The most

2.2 Mortality and the risk of AIDS infection

We perform 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 (2003).

At the individual level we suppose that 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), we write:

$$P = \rho\beta Y \qquad (1)$$

where P is the individual 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 Ivorian 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,

critical in doing this is that with cross-section data we cannot separate age, period, and cohort effects.

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. This is of course a very extreme assumption as knowing somebody with AIDS may also reflect individual social capital and may induce more cautious sexual behavior (see below).

In order to obtain a predictor for P for our simulation model, each of these three variables is regressed, separately for men and women, on a vector of observed variables containing age, education, region of residence, 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. For the men's ρ, we choose an ordered probit specification. For all other equations, we use a simple binary probit model.

The so constructed model suggests that the predicted individual risk of infection P and thus the risk of dying through AIDS increases with educational attainment. This is consistent with empirical evidence summarized by Hargreaves and Glynn (2002) and with the results of the first representative household survey with HIV testing undertaken in South Africa.[12] The driv-

[12] In this survey, HIV prevalence significantly and monotonically increases with educational attainment among African adults, i.e. going from 8.7 percent for those with no schooling to 21.1 percent for those who have completed high school (HSCR 2002).

ing forces behind this relation are that educated people are more likely to have several sexual partners and that they act in a more risky social network. In that sense the Y component reinforces the correlation between the risk factor and education implying that our "heterogenous" scenario called "WAIDSH" constitutes a kind of maximum benchmark through which we try to assess the importance of heterogenous risk factors for the economic impact of the AIDS epidemic. Important factors linked to education may be higher income and social status, personal autonomy, spatial mobility, and polygamy. However, the positive correlation between risk of infection and education is partly offset by a higher probability of condom use among educated people. Some argue that these 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; de Walque 2002; Hargreaves and Glynn 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. We based our analysis 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). Furthermore, the model implies that the predicted infection risk for men is higher in rural areas for the age groups 15 to 39, whereas it is lower for the age groups 40 to 54. For women, they are in the early stage of the epidemic always higher in rural areas, but as the overall level of infection increases, they are slightly higher in urban areas for all age groups older than 25. It might seem surprising that the AIDS death probabilities are not significantly lower in rural areas than in urban areas, but one should note that levels of HIV seroprevalence among pregnant women are in fact not very different between Abidjan and the other nine cities where pre-natal detection is conducted (International Program Center 2000). These tests probably exclude pregnant women in remote rural areas; nevertheless, according to the Ivorian DHS of 1994, more than 80 percent of pregnant women attend a pre-natal examination.

The predicted individual risk factors P are then calibrated on dynamic mortality tables for men and women, supposing implicitly that the risk of dying through AIDS is proportional to the risk of infection. 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). 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. Because of lack of data for women older than 49 years in the Ivorian DHS, we introduce no risk heterogeneity for that age group. For children under five, we apply the risk factor of the mother. In households where an AIDS death occurred, the Y variable is set to one 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. During the simulation, we update 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.

[please insert Table 1 about here]

As Table 1 shows the risk of dying through AIDS increases significantly in the 1990s. For instance, in the year 2000 our model implies that for men and women between 20 to 45 years old 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.

If the household head dies, this position is given to another household member according to her/his relation to the former household head and her/his age.

2.3 Occupational 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) and Magnac (2001). It is competitive in the sense that no segmentation or job rationing prevails. But it is only weakly competitive 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, the household head is considered as a permanent farmer bound to the available land or cattle.Wage work includes all other kinds of workers, from agricultural or informal wage workers to civil servants or workers in large formal firms.

To self-employed work and wage-work we associate two potential earnings functions:

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

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

where for each individual i and for each labor market segment $j = 1, 2$, w_{ji} are the individual potential earnings, X_{ji} are observable individual characteristics (human capital, region of residence, sex, nationality), t_{ji} are sector-specific unobservable individual productive abilities, and p_j is 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 agricultural households, we 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 amount of labor used for agricultural activity, Z_h other household characteristics like cultivable land, and u_{0h} stands for the unobservable idiosyncratic factors' global productivity.

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. When the household head is a farmer, secondary members may participate in farm work and therefore $\widetilde{w}_{0i}$ is also 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}: $\ln \Delta\Pi_{0i} = \ln p_0 + \ln \left(L^{\alpha}_{h+i} - L^{\alpha}_{h-i}\right) + Z_h\theta + u_{0h}$, 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 other household members and is not simultaneous among other household members, i.e. they do not take into account the consequences of their activity choice on that of other household members.

Comparing the respective values attributed to the three labor opportunities, workers allocate their labor force in order to maximize their earnings:[13]

$$i \text{ chooses family work iff } \widetilde{w}_{0i} > w_{1i} \text{ and } \widetilde{w}_{0i} > w_{2i} \tag{6}$$

$$i \text{ chooses self} - \text{employment iff } w_{1i} > \widetilde{w}_{0i} \text{ and } w_{1i} > w_{2i} \tag{7}$$

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

2.3.2 Econometric identification and results

For the econometric identification of our "hierarchical and non-simultaneous" model of labor supply decisions, we assume independence for the unobserv-

[13]Multi-activity in the sense that an individual carries out two activities, either in a seasonal rhythm, or by working in each activity part-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 household head, i.e. there is a relatively strong specialization on the individual level and income diversification is managed principally at the household level.

able factors $\left(\widetilde{t}_0, t_1, t_2\right)$ between individuals and even between 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. Only some elements of the underlying covariance structure between unobservable factors can be identified, because observed wages are measured with errors and/or include a transient component ε_j $(j = 1, 2)$ which does not enter into labor supply decisions of (risk-neutral) individuals. Finally we assume joint normality for the vector of unobservables:

$$\left(\widetilde{t}_0, t_1, t_2, \varepsilon_1, \varepsilon_2\right) \rightsquigarrow N\left(0, \Sigma^*\right) \tag{9}$$

Under these assumptions, we can adopt the following estimation strategy. For non-agricultural households, we estimate by maximum likelihood techniques the occupational choice and earnings model represented by equations (2)-(4) and the series of selection conditions (6)-(8); we obtain a bivariate tobit as shown in Magnac (1991). 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; in a second step, we estimate the reservation wage equation (4) by including this latter variable and retaining the wage functions estimated for non-agricultural households (because of the small sample of individuals living in agricultural households but working outside). Maximum likelihood estimation allows for the identification of the parameters of the wage, self-employment profit and family work value equations: $\beta_1, \beta_2, \beta_0$. Now, nine variance and correlation parameters can be identified.[14]

[14] $\rho = corr\left(t_1 - t_0, t_2 - t_0\right)$, $\sigma_j = \sqrt{\operatorname{Var}\left(t_j + \varepsilon_j\right)}$, $\theta_j = \sqrt{\operatorname{Var}\left(t_j - t_0\right)}$, $\lambda_j = corr(t_j + \varepsilon_j, t_j - t_0)$, $\mu_j = corr(t_j + \varepsilon_j, t_2 - t_1)$. Given that only the reservation value function is different between members of agricultural non-agricultural households, two series of estimates are computed for β_0, θ_1, θ_2, ρ, λ_1, λ_2, whereas only one series is computed for $\beta_1, \beta_2, \sigma_1, \sigma_2, \mu_1, \mu_2$. The θ_1, θ_2 and ρ estimates are also computed in order to respect a common constraint, $\operatorname{Var}\left(t_2 - t_1\right) = \theta_1^2 + \theta_2^2 - 2\rho\theta_1\theta_2$ which are the same in both cases.

Table A4 (Appendix) shows the estimation results for non-agricultural household members including the household head. As expected, the returns to education are the highest in the wage earner sector with a 17% increase for each additional year. They are the lowest in the informal sector with only 7%. The impact of education on the reservation wage lies in-between, but close to the self-employment coefficient (10%). Returns to experience are similar in 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. Non-Ivorians have, as expected, a lower reservation value and are discriminated against Ivorians in the wage sector (or have unobservable worse skills on average). However, this is not the case in the informal sector. For women, other things being equal, the competitive potential wage appears as 83% lower than for men. But, 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. 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 household head. Indeed female household heads tend to participate more of their time and more frequently than male household heads. 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 adult men, but not that of adult women, tends to decrease participation.

Table A3 (Appendix) shows the estimated agricultural profit function. 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 in contrast to cotton (grown in the north) in the period of data collection (1992/93).

Table A4 (Appendix) shows the estimation results for secondary members of agricultural households. As noted before, self-employment earnings and wage functions have been constrained to be the same as those 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 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 the simulation exercise, we need to recover the whole covariance structure Σ^*. Therefore, we proceed to a calibration. We first assume that the measurement error and transient component of wages is low (i.e. $\varepsilon_2 = 0$). Second, we assume that the unobservable term of the reservation value is not correlated with the measurement error and transient component of self-employment earnings (i.e. $corr\left(t_0, \varepsilon_1\right) = 0$). These two assumptions allow for a straightforward identification of the remaining part of the covariance matrix. With the estimated coefficients, we obtain rather reasonable estimates:

- rather close standard errors for the permanent components of individual task unobservables, i.e. $\sigma\left(t_1\right) \approx \sigma\left(t_2\right) \approx 0.8$;
- almost no correlation between the two: $\text{corr}\left(t_2, t_1\right) \approx 0.0$;
- positive and reasonably close correlations between these unobservables and the unobservable in the reservation value, i.e. $\text{corr}\left(t_1, t_0\right) \approx \text{corr}\left(t_2, t_0\right) \approx 0.5$;
- a large measurement error and transient component for self-employment benefits: $\sigma\left(\varepsilon_1\right) = 1.4 * \sigma\left(t_1\right)$;
- 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. We just have to draw, for each individual, a vector of unobservables. This vector of unobservables is constrained to respect the inequality constraints (6)-(8) for individuals who are at least 11 years old in 1993 and for which the initial occupational choice is observed. 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 the evolution of labor supply and labor demand. The employment 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. Furthermore, 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. 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 its members, is reallocated in equal parts within each region among the households without land, 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. This increase can also be interpreted as an increase in the productivity of land. 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, $L < \bar{L}$. 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).

3 Simulation results

Drawing on 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, region of residence, marital status, position in the household and the size of the household (WAIDSH, the "H" standing for Heterogenous). As mentioned, each of these three scenarios respects the United Nations' projections for the impact of AIDS on life expectancy at birth.

3.1 Aggregate results

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

[please insert Table 2 about here]

Table 2 shows that, according to our simulations, AIDS has a more important impact on the size of the population and the economy than it has on the level and on the distribution of individual incomes. Demographic growth decreases by around 0.5 percentage points 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. However, the average size of households is projected to decrease due to AIDS by around 0.45 persons.

Although AIDS kills in particular adults of working age, the dependency ratio does not increase, but instead decreases, particularly in the WAIDSH scenario. This effect will be commented 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 the population. Therefore growth of income per capita or income per adult equivalent do not change much. However, it should be reminded that the model does not introduce any of the factors which macro-studies have pointed out to influence per capita growth. First, 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 may become inactive some years before they die. Third, workers deaths generate turnover costs.

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

[please insert Table 3 about here]

Table 3 recapitulates changes in the employment structure and in school 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 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 workers increase by around 3 percentage points. The main differences introduced by the AIDS scenarios lie in an accelerated decrease of the inactivity rate and a smaller 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. The increase of the share of independent farmers stems from automatic replacements of dead household heads. The three scenarios also show no differences with respect to school enrolment of children. However, we do not pretend to have a fully reliable model of school enrolment which would allow to derive the impact of adult deaths on the schooling of children and especially orphans. As described in the appendix, our model indeed introduces the link to the household head—which Case, Paxson and Ableidinger (2002) put forward as the main variable—and also to the household size. Like the Case *et al.* (2002) model, our enrolment model is however estimated in cross-section and might be biased as Evans and Miguel (2004) argue. But, the estimates of these latter authors using panel data for Kenya only reveal a moderate impact of adult deaths on school enrolment too, mitigating the catastrophic long-run forecasts drawn by Bell *et al.* (2003). Furthermore and most importantly, here we do not examine this very long-run impact on growth and income distribution given that we only examine a period of fifteen years.

3.2 The impact of AIDS on individual welfare

Here we analyze the main behavioral changes implied by the occurrence of an AIDS death. This will help to understand 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. For 20 to 59 years old men and 20 to 49 years old women 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 the risk factor of all household members through the "matching component" Y (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 they lived in ("households of passage"), 19% have experienced an unique AIDS-death, and the remaining 15% have experienced two or more AIDS deaths.

[please insert Table 4 about here]

Table 5 illustrates the mortality differentials introduced by AIDS with respect to education and occupation. Among 15 to 60 years old individuals, 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 AIDSrelated deaths is 15 percentage points higher (in 2007) in the WAIDSH scenario than in the WAIDSU scenario. The distribution of AIDS deaths by occupation (over the population older than eleven years and not enrolled in school) reveals a rather different picture. Now, the heterogenous AIDS epidemic kills more often farmers and less often self-employed workers and inactive people.

[please insert Table 5 about here]

Figure 1 draws the concentration curve of AIDS deaths inside the distribution of income per capita. One can see that in both AIDS scenarios the epidemic kills more often people in the bottom-half of the income distribution. For instance, the poorest 50% 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.[15] 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. 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.

[please insert Figure 1 about here]

Having described the differences in the AIDS deaths profiles between the two scenarios, we now turn to the micro-economic explanation of the aggre-

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

gate results. A first striking feature, which has to be explained, is the evolution of the dependency ratio, which seems to determine strongly income, inequality and poverty. 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 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 three scenarios, but the two AIDS scenarios come out as lower and higher bound—the WAIDSU scenario being the most pessimistic and the WAIDSH scenario the most optimistic.

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: children as well as students, inactive and unemployed people in urban areas. The heterogenous epidemic kills slightly more often inactive people than the uniform epidemic, due to the modelling of intra-household transmission and due to the correlation of infection risk with education. Second, the death of a woman in the fertility relevant age group decreases total fertility of the corresponding household.[16] 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 due to 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

[16] The physiological decrease of fertility observed among infected women is even not taken into account here. See Desgrées du Loû, Mselatti, Yao*et al.* (1999).

factors explain why in AIDS affected households the dependency ratio may not necessarily increase, or may even decrease. 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. Likewise, projections of the dependency ratio for 2010 from the International Program Center at the US Bureau of the Census do not show any systematic differences either between the with AIDS and without AIDS scenarios for nine countries of Southern Africa (see Haacker 2002). 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 can be written for each period after 1994 as follows:

$$y_{i,t+1} = \lambda y_{i,t-1} + \alpha ad_{i,t} + \beta od_{i,t} + u_i + \varepsilon_{i,t+1} \tag{10}$$

where $y_{i,t}$ stands for the (log) of income per capita, $ad_{i,t}$ for the occurrence of an AIDS death in the relevant household in year t, and $od_{i,t}$ for the occurrence of an other death in the relevant household in year t. 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.[17] Given the presence of an individual fixed effect, this model may be better estimated in first differences. However Table 6 shows that the level and first difference estimators are consistent.

Having experienced an AIDS death in the relevant household in year t lowers on average income per capita in $t+1$ by roughly 3%. In contrast, having experienced a death from another cause increases on average income

[17] I.e. 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.

per capita by roughly 1.5%. The difference between the two "types" 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 children and older persons, lowering the dependency ratio.

[please insert Table 6 about here]

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 makes survivors a little poorer in terms of income. In other words, AIDS kills more often people around the poverty line and pushes some survivors under the poverty line. 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.

4 Conclusion and policy implications

To our knowledge, this analysis is the first attempt to link the distribution of the AIDS epidemic over an African population and the distribution of income. It reveals the complexity of the interaction between demographic behavior and the income generating process.

When one focuses on the labor supply effects of over-mortality, 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. In contrast with an often heard argument, the dependency ratio is not much modified by the epidemic. These conclusions do not seem to depend on the degree of heterogeneity and clustering of the HIV/AIDS infection over the population, as may be inferred from the comparison between our two epidemiological scenarios. Of course, if the impact of incapacity in the years preceding the AIDS deaths was taken into account or if the prospects of labor demand were significantly affected by AIDS (e.g. through a collapse of investment or organizational problems in firms), then both the overall and micro-economic impact of the epidemic would appear more dramatic.

This study also illustrates that such an epidemic finally reaches all socio-economic groups of a society. AIDS mortality hurts only a little more the lower middle class of the Ivorian population, that is the richest of the poor. It confronts survivors of an affected household to downward, although moderate, transitions through the distribution of income. However, for the two epidemiological profiles we considered, the epidemic turns out to be rather evenly distributed over the population. For instance, in contrast with another often heard idea, AIDS is not so much concentrated in urban areas.[18] Even if in our two scenarios in cities AIDS deaths occur more often than deaths from other causes, about a half of AIDS deaths hit people originating from rural areas. This latter proportion is even higher when we look at orphans, whatever the definition we consider. For instance, more than 60 percent of orphans come from rural areas. Furthermore, among the less than 15 years old children whose biological father and mother are observed in the 1992/93 survey or who are born during the simulation period, 9% loose one of their parent during the fifteen years period. More generally, 10% of children experience the death of the household head or of the first spouse of the household

[18] This common view probably comes from the fact that AIDS are more often detected and reported in urban areas. As in 1995, 3,401 out of 5,380 reported AIDS cases were in Abidjan (Koné, Silué, Agness-Soumahoro *et al.* 1998). But the distribution of reported cases is not consistent with the seroprevalence data from surveillance centers for pregnant women (see section 2.2).

head. In the year of their parents deaths more than 35 percent of all orphans live in a household among the poorest quintile in the distribution of income per capita.

Our study does not question the fact that the AIDS epidemic represents a terrible human catastrophe that calls for a more vigorous national and international mobilization. Concerning the provision of appropriate health care and treatment, our analysis shows that the great majority of AIDS patients cannot even afford the cost of care for opportunistic infections (OI) or highly active anti-retroviral therapies (HAARTs). Bonnel (2001), for instance, estimates the annual medium cost for opportunistic infections care and palliative treatment at 360US$ (resp. 240US$) (in prices of 2000) for an adult (resp. a child) in a low-income African country. Taking a 250,000 CFAF benchmark (prices of 1998, approx. 425US$) as a unitary annual cost for the clinical management of OI in Côte d'Ivoire, we computed that 60 percent of AIDS infected individuals lived in a household whose total income per capita was under that benchmark in the year preceding their death. As Figure 2 clearly shows, the annual cost of a HAART treatment is out of reach for almost all infected persons in Côte d'Ivoire, in particular if we choose the higher bound of 1,000 US$ (at 1998 prices, approx. 589,900 CFAF), which are the estimated annual costs estimated by the Harvard University.[19] Of course households are not only constrained by their budget, but also by the availability of health infrastructures and services. In the case of Côte d'Ivoire, many studies have shown that much remains to be done to modify the elitist bias of past health policies marked by heavy investment biased toward Abidjan (see e.g. Brunet-Jailly 2002).

[19] See "Consensus Statement on antitretroviral treatment for AIDS in poor countries" establised by the faculty of Harvard University in March 2001.

[please insert Figure 2 about here]

Appendix

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

[please insert Tables A1 to A4 about here]

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 5,935 households, comprising 8,099 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, e.g. 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 "assortative 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 16,125 households (58,378 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 to estimate transition rates into and out of schooling. The *Enquête de Niveau de Vie* of 1998 is very similar to the EP 1993, but the sample size is smaller by 50%. 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 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.

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Tables

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).

Table 2
Simulation results in terms of population, growth, inequality, and poverty
(income in 1000 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 to which we assigned a value 0.5.

Source: Simulations by the authors.

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.

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
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 over-proportionally affected by AIDS deaths. *Source:* Simulations by the authors.

Table 6
Regressions of log household income per capita on having known a death
in the relevant household 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.

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 head 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 for household head

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 head of household	-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

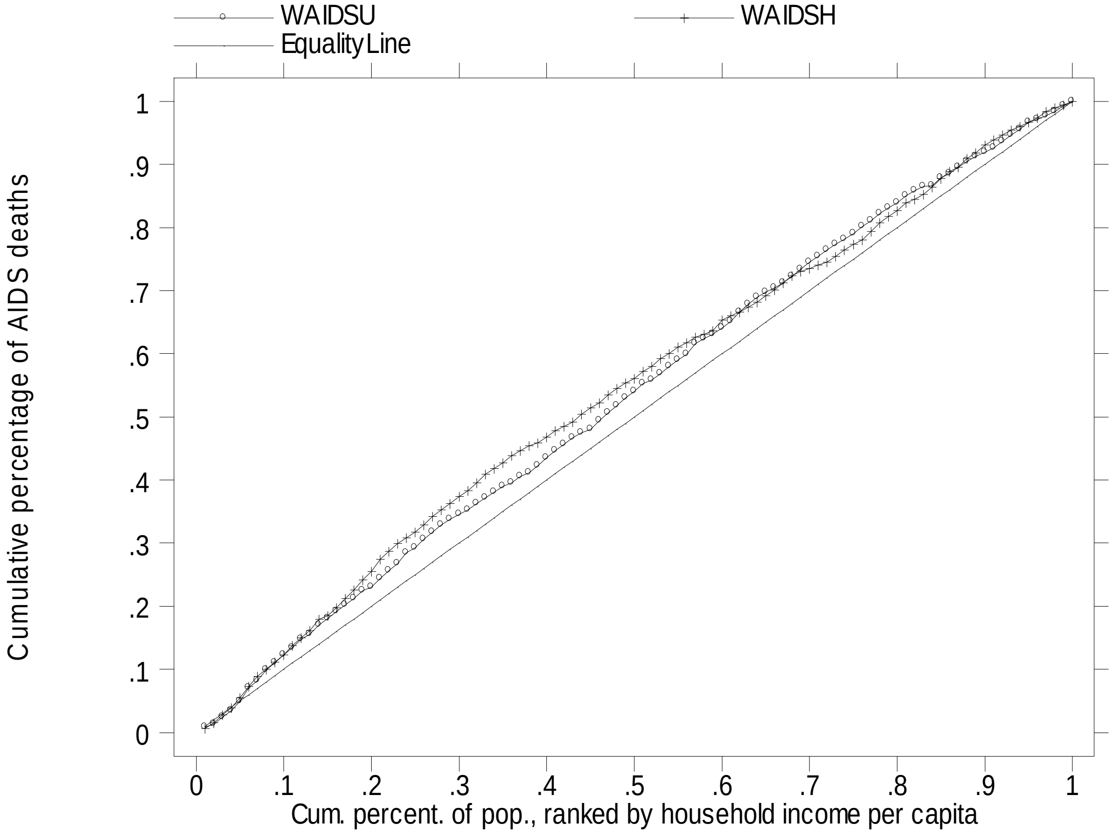
Dependent variables	Non-farm self.		Wage earner		Reserv. w.	
log monthly earnings and occup. choice	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
NON-AGRICULTURAL HOUSEHOLDS (all household members 12 years and older)						
Schooling	0.069 *	(0.004)	0.171 *	(0.004)	0.101 *	(0.005)
Experience	0.078 *	(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 (secondary household members 12 years and older)						
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.

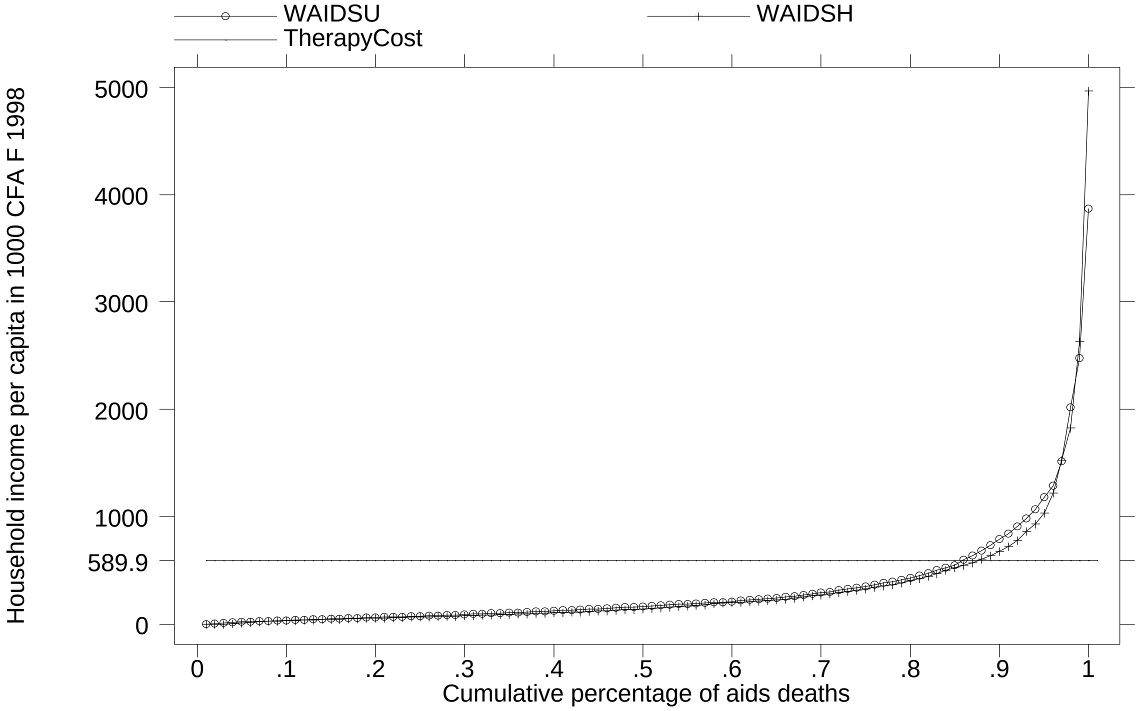
Figures

Figure 1
AIDS deaths concentration curve
(household income per capita in 1998)



Notes: Figure based on households existing in 1993 and 2007. The cumulative AIDS deaths include all AIDS deaths, which have occurred between 1993 and 2007.
Source: Simulations by the authors.

Figure 2
AIDS mortality, income distribution and
approximate therapy cost per person per year
(income per capita in the year preceding the AIDS death)



Source: Simulations by the authors.